Essays on barriers to international and intranational trade

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Présentée et soutenue publiquement par

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DOCTORAL THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Essays on barriers to international and intranational trade

Publicly presented and defended on June 20, 2023 by

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Résumé: Cette thèse de doctorat est motivée par deux domaines de recherche qui traitent de l'impact économique des barrières commerciales: la pertinence des coûts liés au transport et le rôle des barrières non tarifaires, en particulier les règles d'origine préférentielles et les exigences en matière de contenu local.

Ces barrières constituent le thème principal de ma thèse, dans laquelle j'examine et quantifie leurs effets sur le commerce intra- et international. Dans mon premier chapitre, je contribue à la littérature commerciale en quantifiant l'impact des coûts de transport spécifiques à chaque mode sur le commerce intranational et en mettant en évidence les différences de ces barrières commerciales entre les modes et les catégories de marchandises - une conclusion qui est également importante dans le context du commerce international. Dans mon deuxième chapitre, je montre que les efforts des gouvernements visant initialement à soutenir le commerce international, notamment par la négociation et la mise en œuvre d'accords commerciaux préférentiels, peuvent en fait imposer des coûts de mise en conformité qui constituent des obstacles au commerce international, notamment par le biais des règles d'origine. Dans mon troisième chapitre, je souligne l'importance du secteur des transports pour le commerce intranational et montre essentiellement que les barrières commerciales induites par les politiques dans ce secteur peuvent affecter les résultats économiques non seulement dans le secteur cible, mais aussi au-delà – dans les industries en amont et en aval d'un pays.

Summary: This dissertation is motivated by two areas of research that address the impact of trade barriers on economic outcomes: the relevance of transport-related costs and the role of non-tariff barriers, particularly preferential rules of origin and local content requirements.

These barriers are the overarching theme of my dissertation, in which I examine and quantify their effects on intra- and international trade. In my first chapter, I contribute to the trade literature by quantifying the impact of mode-specific transport costs on intranational trade and highlighting differences in these trade barriers across transport modes and categories of goods – a finding that is also important in the context of international trade. In my second chapter, I show that government efforts originally intended to support international trade, such as through the negotiation and implementation of preferential trade agreements, can actually impose compliance costs that act as barriers to international trade, such as through RoO. In my third and last chapter, I highlight the importance of the transport sector for intranational trade and essentially show that policy-induced trade barriers in this sector can affect economic outcomes not only in the target sector, but also beyond – in a country's upstream and downstream industries.

Mots-clés

Frictions commerciales intranationales - Élasticités de distance - Modes de transport
Règles d'origine - Règles d'origine spécifiques aux produits - coûts de mise en conformité
Cabotage, commerce intérieur, modèles entrées-sorties

Keywords

Intranational trade frictions – Distance elasticities – Transport modes
Rules of origin – Product-specific rules of origin – compliance costs
Cabotage, Domestic trade, Input-Output models

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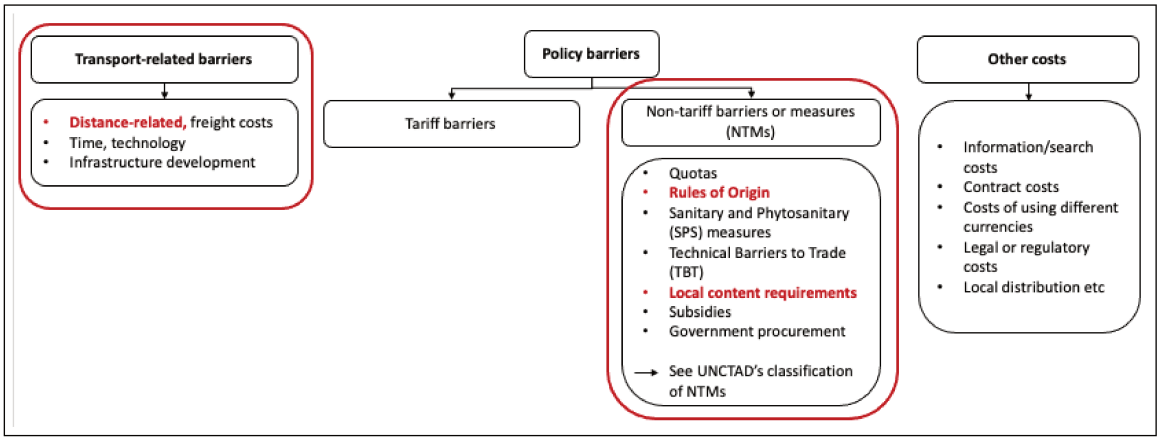
General introduction

Trade in goods is overall positively associated with welfare gains and economic development (Feyrer, 2019, 2021; Frankel and Romer, 1999; Arkolakis et al., 2012; Adão et al., 2022, cf.). It is therefore crucial to understand the factors that inhibit trade from materialising. Barriers to inter- and intranational trade may take various forms, as illustrated in Figure 1.

Figure 1 *Trade barriers*



Notes: Other trade costs involve informational frictions (Allen, 2014; Blum and Goldfarb, 2006; Chaney, 2018; Huang, 2007; Lendle et al., 2016)), contract costs, costs of using different currencies, legal or regulatory costs and local distribution costs.
Source: Author based on Anderson and van Wincoop (2004).

Transport-related barriers refer, for instance, to freight and insurance costs or time to ship a product from origin to destination, and more broadly to the quality and development of domestic and international transport infrastructure. The COVID-crisis demonstrated the negative consequences of interrupted transport sectors for trade. According to IMF work (Komaromi et al., 2022), global congestion led to a 25 percent increase in travel time, and the additional delays in transit of average shipments in December 2021 can be compared to an ad-valorem equivalent (AVE) tariff of 0.9 to 3.1 percent. This AVE tariff is significant when compared to the weighted global average of effectively applied tariffs for all products of 3.9 percent (UN COMTRADE). The existing literature uses observed freight and insurance costs to investigate the negative effect of transport costs on international trade (Asturias, 2020;

Hummels, 1999, 2001; Limao and Venables, 2001; Martínez-Zarzoso et al., 2003; Martínez-Zarzoso and Suárez-Burguet, 2005; Volpe Martincus et al., 2014) . Furthermore, Hummels and Schaur (2013) examine transport time as a barrier to trade, while Blonigen and Wilson (2008); Clark et al. (2004); Coşar and Demir (2016); Limao and Venables (2001); Wessel (2019) study the role of infrastructure quality, efficiency and development as a determinant of international trade. However, most of research on trade barriers has been conducted at the international-level although intranational trade is significant in value and often represents a multiple of a country's international trade. As such, a better understanding of domestic trade barriers is crucial for gains from intranational trade to materialise.

Policy-induced barriers include tariffs, which directly increase the final price of goods, thus reduce consumer demand, and non-tariff measures (NTMs). While tariff-related barriers have become less important with the decline in tariffs and the increasing number of preferential trade agreements that provide for lower tariffs, NTMs are becoming increasingly relevant. Around 3,000 new or changed NTMs have been reported to the World Trade Organization between 2013 and 2018 (UN, 2019), while tariffs have fallen by about half between 2000 and 2020 (from 7.66% to 3.91% of effectively applied tariffs) (UN COMTRADE). UN (2019) states that "Trade costs of NTMs are more than double that of ordinary customs tariffs." NTMs include, for example, export quotas (Gourdon et al., 2016), Sanitary and Phytosanitary (SPS) measures, Technical Barriers to Trade (TBT) (Cadot and Gourdon, 2016; Disdier et al., 2020), rules of origin (RoO), local content requirements (LCRs) or subsidies (UNCTAD, 2019). These measures implemented by governments may impose compliance costs (intentionally as a protectionist tool or unintentionally) or restrict market access, thus impeding trade (Bora et al., 2002; Carrère and De Melo, 2011; Fugazza, 2013).

One type of NTM is rules of origin (RoOs) which establish the origin requirements that products must meet to qualify for preferential market access under preferential trade agreements (PTAs). Unlike non-preferential RoOs, such as those related to anti-dumping measures, "preferential RoOs" are intended to prevent the transshipment of products between partners with low tariffs in a Free Trade Area (trade deflection). RoOs, while indispensable, can negate the benefits of PTAs. As described in Angeli et al. (2020), if these rules are too restrictive or complex to implement, firms may not be able to take advantage of tariff concessions. Some firms may be unable to fulfil the requirements because of technological or managerial constraints, putting them at a competitive disadvantage and even exit the market. Others may simply not utilize the preferences because the expected costs of complying with the rules significantly outweigh the associated tariff reductions. Studies in this area generally highlight the compliance costs of various types of RoO that hinder the use of PTAs and global value chain integration (Cadestin et al., 2016; Cadot and Ing, 2016; Conconi et al.,

2018; Hayakawa et al., 2019, 2016). However, existing studies typically only address the RoOs of one PTA or multiple PTAs in specific regions, such as ASEAN, while analyses of RoO of the quasi-entire spectrum of global PTAs can provide stylized facts about the average compliance costs of different categories of RoO.

Local content requirements (LCR), another NTM, require companies to source a minimum percentage of value added or inputs domestically.[1] LCR typically relate to goods, services, data storage, staffing, or subcontractor requirements. In other cases, firms are also required or encouraged to provide economic benefits to the local economy, such as in-country investment, technology or knowledge transfer, licensed production, or exporting assistance (Gourdon et al., 2017). Most studies on LCR highlight the long-term inefficiencies that arise in the economy as a result of the commitment to local sourcing, increasing input prices through excessive costs and reducing aggregate demand (Anouti et al., 2013; Belderbos and Sleuwaegen, 1997; Hufbauer et al., 2013; Stone et al., 2015; Veloso, 2006).

This dissertation is motivated by two areas of research that address the impact of trade barriers on economic outcomes: the relevance of transport-related costs and the role of non-tariff barriers, particularly preferential rules of origin and local content requirements. These barriers are the overarching theme of my dissertation, in which I examine and quantify their effects on intra- and international trade.

***

My first chapter, *Heterogeneous distance effects in intra-US trade – The role of transport modes,* broadly relates to the literature on transport costs. In contrast to this literature, I look at intranational trade which is so far less studied. Also, I approximate transport costs by shipping distances to investigate the effect of distance-related trade costs on intra-US trade by drawing on the gravity model of trade. By using mode-specific routed distances in miles, I am able to more precisely measure trade distances compared to traditional distance measures, such as great-circle distance. Routed distances are shaped by the nation's infrastructure and internal geography and thereby capture more realistically transport costs.

The results confirm that traditional distance measures underestimate the distance-effect. The empirical results reveal a distance elasticity of intra-US trade of -1.793, while the standard measure of great-circle distances underestimates the distance effect by around 12%. The study furthermore shows that the distance effect indeed varies across transport modes. Trade via road by truck is most sensitive to changes in distances, followed by water, rail and air. For instance, a 10 percent change in road distance is associated with a decline in intra-US trade in goods of around 21 percent.

[1] Part of this description are taken from Gourdon and Guilhoto (2019).

Further findings in this paper suggest that the trade effect of distance significantly declines (in absolute terms) with increasing distances and varies across different categories of goods with higher elasticities for low-value or perishable goods than high-value or non-perishable commodities. Finally, the paper finds domestic border effects only for truck, rail and water transport while domestic US State borders are irrelevant for air trade.

Overall, this analysis contributes to the trade literature by quantifying the impact of mode-specific transport costs on intranational trade and highlighting differences in these trade barriers across transport modes and categories of goods – a finding that is also important in the context of international trade.

***

In my second chapter, *The trade effect of preferential product-specific Rules of Origin* joint with Julien Gourdon and Jaime de Melo, we relate to the literature on NTMs by focusing on the role of RoO in explaining international trade. We investigate for 128 Regional Trade Agreements (RTAs) over the period 1990-2015 the effect of different types of Product-Specific Rules of Origin (PSRs) on bilateral trade intensity. We use the World Bank's recently available Deep Trade Agreement (DTA) database that collects PSRs and Regime-wide Rules (RWRs).

Our results are based on a structural gravity model controlling for confounding factors. The study's findings suggest that more flexible PSRs are associated with a significantly stronger trade effect compared to more restrictive ones where exporters do not have a chocie among PSRs or have to satisfy multiple rules. A simulation exercise reveals that a radical simplification reform leading to the adoption of flexible PSRs providing alternative choices to prove origin would have increased global trade under RTAs by on average 2.7 percent during the sample period.

In summary, this paper shows that government efforts originally intended to support international trade, such as through the negotiation and implementation of preferential trade agreements, can actually impose compliance costs that act as barriers to international trade, such as through RoO.

***

In my third chapter, *US maritime cabotage: An economic assessment of the Jones Act policy*, which I co-authored with Joaquim José Martins Guilhoto, we draw on the NTM literature by assessing a long-standing local content requirement in the US. This policy, known as the *US Jones Act*, mandates that maritime trade within the US be conducted with US-built, US-owned, US-crewed and US-flagged vessels, thereby protecting the domestic US shipbuilding industry and artificially inflating domestic shipping prices.

In our study, we simulate the impact of a hypothetical repeal of the Act on the US economy and show which up- and downstream industries are most affected by this policy. Our work is based on a novel version of OECD's Inter-Country Input-Output (ICIO) database, which is disaggregated to the level of the US shipbuilding industry and captures the dynamics of ship production in 2018 across 46 industries and 67 countries.

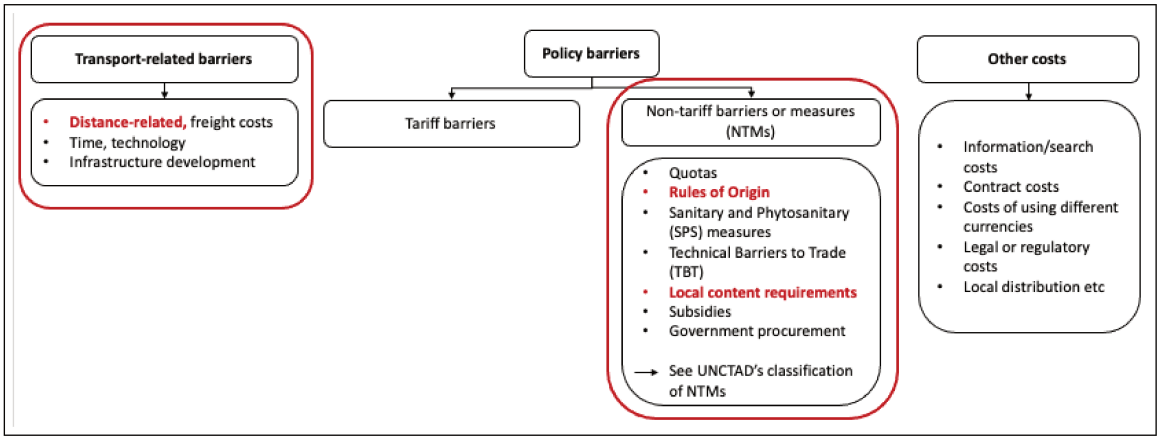
Simulation results are based on a static multi-country input-output model and show losses for the US services sector, but economic gains for the US food industry, agricultural products sector, pharmaceutical sector, electronics industry, and petroleum products sector.

This chapter summarizes the role of transport-related and policy-induced barriers to trade. It highlights the importance of the transport sector for intranational trade and essentially shows that policy-induced trade barriers in this sector can affect economic outcomes not only in the target sector, but also beyond – in a country's upstream and downstream industries.

Introduction générale

Les échanges de biens sont généralement associés de manière positive aux gains de bien-être et au développement économique (Feyrer, 2019, 2021; Frankel and Romer, 1999 ; Arkolakis et al., 2012 ; Adão et al., 2022, cf.). Il est donc essentiel de comprendre les facteurs qui empêchent le commerce de se réaliser. Les obstacles au commerce international et intranational peuvent prendre diverses formes, comme l'illustre la figure 2.

Figure 2 *Les obstacles au commerce*



Notes: Les autres coûts commerciaux comprennent les frictions informationnelles (Blum2006, Huang2007, Allen2014b, Lendle2016, Chaney2018a), les coûts contractuels, les coûts liés à l'utilisation de devises différentes, les coûts juridiques ou réglementaires et les coûts de distribution locaux.
Source: Autrice basée sur Anderson and van Wincoop (2004).

Les barrières liées au transport se réfèrent, par exemple, aux coûts de fret et d'assurance ou au temps nécessaire pour expédier un produit de son origine à sa destination, et plus largement à la qualité et au développement des infrastructures de transport nationales et internationales. La crise du COVID a démontré les conséquences négatives de l'interruption des secteurs de transport sur le commerce. Selon les travaux du FMI (Komaromi et al., 2022), la congestion mondiale a entraîné une augmentation de 25 pour cent du temps de voyage, et les retards supplémentaires dans le transit des expéditions moyennes en décembre 2021 peuvent être comparés à un tarif équivalent ad valorem (EAV) de 0,9 à 3,1 pour cent. Ce tarif EAV est significatif par rapport à la moyenne mondiale pondérée des tarifs effectivement

appliqués pour tous les produits, qui est de 3,9% (UN COMTRADE). La littérature existante utilise les coûts de fret et d'assurance observés pour étudier l'effet négatif des coûts de transport sur le commerce international (Asturias, 2020; Hummels, 1999, 2001; Limao and Venables, 2001; Martínez-Zarzoso et al., 2003; Martínez-Zarzoso and Suárez-Burguet, 2005; Volpe Martincus et al., 2014) . En outre, Hummels and Schaur (2013) examine le temps de transport en tant qu'obstacle au commerce, tandis que Blonigen and Wilson (2008); Clark et al. (2004); Coşar and Demir (2016); Limao and Venables (2001); Wessel (2019) étudie le rôle de la qualité, de l'efficacité et du développement de l'infrastructure en tant que déterminant du commerce international. Cependant, la plupart des recherches sur les barrières commerciales ont été menées au niveau international, bien que le commerce intranational soit bien plus important en valeur que le commerce international d'un pays. Il est donc essentiel de mieux comprendre les barrières commerciales nationales pour que les gains du commerce intranational se matérialisent.

Les barrières commerciales qui résultent des politiques mises en place comprennent les droits de douane, qui augmentent directement le prix final des marchandises et réduisent ainsi la demande des consommateurs, et les mesures non tarifaires (MNT). Si les barrières tarifaires ont perdu de leur importance avec la baisse des droits de douane et le nombre croissant d'accords commerciaux préférentiels qui prévoient des droits de douane moins élevés, les MNT deviennent de plus en plus importantes (Orefice, 2017). En moyenne, environ 300 nouvelles MNT sont introduites chaque année, alors que les droits de douane ont diminué de moitié entre 2000 et 2020 (de 7,66% à 3,91% des droits de douane effectivement appliqués) (UN COMTRADE). Les MNT comprennent, par exemple, les quotas d'exportation (Gourdon et al., 2016), les mesures sanitaires et phytosanitaires (SPS) ou les obstacles techniques au commerce (OTC) (Cadot and Gourdon, 2016; Disdier et al., 2020), les règles d'origine (RoO), les exigences en matière de contenu local (LCR) ou les subventions (UNCTAD, 2019). Ces mesures mises en œuvre par les gouvernements peuvent imposer (intentionnellement comme outil protectionniste ou non) des coûts de mise en conformitéou restreindre l'accès au marché, entravant ainsi le commerce (Bora et al., 2002; Carrère and De Melo, 2011; Fugazza, 2013).

Les règles d'origine constituent un type de MNT, elles sont nécessaires dans le cas des accords commerciaux préférentiels (ACP) pour établir les conditions que les produits doivent remplir pour bénéficier d'un accès préférentiel au marché dans les ACP, qu'ils soient réciproques ou non réciproques. Contrairement aux RdO non préférentielles, telles que celles liées aux mesures antidumping, ces "RdO préférentielles" sont destinées à empêcher le détournement de produits entre des partenaires ayant des droits de douane peu élevés dans une zone de libre-échange (détournement de trafic). Bien qu'indispensables, les RdO peuvent réduire significativement les avantages des Zones de Libre Échanges (ZLE). Comme décrit

dans Angeli et al. (2020), si ces règles sont trop restrictives ou complexes à mettre en œuvre, les entreprises peuvent ne pas être en mesure de profiter des concessions tarifaires. Certaines entreprises peuvent être incapables de satisfaire aux exigences en raison de contraintes technologiques ou managériales, ce qui les place dans une situation de désavantage concurrentiel et les conduit même à quitter le marché. D'autres peuvent tout simplement ne pas utiliser les préférences parce que les coûts prévus pour se conformer aux règles dépassent largement les réductions tarifaires associées. Les études dans ce domaine mettent généralement en évidence les coûts de mise en conformité des différents types de RdO qui entravent l'utilisation des ACP et l'intégration dans la chaîne de valeur mondiale (Cadestin et al., 2016; Cadot and Ing, 2016; Conconi et al., 2018; Hayakawa et al., 2019, 2016). Toutefois, les études existantes ne portent généralement que sur les RdO d'une ZLE ou de plusieurs ZLEdans des régions spécifiques, telles que l'ANASE, alors que les analyses des RdO de la quasi-totalité des ZLE mondiales peuvent fournir des faits stylisés sur les coûts moyens de mise en conformité des différentes catégories de RdO.

Les exigences de contenu local (ECL), une autre MNT, obligent les entreprises à s'approvisionner en produits nationaux pour un pourcentage minimum de la valeur ajoutée ou des intrants.[2] Les ECL portent généralement sur les biens, les services, le stockage des données, le personnel ou les exigences des sous-traitants. Dans d'autres cas, les entreprises sont également tenues ou encouragées à fournir des avantages économiques à l'économie locale, tels un montant significatif d'investissement dans le pays, le transfert de technologie ou de connaissances, la production sous licence ou l'aide à l'exportation (Gourdon et al., 2017). La plupart des études sur le ECLmettent en évidence les inefficacités à long terme qui apparaissent dans les conomies engagées dans ce politiques d'exigence enapprovisionnement local, de part l'augmentation des prix des intrants en raison des coûts excessifs et de la réduction de la demande globale (Anouti et al., 2013; Belderbos and Sleuwaegen, 1997; Hufbauer et al., 2013; Stone et al., 2015; Veloso, 2006).

Cette thèse de doctorat est motivée par deux domaines de recherche qui traitent de l'impact économique des barrières commerciales: la pertinence des coûts liés au transport et le rôle des barrières non tarifaires, en particulier les règles d'origine préférentielles et les exigences en matière de contenu local. Ces barrières constituent le thème principal de ma thèse, dans laquelle j'examine et quantifie leurs effets sur le commerce intra- et international.

***

Mon premier chapitre, *Les effets hétérogènes de la distance dans le commerce intra-américain – Le rôle des modes de transport,* se rapporte largement à la littérature sur les coûts de

[2]Une partie de cette description est tirée de Gourdon and Guilhoto (2019).

transport. Contrairement à cette littérature, je me penche sur le commerce intranational qui a été moins étudié jusqu'à présent. En outre, j'approxime les coûts de transport par les distances d'acheminement afin d'étudier l'effet des coûts commerciaux liés à la distance sur le commerce intra-américain en m'appuyant sur le modèle gravitationnel du commerce. En utilisant des distances d'acheminement spécifiques à chaque mode en miles, je suis en mesure de mesurer plus précisément les distances commerciales que les mesures de distance traditionnelles, telles que la distance orthogonale. Les distances d'acheminement sont façonnées par l'infrastructure et la géographie interne du pays et reflètent donc de manière plus réaliste les coûts de transport.

Les résultats confirment que les mesures traditionnelles de la distance sous-estiment l'effet de la distance. Les résultats empiriques révèlent une élasticité du commerce intra-américain liée à la distance de $1,793$, alors que la mesure standard des distances orthogonales sous-estime l'effet de la distance d'environ 12%. L'étude montre en outre que l'effet de la distance varie en fonction des modes de transport. Le commerce par route et par camion est le plus sensible aux changements de distances, suivi par le transport par bateau (maritime et fluvial), le transport ferroviaire et le transport aérien. Par exemple, une variation de 10% de la distance routière est associée à une baisse d'environ 21% des échanges de marchandises à l'intérieur des États-Unis. D'autres conclusions de ce document suggèrent que l'effet de la distance sur le commerce diminue de manière significative (en termes absolus) avec l'augmentation des distances et varie selon les différentes catégories de biens, avec des élasticités plus élevées pour les biens de faible valeur ou périssables que pour les produits de grande valeur ou non périssables. Enfin, l'étude constate des effets de frontières intérieures uniquement pour le transport routier, ferroviaire et maritime, tandis que les frontières intérieures des États américains n'influent pas significativement sur le commerce aérien.

Dans l'ensemble, cette analyse contribue à la littérature commerciale en quantifiant l'impact des coûts de transport spécifiques à chaque mode sur le commerce intranational et en mettant en évidence les différences de ces barrières commerciales entre les modes et les catégories de marchandises - une conclusion qui est également importante dans le contexte du commerce international.

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Dans mon deuxième chapitre, *L'effet sur le commerce des règles d'origine préférentielles spécifiques aux produits*, rédigé conjointement avec Julien Gourdon et Jaime de Melo, nous nous inscrivons dans la littérature sur les MNT en nous concentrant sur le rôle des RdO sur le commerce international. Nous étudions pour 128 accords commerciaux régionaux (ACR) sur la période 1990-2015 l'effet de différents types de règles d'origine spécifiques aux produits

(RSP) sur l'intensité du commerce bilatéral. Nous utilisons la base de données des Accords commerciaux récemment mise à disposition par la Banque mondiale, qui recueille les RSP et les règles générales

Nos résultats sont basés sur un modèle structurel de gravité contrôlant les facteurs de confusion. Les résultats de l'étude suggèrent que des RSP plus flexibles sont associés à un effet commercial significativement plus fort que des RSP plus restrictives où les exportateurs n'ont pas le choix entre plusieurs RSP ou doivent satisfaire de multiples règles. Un exercice de simulation révèle qu'une réforme radicale de simplification conduisant à l'adoption de RSP flexibles offrant le choix en plusieurs règles pour prouver l'origine aurait augmenté le commerce mondial dans le cadre des ACR de 2,7% en moyenne au cours de la période étudiée.

En résumé, ce document montre que les efforts des gouvernements visant initialement à soutenir le commerce international, notamment par la négociation et la mise en œuvre d'accords commerciaux préférentiels, peuvent en fait imposer des coûts de mise en conformité qui constituent des obstacles au commerce international, notamment par le biais des règles d'origine.

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Dans mon troisième chapitre, *US maritime cabotage : Une évaluation économique de la politique du Jones Act*, que j'ai coécrit avec Joaquim José Martins Guilhoto, nous nous inscrivons dans la littérature sur les MNT en évaluant une exigence en matière de contenu local aux États-Unis, qui existe depuis longtemps. Cette politique, connue sous le nom de *US Jones Act*, exige que le commerce maritime à l'intérieur des États-Unis soit effectué avec des navires construits aux États-Unis, appartenant aux États-Unis, dotés d'un équipage américain et battant pavillon américain, protégeant ainsi l'industrie nationale de la construction navale et gonflant artificiellement les prix du transport maritime national.

Dans notre étude, nous simulons l'impact d'une hypothétique abrogation de la loi sur l'économie américaine et montrons quelles industries en amont et en aval sont les plus affectées par cette abrogation de la mesure. Notre travail s'appuie sur une nouvelle version de la base de données ICIO (Inter-Country Input-Output) de l'OCDE, qui est désagrégée au niveau de l'industrie de la construction navale américaine et saisit la dynamique de la production navale en 2018 dans 46 industries et 67 pays.

Les résultats de la simulation sont basés sur un modèle statique d'entrées-sorties multi-pays et montrent des pertes pour le secteur des services américain, mais des gains économiques pour l'industrie alimentaire américaine, le secteur des produits agricoles, le secteur pharmaceutique, l'industrie électronique et le secteur des produits pétroliers.

Ce chapitre résume le rôle des obstacles au commerce liés au transport et induits par les politiques. Il souligne l'importance du secteur des transports pour le commerce intranational et montre essentiellement que les barrières commerciales induites par les politiques dans ce secteur peuvent affecter les résultats économiques non seulement dans le secteur cible, mais aussi au-delà - dans les industries en amont et en aval d'un pays.

1 Heterogeneous distance effects in intra-US trade – The role of transport modes

Abstract

This paper investigates the effect of distance-related transport costs on intra-US trade by drawing on the gravity model of trade. A key feature of this work lies in the availability of routed distances in miles by transport mode. Unlike traditional distance measures used in the trade literature, such as great-circle distances, the measure of routed distances is more precise as it exhibits variation across transport modes reflecting the US transport infrastructure and internal geography. The empirical results reveal a distance elasticity of intra-US trade of -1.793, while the standard measure of great-circle distances underestimates the distance effect by around 12%. Distance elasticities also vary across major transport modes in US domestic trade: the distance effect is significantly different for trade by truck (-2.150), water (-1.001), rail (-0.762) and air (-0.205). Furthermore, the trade effect of distance significantly declines in absolute terms with increasing distances and varies across different categories of goods with higher elasticities for low-value or perishable goods than high-value or non-perishable commodities. Finally, the paper finds domestic border effects only for truck, rail and water transport while domestic US State borders are irrelevant for air trade.

Keywords: Intranational trade frictions; Distance elasticities; Transport modes.

JEL Classification: F13; F14; L91.

Acknowledgements: The author is grateful to Céline Carrère, Claudia Steinwender, Andrei Levchenko, Natalie Chen, participants at the European Trade Study Group (ETSG) in 2021 for their useful comments and discussions, and the provision of data by Luis Martinez (ITF) at early stages of the work.

1.1 Introduction

Trade internal to a country is significant and often represents a multiple of an economy's international trade (Agnosteva et al., 2019; Borchert et al., 2021; Yilmazkuday, 2020). Like international trade, intranational trade contribute to economic development and lead to welfare gains (Albrecht and Tombe, 2016; Donaldson and Hornbeck, 2016; Tombe and Winter, 2013; Yilmazkuday, 2020).[1] As such, a better understanding of domestic trade impediments is crucial for gains from intranational trade to materialise. Even beyond domestic considerations, findings about a country's internal trade costs can be useful in explaining dynamics in the international economy (Ramondo et al., 2016).

While the impact of various forms of barriers on international trade has already been examined in a large body of research (Anderson and van Wincoop, 2004), the impact of domestic trade costs on intranational trade has been less studied. In addition, barriers to international trade such as tariff and non-tariff barriers, cultural or historical differences do not occur or are less pronounced at the intranational level.

This paper investigates the effect of domestic trade costs on intra-US trade of goods. Since transport infrastructure is the backbone of trade in goods, trade costs at the intranational level are essentially transport costs. Due to the lack of detailed data on transport costs, I use routed distances by different modes of transport as a proxy. This approach allows to study the effect of distance-related transport costs on intra-US trade.

For the empirical work, I exploit a detailed dataset of good-specific trade flows by transport mode within and between US States across four 5-years intervals starting in 1997. The dataset allows deriving mode-specific routed distances in miles that have been estimated from a spatial representation of the US multimodal infrastructure network. Unlike traditional distance measures used in the trade literature such as great-circle distances, the measure of routed distances exhibits variation across transport modes due to differences in transport infrastructure and US internal geography. For instance, while bridges allow roads to traverse rivers, waterways follow pre-defined rivers that might result in longer distances than for other modes for same trading pairs. Similarly, while intranational airways follow relatively straight-line routes, railway construction takes account of geographical features such as mountains or lakes, leading to non-linear routes between trading partners.[2] Mode-specific routed distances thereby capture the cost of travelling via different modes of transport (Allen and Arkolakis, 2014).

[1] See Feyrer, 2019, 2021; Frankel and Romer, 1999, c.f.Adão et al., 2022; Arkolakis et al., 2012 for studies on the economic effect of international trade.

[2] Note that I explicitly mention intranational airways in this argument as international airways may not always follow straight-line routes because of certain no fly zones (Besedes and Chu, 2021).

The paper's Ordinary-Least-Squares (OLS) estimation is based on the theoretical gravity model of trade and exploits variation in trade flows of the same good transported by the same mode in the same year from the same origin (destination) US State across all destination (origin) US States using fixed effects. The study leads to five main results: First, I find a distance effect in intranational US trade of -1.793 implying that a 1% increase in routed distance leads to a decline in intra-US trade by on average 1.793%. Further results suggest that traditionally applied measures in the literature such as great-circle distances underestimate the distance effect by around 12%. While great-circle distances measure the shortest distance along the Earth's surface between two locations, routed distances are more precise as they are based on the actual US transport network that rarely follows straight lines due to geographic reasons.

Second, I show that distance-related transport costs significantly vary across transport modes. The estimated distance elasticity of road transport by truck amounts to -2.150 and is statistically different from point estimates for water, rail and air travel amounting respectively to -1.001, -0.762 and -0.205. The ranking in mode-specific coefficients is robust to different estimates including the Poisson-Pseudo Maximum Likelihood (PPML) estimator and different data samples.

Third, I find that intra-US distance effects decrease in absolute terms with increasing distances. Estimates show a distance effect of -1.981 for shipments below 500 miles and a distance effect of -0.381 for shipments equal or above 1,500 miles. The pattern remains for truck and rail transport while air trade becomes insignificant to distance for shipments equal or above 1,500 miles.

Fourth, I show that the distance effect is significantly different between different categories of goods. Trade of high value (low-weight) or non-perishable goods is less sensitive to changes in routed distances than low value (heavy-weight) or perishable goods.

Fifth, I find that trade within the same US State is significant for truck, rail and water transport but insignificant for air trade as air transport is particularly used for long hauls across US States.

This paper is related to two strands of literature. First, by providing evidence of heterogeneous distance effects across transport modes, the paper's findings relate to the literature about the effect of distance-related transport costs on trade.[3] Some of the studies in this area use actual transport costs, such as freight and insurance costs and time (Asturias, 2020; Combes and Lafourcade, 2005; Combes et al., 2005; Hummels, 1999, 2001; Limao and

[3] Another strand of literature deals with fixed transport costs, rather than distance-related costs. Such work draws on indices capturing infrastructure quality, efficiency or development as a proxy for transport costs (Blonigen and Wilson, 2008; Clark et al., 2004; Coşar and Demir, 2016; Limao and Venables, 2001; Wessel, 2019).

Venables, 2001; Martínez-Zarzoso et al., 2003; Martínez-Zarzoso and Suárez-Burguet, 2005; Volpe Martincus et al., 2014). While these direct cost measures capture the costs associated with transport, they are hardly publicly available and often restrict the analysis to only one or two transport modes. For instance, Asturias (2020) draws on detailed cost data for the transport of a 20-foot container from US ports to more than 300 destination in October 2014 to estimate welfare effects associated with changes in maritime transport costs. Combes and Lafourcade (2005) develop a generalized transport cost measure of transport by truck between French regions. Their measure captures distance- and time-related transport costs by including actual cost per kilometre, such as fuel and highway tolls, and a time cost, such as observed drivers' wages or insurance.

Further studies use physical distance measures that can be estimated based on geographic information which is publicly available. Since other costs than transport costs can be correlated with distance, such as informational frictions (Allen, 2014; Blum and Goldfarb, 2006; Chaney, 2018; Huang, 2007; Lendle et al., 2016), these studies exploit external shocks to isolate changes in transport costs from distance-related (time-invariant) trade costs (Besedeš and Panini, 2017; Feyrer, 2021; Volpe Martincus and Blyde, 2013; Volpe Martincus et al., 2014). These approaches, however, focus only on one transport mode and therefore cannot exploit variation of distances across different modes.

By investigating several transport modes, Wessel (2019) provides some evidence for the heterogeneous distance effect across modes in international trade. However, as the author is mainly interested in the effects of quality differences in mode-specific infrastructure, his work uses as a control the same great-circle distances for all transport modes rather than variation in mode-specific routed distances as it is the approach of the present paper.

Second, this paper broadly relates to a large literature about border effects by showing that trade within US States is significantly larger than across US State borders for road, rail and water transport. By showing that Canadian provinces trade significantly more with each other than with US States, McCallum (1995) introduced the phenomenon of the international border effect to the literature. The trade-reducing effect of regulatory borders has been confirmed in many subsequent studies both at the international (Anderson and van Wincoop, 2003; Chen, 2004; Nitsch, 2000) and intranational level (Agnosteva et al., 2019; Albrecht and Tombe, 2016; Coughlin and Novy, 2012; Hillberry and Hummels, 2008; Millimet and Osang, 2007; Wolf, 2000). The paper's findings are also related to work in a small literature on provincial border barriers in Canada which may be present in a similar but in a more subtle form in the US. For instance, different provincial regulations for road transport of heavy weight products or product safety standards can increase the costs of trade between Canadian provinces (Albrecht and Tombe, 2016). Beaulieu and Zaman (2019) describes

inter-provincial trade barriers in Canada and investigates to what extent subnational trade agreements mitigate their effects. Albrecht and Tombe (2016) analyse domestic trade costs across sectors for Canadian provinces and their welfare implications. The authors' results highlight that a reduction in inter-provincial trade costs by 10% leads on average to aggregate welfare gains of 0.9%. In the US particularly for inter-State road transport, truck drivers need to adhere to the regulations of the Federal Motor Carrier Safety Association (FMCSA) which are often stricter (in terms of insurance etc.) than regulations applicable to intra-State trade. Such more expensive requirements for compliance may explain domestic border effects across transport modes.

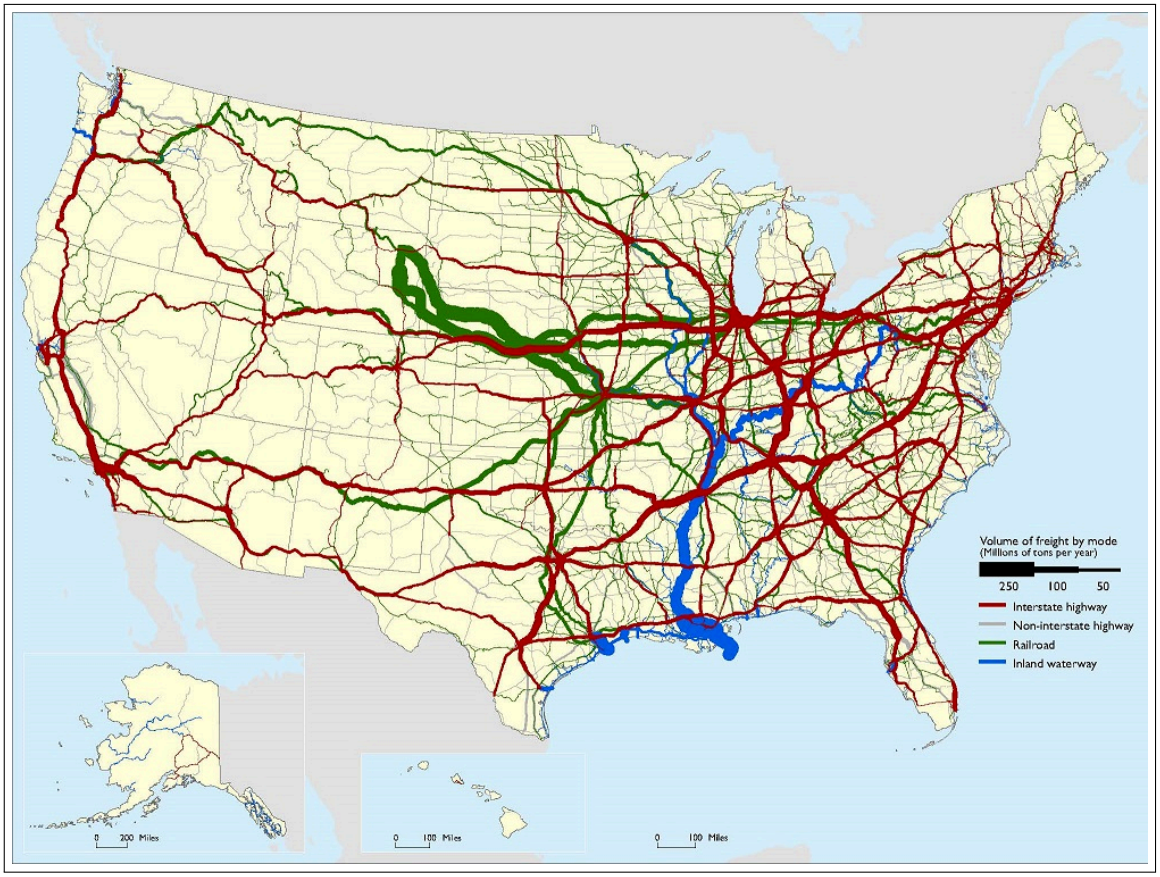
The rest of the paper is organised as follows. Section 1.2 provides an overview of the US national transport network. Section 1.3 presents the empirical strategy. Section 1.4 discusses the data used for the analysis. Section 1.5 outlines the empirical specifications by addressing concerns raised in the data section and by respecting the empirical strategy. The same section presents the estimation results in three subsections. Section 1.6 concludes.

1.2 US national transport network

This section describes features of the US national transport network for a better understanding of the spatial distribution of domestic trade and the providers of the US transport system. As shown in Figure 1.1, US intranational freight transport relies on an extensive network of highways, railroads, air- and waterways that are mainly located in the Eastern part of the US due to geographic and population-related reasons.

The US national highway freight network spans throughout the US and is classified into four classes of roadways: first, the primary highway freight system (PHFS) that is considered as the most critical highway portion of the system; second, other interstate portions that are not on the PHFS (first and second are highlighted in red in Figure 1.1); third, critical rural freight corridors (CRFCs) which are public roads outside of urbanized areas and providing access to the PHFS and the interstate highways; fourth, the critical urban freight corridors (CUFCs) which are within urbanized areas (FHWA, 2022) (third and fourth are highlighted in grey in Figure 1.1).

Figure 1.1 *Freight flows in tons by highway, railroad and waterway, 2012*



Note: 2012 is the last year in the database for this paper's empirical analysis.
Source: BTS (2012a).

Furthermore, the US transport system covers around 22 regional and more than 500 local railroads (Department of Transportation, 2020). Almost 70% of rail lines are operated by seven Class I private railroad companies (AAR, 2021).[4] Rail freight consists mostly of large volumes of bulk commodities, such as coal which is shipped between the Powder River Basin in Wyoming and the Midwest (BTS, 2020). Also, the US offers around 12 000 miles of navigable inland waterways for freight transport with the majority over the Mississippi and Ohio rivers and a smaller share over the Gulf Intracoastal waterways and Columbia river (BTS, 2012b). Airports handling most of domestic freight tons in 2020 are Memphis (20% of total domestic freight by BTS FAF), Louisville (12%), Anchorage, Cincinnati and Indianapolis (5% each) (ACI, 2020).

While local and State governments own primarily highways and streets, airports, waterways and transit facilities, the private sector's capital stock includes railroads, trucks, planes,

[4]Class I railroad companies are characterised by annual revenues above USD 505 million (AAR, 2021).

ships and pipelines (BTS, 2012b, 2020). Private investments in equipment and maintenance of railroads come from the Association of American Railroads (AAR) and amounts to around 19% of annual revenues or around USD 25 billion (AAR, 2021).

Public expenditure in US national transport infrastructure is among the five most costly functions in US States' and local governments' policy agenda. In 2017, State and local governments financed a total of USD 318 billion transport-related projects to build, rehabilitate, maintain and operate the country's infrastructure. This amount represents around 9% of total government expenditures. Highway expenditures made up the lion's share with around two-thirds of all transport expenditures.[5] However, major restructuring projects of the US national transport system lie outside of the paper's sample period. The US government announced the latest infrastructure investment ("Bipartisan Infrastructure Law") in December 2021 with an additional investment of USD 110 billion to repair and rebuild national bridges and roads (The White House, 2021). According to the US government, the infrastructure law makes "the single largest investment" in US infrastructure since the construction of the interstate highway system that started in the 1950s (The White House, 2021).

In contrast to air and land transport, US domestic maritime trade is regulated by a cabotage policy, known as the US Jones Act. The Act requires that all goods transported between two US ports be carried on ships that have been built in the US, are registered under a US flag, are crewed with US citizens or US permanent residents, and are owned by US citizens (Cato Institute, 2018). Findings in the literature about the economic side-effects resulting from the Act's restrictions include inflated water transport costs and ship prices as well as depressed domestic trade (Bergstresser and Melitz, 2017; Cato Institute, 2019; Olney, 2020).

1.3 Empirical strategy

To estimate the effect of transport distance on intranational US trade I base my empirical strategy on the theoretical gravity structure derived from the demand-side by Anderson and van Wincoop (2003) that aggregates over all sectors.[6] For simplicity, subscript m indicating the transport mode is not taken into account in this section. As demonstrated in Anderson

[5] BTS (2020) states a total transport expenditures of USD 318 billion whereof USD 219 bn are recorded for highways. Total State and local government expenditures amounted to around 3,667 bn in 2017 according to the US Census Bureau (2017). Functions with highest State and local government expenditures in 2017 are education and social services, each 30%, public safety as well as utilities followed by transport.

[6] Eaton and Kortum (2002) derive the gravity structure from the supply-side in a Ricardian framework with intermediate goods where the term $(1-\sigma)$ in the demand-side model by Anderson and van Wincoop (2003) becomes $-\theta$ representing the Fréchet parameter which controls the dispersion within the Fréchet distribution Yotov et al. (2016). Both approaches lead to isomorphic gravity systems (ibid.).

and van Wincoop (2004), the gravity model is separable by sectors which is a useful feature for my work to accommodate transported good-specific flows:[7]

$$X_{ij,t}^{k} = \underbrace{\frac{Y_{i,t}^{k} E_{j,t}^{k}}{Y_{t}^{k}}}_{\text{size term}} \underbrace{\left(\frac{t_{ij,t}^{k}}{\Pi_{i,t}^{k} P_{j,t}^{k}} \right)^{1-\sigma_k}}_{\text{trade cost term}}$$

where $X_{ij,t}^{k}$ denotes bilateral trade flows of transported good category k (42 commodities) from origin US State i to destination US State j in year t. The gravity equation explains bilateral trade flows by two components that enter multiplicatively in the equation: a size term and a trade friction term (also referred to as trade cost term) (Yotov et al., 2016).[8]

In the size term, $E_{j,t}^{k}$ indicates total expenditures for k in j from all origin US States, $Y_{i,t}^{k}$ are total sales of k from i to all destination US States, and Y_{t}^{k} is total output of k. The positive relationship between country size and bilateral trade interprets the literature by higher exports of large producers than of small ones to all destinations, by higher imports of rich economies from all origins, and by larger bilateral trade flows between trading partners of similar size (Yotov et al., 2016).

The trade cost term consists of three components: bilateral trade costs ($t_{ij,t}^{k}$), and two structural terms coined by Anderson and van Wincoop (2003) as inward ($P_{j,t}^{k}$) and outward ($\Pi_{i,t}^{k}$) multilateral resistance terms representing trade costs between ij relative to average trade costs that each of them face with all their trading partners. $\sigma_k > 1$ denotes the elasticity of substitution of the same good across different locations.

Log-linearizing the gravity model and expanding it with an additive error term ($\epsilon_{ij,t}^{k}$) leads to the following empirical specification (Yotov et al., 2016):

$$lnX_{ij,t}^{k} = lnY_{i,t}^{k} + lnE_{j,t}^{k} - lnY_{t}^{k} + (1-\sigma_k) ln\, t_{ij,t}^{k} - (1-\sigma_k) ln\Pi_{i,t}^{k} - (1-\sigma_k) lnP_{j,t}^{k} + \epsilon_{ij,t}^{k} \tag{1.1}$$

The two structural multilateral resistance (MLR) terms, $\Pi_{i,t}^{k}$ and $P_{j,t}^{k}$, are not observable by the researcher since they originate from a theoretical construct derived by Anderson and van Wincoop (2003) and should be accounted for in the estimation (Baldwin and Taglioni,

[7] Larch and Wanner (2017) and Anderson and Yotov (2016) also formally derive the sectoral gravity model.

[8] Like in physics under Newton's law, international trade is subject to gravitational forces where "[...] a country trades more with countries that are large and nearby than with countries that are small and far away.", Blum and Goldfarb (2006). While under Newton's law, physical distance is the gravitational friction, in international economics the equivalent trade cost parameter captures any trade impediments beyond physical distance, see equation 1.3 of the trade cost parameter.

2006; Olivero and Yotov, 2012; Yotov et al., 2016). For a proper treatment of these terms in a dynamic panel setting, Olivero and Yotov (2012) extend the cross-sectional approach by Feenstra (2004) and suggest time-varying directional (origin-time and destination-time) fixed effects.[9] To properly account for MLR terms at the sectoral level, these fixed effects must be sector specific because supply capacity of i and total expenditures of j are not necessarily identical across industries due to differences in comparative advantages or consumer preferences (Head and Mayer, 2014). As such, the gravity model can either be estimated for each sector (Anderson and Yotov, 2016; Larch and Wanner, 2017), or in a pooled regression across sectors where the multilateral resistance terms are time-varying directional sector fixed effects. As these fixed-effects will capture any time-varying origin-sector and destination-sector specific characteristics they will also absorb the size terms $Y_{i,t}^k$ and $E_{j,t}^k$ (Yotov et al., 2016).

The trade cost component, $t_{ij,t}^k$, captures all frictions present in the trade of goods between partners. The empirical trade literature usually approximates trade costs as a function of bilateral distance, d_{ij}^{ρ} with ρ as the elasticity of trade costs with respect to distance, and a set of (usually time-invariant) observables, z_{ij}^m (Anderson and van Wincoop, 2003, 2004; Carrere et al., 2009), as follows :

$$t_{ij} = d_{ij}^{\rho} \prod_{m=1}^{M} \left(z_{ij}^m\right)^{\gamma_m} \tag{1.2}$$

Log-linearizing the trade cost term results in the following relationship as part of the structural gravity model:

$$(1-\sigma) ln\left(t_{ij}\right) = (1-\sigma)\rho ln\left(d_{ij}\right) + \sum_{m=1}^{M} (1-\sigma)\gamma_m ln(z_{ij}^m) \tag{1.3}$$

As part of the trade cost term, time-invariant trade cost determinants (z_{ij}^m) include different forms of geographic, cultural and trade policy variables.[10] Tariffs increase the final price of goods and have a negative effect on international trade flows. Trade costs fall with common language and cultural proximity. The presence of contiguous (international) land borders is associated with an increase in trade flows, ceteris paribus, due to typically more integrated

[9] Fally (2015) supports the inclusion of these fixed effects and shows that they – if based on a Poisson-Pseudo-Maximum-Likelihood (PPML) estimation – perfectly fit the structural parameters for multilateral resistance terms from the theory.

[10] CEPII publishes a number of gravity variables to approximate physical distance and other time-invariant trade cost determinants.

infrastructure networks and transit agreements reducing transit times (Limao and Venables, 2001) or increased cooperation in trade, investment or labour mobility because of geographic proximity (Agnosteva et al., 2019). Anderson and van Wincoop (2004) provide a detailed discussion about trade costs including determinants of trade barriers in an international setting, such as tariffs, non-tariff measures, transport costs, currency, contiguity, common language or colonial ties. As this present work focuses on intranational trade the influence of such cost determinants within the US is essentially weaker or even non-existent (e.g. tariffs, international borders etc.).

The elasticity of bilateral distance on trade flows (d_{ij}^{ρ}) is the parameter of interest in the paper's analysis. Physical distance between trading partners represents a robust empirical approximation of bilateral trade costs (Anderson and van Wincoop, 2004; Borchert and Yotov, 2017; Head and Mayer, 2014) and it consistently has a negative effect on trade flows (Disdier and Head, 2008) as trade costs tend to increase with distance. Although the trade literature agrees that distance proxies for trade costs it is unclear why distance has a negative trade effect and what role it plays in explaining international trade (Chaney, 2018). Studies argue that distance captures information frictions (Allen, 2014; Chaney, 2018; Head and Mayer, 2014; Huang, 2007; Lendle et al., 2016; Rauch, 1999) and transport costs (Anderson and van Wincoop, 2004; Behar and Venables, 2011; Huang, 2007; Obstfeld and Rogoff, 2000) – both are positively associated with distance.[11]

The present paper draws on routed distances in miles by transport mode as a measure of distance-related transport costs of goods due ot lack of observable transport cost data. Transport costs increase with distance because it is more costly to transport goods faraway than nearby due to increasing fuel consumption, among others (Combes and Lafourcade, 2005). By exploiting variation of routed distances by transport mode this distance measure captures differences in infrastructure and the vehicle used which feature differences in fuel consumption and other operating costs (Combes and Lafourcade, 2005). By controlling for the type of transported good, routed distances also capture differences in transport costs related to the size, value or perishable nature of the commodity (Combes and Lafourcade, 2005). Finally, by looking at trade within the same country, informational frictions should be much weaker than in an international setting and there is no obvious reason why informational frictions for buyers and/or sellers should vary across the mode of transport. In this setting, I argue that trade costs are essentially transport costs and can be approximated by mode-specific routed distances.

[11] Combes et al. (2005) apply a generalized transport cost measure to study the role of network effects (reducing information costs lead to the diffusion of preferences) and find that by accounting for those effects the impact of transport costs on intranational trade in France is significantly reduced.

1.4 Data

This section presents the data to investigate the distance effect on trade flows by transport mode (m) between origin and destination US States (ij) for 42 good categories (k) across the years (t) 1997, 2002, 2007 and 2012. It comprises three subsections. First, it outlines the source and structure of the database on intranational trade flows. Second, it presents mode-specific routed distances derived from parameters in the trade database and discusses distance measures commonly used in the trade literature. Third, it provides summary statistics of the final sample to support the empirical analysis.

1.4.1 US intranational trade flows by transport mode

The empirical analysis draws on good-specific intranational trade flows by transport mode from the US Freight Analysis Framework (FAF) version 4 published by the US Bureau of Transportation Statistics (BTS). The dataset covers the years 1997, 2002, 2007 and 2012. It reports freight shipments of 42 goods under the Standard Classification of Transported Goods[12] within and between the 50 US States.[13] The database records nominal shipment values in million USD (i.e. net selling value excluding freight charges and taxes), weight in kilotons and ton-miles which is the key parameter to derive my routed distance measure presented in section 1.4.2.

It furthermore reports for each origin-destination-year-good combination the transport modes truck, rail, water, air, pipeline, or multiple modes and mail. I focus on the four major transport modes of air, rail, truck and water representing together 85% of intranational trade value (Appendix A.2 on modal trade shares, table A.2)). FAF data builds upon the US Commodity Flow Surveys (CFS) from which around 70% of FAF data originate (Hwang et al., 2016). The remaining 30% of the FAF database comes from further datasets, such as USDA Census of Agriculture, USDA Fishery data or IEA petroleum and gas data, to map US freight movements of establishments that are classified in transportation, construction, extraction and agriculture sectors (Hwang et al., 2016).

As described in US Census Bureau (2021), the CFS sample was selected based on a stratified three-stage design with a first stage dealing with establishment selection, a second stage with reporting week selection and a third stage with shipment selection. First, establishment records were extracted from the US Census Bureau's Business Register, where establishments were required to have paid employees, be located in the 50 US States and

[12] SCTG at the 2 digits-level, see Appendix A.1.

[13] The analysis excludes the two non-contiguous US States of Hawaii and Alaska as well as DC because of data quality concerns (Appendix A.2).

District of Columbia and be classified under the North American Industry Classification System (NAICS) in mining, manufacturing and wholesale. The final CFS sample covers more than 100,000 business establishments out of around 800,000 establishments in the initial sampling frame. Second, the selected establishments report their shipments for four reporting weeks so to have one week in each quarter of the reference year.[14] Third, a maximum of 40 shipments during the reporting week were selected (US Census Bureau, 2021).

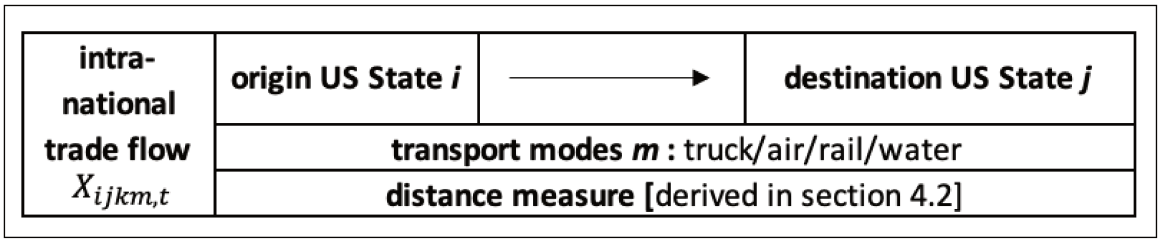
FAF data aims to create a comprehensive mapping of freight movements among US States by all transport modes and is updated every five years (Hwang et al., 2016). Along with the CFS data, it represents for the time being the only available data source to understand intranational US trade flows of goods across years and transport modes.

A note on the preference of FAF over CFS data. Although a large number of publications in the trade literature investigating intra-US trade flows uses the CFS (for instance, in McCallum (1995); Wolf (2000); Hillberry and Hummels (2003); Anderson and van Wincoop (2003); Yilmazkuday (2012); Allen and Arkolakis (2014); Ramondo et al. (2016)), the FAF database has two advantages that are convenient for the present paper's analysis. First, it reports estimated ton-miles and kilo tons that allow deriving routed distances by mode. Second, FAF data offers a longer sample period than the CFS which is currently only (publicly) available for the years 2012 and 2017. Third, it incorporates additional sectors such as agriculture, resulting in a more comprehensive mapping of domestic trade flows by transport mode.

Figure 1.2 provides an overview of the structure of the FAF data. A typical observation tracks transport flows in value, tons and ton-miles by mode of transport from domestic origin *i* to domestic destination *j*, where $i = j$ for intra-State trade and $i \neq j$ for inter-State trade. For instance, in 1997 the data reports shipments of meat/seafood from Arkansas to Pennsylvania of 200 million USD by truck with a distance of around 1090 miles or of about 15 million USD by rail with a distance of approximately 1225 miles. Importantly, the data reports for the same domestic origin-destination pair several transport modes if transport infrastructure is available.

[14] For instance, an establishment reports its shipments during the 5^{th} week of each quarter which in this case would correspond to the 5^{th}, 18^{th}, 31^{st} and 44^{th} week of the reference year (US Census Bureau, 2021).

Figure 1.2 *Illustration of mode-specific intranational trade flows (X_{ijm}) of goods (k) in year t*



Source: Author.

1.4.2 Distance measures

To proxy for intranational transport costs I derive distance measures between two US States, *ij*, in two ways: first, as mode-specific routed distances from available ton-mile parameters in the FAF database and second, as a traditional distance measure via great-circle distances from origin- and destination-States' geographic coordinates.

Mode-specific routed distances

A key feature of my data is the availability of ton-miles which measure the volume shipped in tons and the distance shipped in miles (= transported tons multiplied by miles) for each good category by transport mode per origin-destination pair in a given year. As FAF data does not directly publish mode-specific routed distances in miles I use the available ton-miles measure and divide it by tons to derive routed distances in miles per origin-destination-good-mode-year combination.[15]

Originally, miles in FAF's ton-mile measure were calculated from estimated mode-specific routed distances by using shipment information submitted by the respondents to the CFS. As described by the US Census Bureau (2021), shippers generally do not know the precise travel distance of their shipments. Therefore, the CFS asks for origin and destination ZIP codes along with the chosen transport mode such as a shipment by truck from Birmingham in Alabama (ZIP code 35242) to Phoenix in Arizona (ZIP code 85032).

Using this information in combination with a software tool developed by BTS, called GeoMiller, routed distances are calculated for each shipment of goods by transport mode.[16] GeoMiller calculates routed distances in miles by using Geographic Information System (GIS) technology and spatial multimodal network databases. It uses algorithms that find the

[15]The exercise leads to a small number of missing observations (2.3% of sample observations) which I impute via a four-steps procedure (Appendix A.2 on deriving intranational routed distances).

[16]This paragraph is based on information in US Census Bureau (2021).

best path route which minimizes the travel impedance between specified origin-destination pairs over a spatial representation of US highway, railway, waterway and airway networks.[17] Mode-specific routed distances are calculated between the centroid of the origin ZIP code and the centroid of the destination ZIP code. For shipments within a ZIP code, GeoMiller estimates routed distances by a formula that approximates the longest distance within the boundaries of that ZIP Code.

The publicly available FAF data do not report information at the ZIP code-level of each State city but at the more aggregated State-level for both origin and destination. Therefore, my approach of deriving routed distances from ton-miles and tons results in average routed distances in miles by origin-destination-good-mode-year combination.

With State-level information only I cannot control for unobserved heterogeneity in my sample data – a limitation to the analysis. Mode-specific routed distances may therefore suffer from measurement error where variations of routed distances across modes may not only arise from the desired heterogeneity in mode-specific infrastructure (i.e. highways feature longer distances than airways between the same origin-destination pair). Instead, variation in routed distances may also be affected by differences in locations of mode-specific infrastructure hubs within the same US State. For instance, airports, rail stations, ports or truck terminals may be located in different locations within the same US State.

Unobserved heterogeneity arising from aggregated State-level information may also introduce variation in mode-specific routed distances across good categories. For same origin-destination-mode-year combinations some goods may be transported (from) to different ZIP Codes within a State as a result of spatial agglomeration of consumer demand. However, variation of routed distances for same origin-destination-mode-year combinations ($ijmt$) is weak: the coefficient of variation (CV) across goods at the $ijmt-$level lies below 1 so that the difference in routed distances is lower than a standard deviation in 99.8% of the cases (see Appendix A.3, Figure A.4).

Routed distances for the same origin-destination-good-mode ($ijkm$) combination may vary across years due to aggregated State-level information. Variation across years in routed distances for same $ijkm$ combinations can partially be a result of changes in consumer demand located in different ZIP codes over time. As major infrastructure projects in the US fall outside of the sample period, significant modification in infrastructure leading to changes in routed distances across years is of less concern. Likewise, no major shutdowns due to accidents, repair work or strikes which could have affected routed distances across years have been reported to my knowledge. Overall, variation of distances at the $ijkm-$level

[17] A travel impedance factor is assigned to each link in a series of links representing routes. Impedance is defined as a function of distance and travel time (US Census Bureau, 2021).

across years is small: in 99.9% of cases, CVs of distances are below one standard deviation (see Appendix A.3, Figure A.5). In a robustness test, I estimate the distance-effect based on time-invariant distances as averages of distances across years at the $ijkm-$level.

Great-circle distances

Owing to the lack of observed routed distances trade economists usually draw on general distance measures independent of transport mode, such as great-circle distances. Great-circle distances measure the shortest distance along the Earth's surface between two locations. The trade literature proposes several types of measures including simple great-circle distances calculated between i) capital cities or ii) most populated cities of origin country *i* and destination country *j*, as well as population weighted great-circle distances (Mayer and Zignago, 2011).

Without knowing the precise locations of origin and destination between US States or within the same US State, the closest approximation of physical distance is a population-weighted distance measure. It captures distances between locations for which trade has likely occurred. Since more populated locations tend to trade more with each other than less populated ones, the likelihood is based on population shares.

To investigate to what extent the aforementioned mode-specific routed distances differ from this traditional distance measure, I derive population-weighted great-circle distances between US States *i* and *j*, d_{ij}, by following Head and Mayer (2010) as applied in Mayer and Zignago (2011):

$$d_{ij} = \left(\sum_{g \in i} \left(\frac{pop_g}{pop_i} \right) \sum_{l \in j} \left(\frac{pop_l}{pop_j} \right) d_{gl}^{\theta} \right)^{\frac{1}{\theta}}$$

where pop_g (pop_l) represents the population of urban agglomeration (city) g (l) in i (j) which I take for the 25 largest cities by US State from simplemaps. d_{gl} denotes great-circle distance between two agglomerations (cities). I use geographical coordinates of cities, that means latitudes and longitudes, from Geonames to estimate d_{gl}. θ captures the elasticity of trade flows with respect to distance for which I choose $\theta = -1$ resulting in a weighted harmonic mean that is supported by the literature as a consistent approximation of the distance effect (Head and Mayer, 2010; Mayer and Zignago, 2011).[18] I apply the same formula to both inter- and intra-State great-circle distances so that $i = j$ in the latter case.

[18] As discussed in Head and Mayer (2010), setting $\theta = -1$ results in the special case of weighted harmonic mean while $\theta = 1$ corresponds to a weighted arithmetic mean. As highlighted by Head and Mayer (2010) and Mayer and Zignago (2011), empirical estimates of distance coefficients usually correspond to a value of around

Table 1.1 shows summary statistics of routed and great-circle distances of the sample. Average routed distance for the whole dataset amounts to 1,065 miles. Average great-circle distance across the whole sample is around 18% smaller than actual routed distance. The difference in miles is even more significant for intra-State trade where great-circle distances make up on average only half of actual routed distances. Great-circle distances measure the shortest path between two locations while routed distances are based on the US infrastructure network which is – for geographic reasons – not always following a straight line (Combes and Lafourcade, 2005).

Table 1.1 *Comparison of routed and great-circle distances in the sample*

	count	mean	sd	min	max
Routed distances, miles	345446	1065.0	711.0	5.6	6943.8
Intra-State routed distances, miles	12742	98.1	90.1	5.6	3453.3
Inter-State routed distances, miles	332704	1102.1	698.1	11.8	6943.8
Great-circle distances, miles	345446	872.6	607.7	9.3	2659.5
Intra-State great-circle distances, miles	12742	50.0	27.4	9.3	132.4
Inter-State great-circle distances, miles	332704	904.1	597.1	17.0	2659.5

Source: Author based on FAF 4 BTS.

1.4.3 Summary statistics of final sample

The final sample covers 345,446 observations over the years 1997, 2002, 2007 and 2012. In a rectangular panel, we would have a total of 1,548,288 observations for 48 origin States, 48 destination States, 4 years, 42 commodities and 4 transport modes. However, the available information from the survey and about the US infrastructure does not allow to classify unreported trade flows into trade relationships that are impossible due to unavailable transport infrastructure, or transactions that could have occurred but did not (zero trade value). I therefore keep only reported trade flows, hence with a positive trade value. By excluding zero trade flows the model cannot exploit the causes of why some US States do not trade with each other (although the transport infrastructure is available) and might create biased estimates. If zero trade tends to occur between US States which are far apart from (close to) each other, then excluding zero trade will underestimate (overestimate) the distance effect as it will reduce (increase) the estimated distance coefficient in absolute terms.

-1 as shown in the meta-analysis by Disdier and Head (2008) (mean of -.95), supporting the harmonic mean as a consistent approximation of the distance effect.

The final data is an unbalanced panel across the four five-years time intervals. The cross-section covers observations ranging between around 67,000 in 2012 and 112,000 in 1997 at the origin-destination-product-mode-level *(ijkm)*, as shown in Table 1.2. Rail, water and air transport report the largest drop in observations between the panel years 1997 and 2002. This decline for each of the three modes is a result of a reduction in the number of reported origin-destination *(ij)* pairs and changes in the number of traded good types *(k)* across time (Appendix A.3, Table A.4). For truck transport, the number of origin-destination pairs remains the same for all years with a total of 2,304 truck routes while the number of observations decreases, implying that for road transport the number of traded good types decreases particularly between 1997 and 2002. Overall, trade seems to become more concentrated on truck routes and in specific commodity groups across time.

Table 1.2 *Number of observations (ijk)* by mode and year

year	Air		Rail		Truck		Water		Total
1997	15,958	14%	25,739	23%	67,080	60%	3,594	3%	112,371
2002	10,633	15%	6,897	9%	54,782	75%	584	1%	72,896
2007	9,032	10%	6,820	7%	76,789	82%	583	1%	93,224
2012	8,953	13%	5,840	9%	51,589	77%	573	1%	66,955
Total	44,576	13%	45,296	13%	250,240	72%	5,334	2%	345,446

Source: Author based on FAF 4 BTS.

A relative shift away from air, rail and water towards road transport (increase from 91% to 93%) is also reflected in Table 1.3 showing mode-specific trade values across years. Furthermore, annual (nominal) value for US intranational trade ranges between USD 9.4 trillion and USD 11.6 trillion per year. On a yearly average, 93% of trade in value terms are transported by road via truck, 4% by rail, and 2% by air or water.

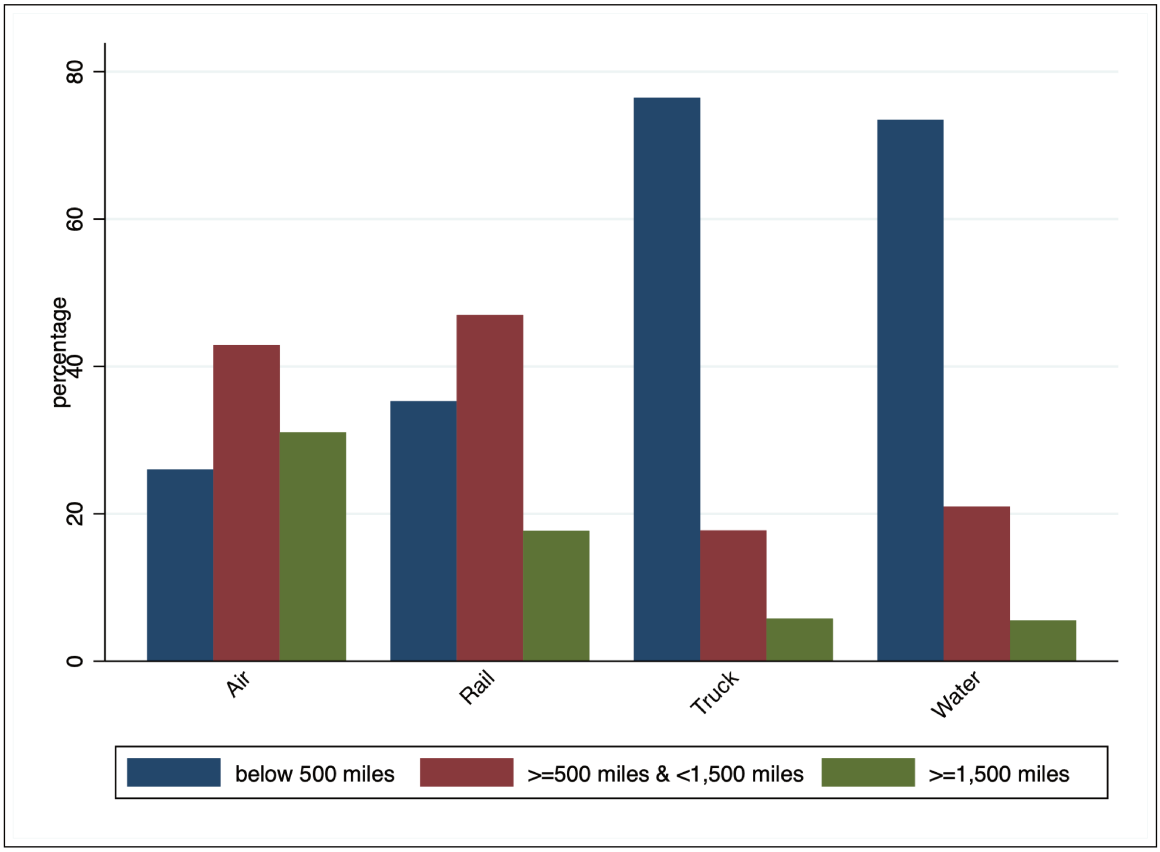
Table 1.3 *Nominal trade value (in billion USD) (ijk)* by mode and year

year	Air		Rail		Truck		Water		Total
1997	262.2	3%	467.4	5%	8,567.9	91%	92.3	1%	9,389.9
2002	235.9	2%	398.7	4%	9,453.5	93%	117.0	1%	10,205.1
2007	157.5	1%	451.9	4%	10,863.2	93%	178.9	2%	11,651.5
2012	128.7	1%	409.0	4%	10,208.8	93%	249.2	2%	10,995.6

Source: Author based on FAF 4 BTS.

The value share for truck and water transport, however, declines with distance while the trade share for air and rail transport increases with distance, as illustrated in Figure 1.3. Truck and water transport generates the highest trade share for distances below 500 miles, while this is the case for rail transport for distances below 1,500 miles and for air transport for distances above 500 miles.[19] Selection of air transport into longer distances is illustrated in Figure 1.4 showing trade-weighted distances by transport mode. Trade weighted distances for all years are highest for air transport followed by rail, truck and water transport in descending order.

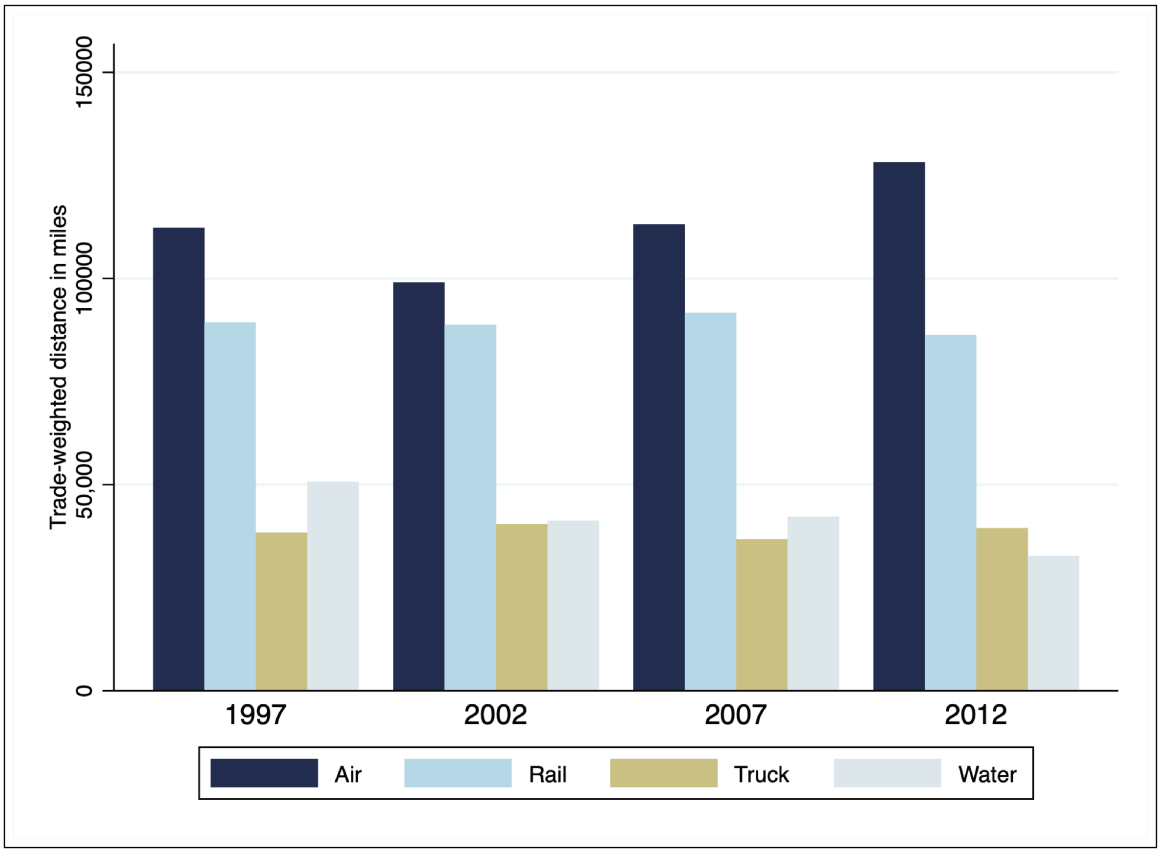
Figure 1.3 *Trade share by transport modes across distance bands*



Note: Percentages for each transport mode make up 100 percent. For instance, the share of trade value transported by airways amounts to around 26 percent for distances below 500 miles, 43 percent for distances equal or above 500 miles and below 1,500 miles, and 31 percent for distances equal or above 1,500 miles.
Source: Author based on FAF 4 BTS.

[19] Appendix A.3, figureA.1 illustrates the number of observations per distance bin and transport mode, highlighting that for all four modes, trade is most frequently observed for distances between 500 miles and 1500 miles.

Figure 1.4 *Trade-weighted distances by transport modes across years*



Source: Author based on FAF 4 BTS.

Average routed distances of the sample are smallest for waterways (914 miles) followed by airways (1,029 miles), truck (1,070 miles) and railways (1,090 miles), as illustrated in Table 1.4. Although air and rail is mainly used for long-distance trade (Figure 1.3 and 1.4), the statistics do not capture that routed distances of airways are shorter than for roads via truck over the same origin-destination route since air transport follows relatively straight lines while surface transport is limited by US internal geography. By looking at individual origin-destination routes featuring all transport modes (Table 1.4), airways have on average the shortest distance followed by truck, railroads and waterways in ascending order.[20] By using a standardised distance measure for all transport modes, great-circle distances, the statistics confirm the findings in Figure 1.3 that air trade is mainly conducted over long distances (average of 1,008 miles) while water trade has the shortest distances on average in

[20]See Appendix A.3, Figure A.3 for an illustration of kernel densities of routed distances by transport modes across routes featuring all four modes. Across all years, 269 origin-destination pairs out of 2,304 (22%) feature all four transport modes.

the sample (425 miles) (Table 1.4). Median routed distances by air and truck tend to have increased over time and declined for rail and water transport (Appendix A.3, Figure A.6).[21]

Table 1.4 *Summary statistics for distances (ijkmt)*

Sample:	count	mean	sd	min	max
Air routed distance, miles	44576	1029.1	643.0	18.9	3500.0
Rail routed distance, miles	45296	1090.6	738.6	7.9	3918.1
Truck routed distance, miles	250240	1070.0	715.6	7.0	4000.0
Water routed distance, miles	5334	914.3	764.2	5.6	6943.8
Routes featuring all four modes:					
Air routed distance, miles	837	473.7	393.2	18.9	2570.0
Rail routed distance, miles	837	624.5	498.6	26.4	3368.9
Truck routed distance, miles	837	550.5	461.3	37.0	2928.5
Water routed distance, miles	837	982.2	844.9	8.9	5964.9
Great-circle (gc) distances:					
Air gc distances, miles	44576	1008.6	650.9	16.4	2659.5
Rail gc distances, miles	45296	796.9	579.5	9.3	2659.5
Truck gc distances, miles	250240	871.6	601.9	9.3	2659.5
Water gc distances, miles	5334	425.8	361.8	12.8	2455.3

Source: Author based on FAF 4 BTS.

The sample average trade value of a shipment is highest for truck transport (USD 156,000), followed by water (USD 119,000), rail (USD 38,000) and air (USD 17,000), as shown in Table 1.5. However, unit values of products shipped by air are significantly higher with USD 2,282 compared to unit values of goods transported by truck (UDS 114), rail (USD 15) or water (USD 8), suggesting that air traded goods are of high-value and low quantity and goods shipped via waterways are of lower unit value and high quantity.

[21] Appendix A.3 shows in Table A.5 the statistical mode of routed distances across years by transport mode.

Table 1.5 *Summary statistics for trade values (ijkmt)*

	count	mean	sd	min	max
Air value	44576	17.6	162.8	0.0	25761.9
Rail value	45296	38.1	219.3	0.0	17274.2
Truck value	250240	156.2	1233.4	0.0	141032.0
Water value	5334	119.5	1072.9	0.0	56490.2
Air unit value	41580	2282.8	28099.1	0.0	2535460.1
Rail unit value	45180	15.9	314.8	0.0	34054.4
Truck unit value	246537	114.2	24470.4	0.0	12091639.7
Water unit value	5322	8.1	147.9	0.0	10178.7

Source: Author based on FAF 4 BTS.

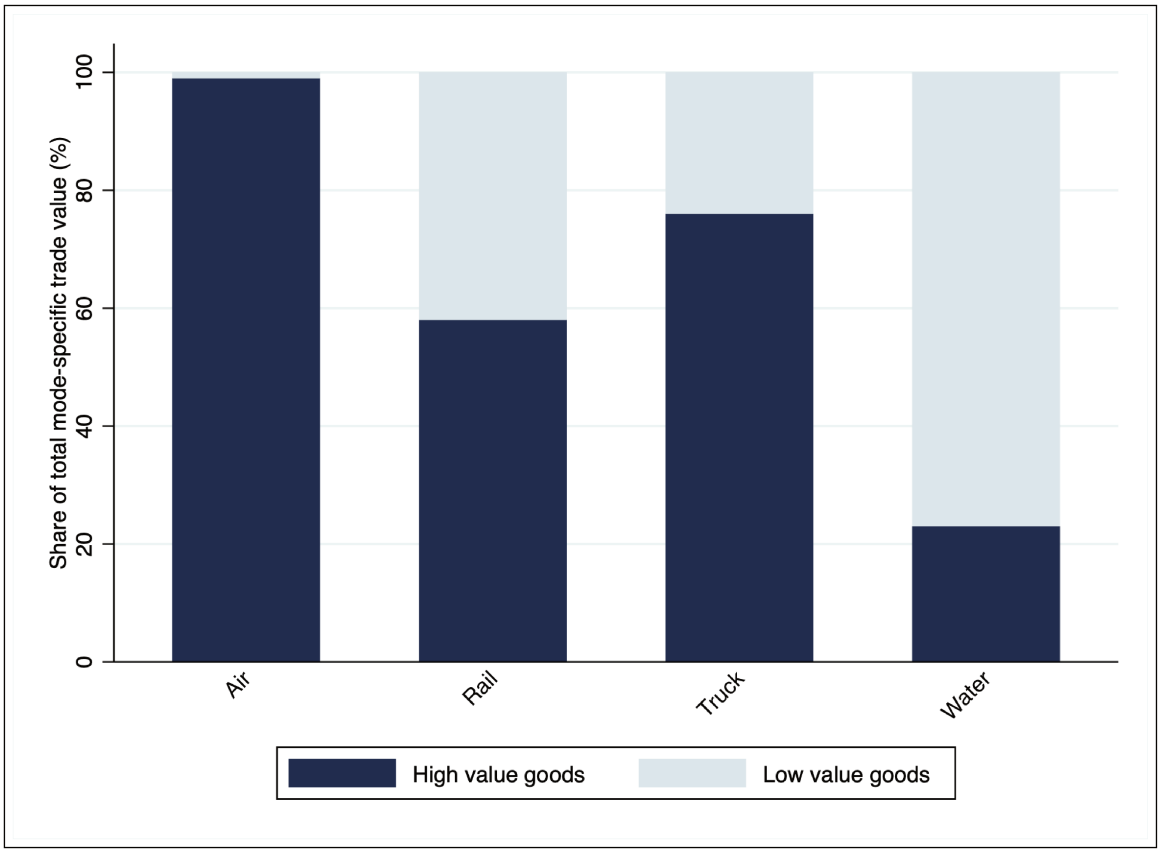
The observation that air trade is concentrated in high-value goods while water transport happens mostly in low value goods is supported by figure 1.5 showing the share of trade in high vs. low-value goods by transport mode. On one extreme, 99 percent of air trade is reported in high-value goods which are mostly electronics, transport equipment, precision instruments and pharmaceuticals.[22] On the other extreme, 77 percent of water trade happens in low-value goods which are mainly fuel oils, gasoline, coal or cereal grains.[23] Trade by road via truck makes up around three-quarters in high-value goods, such as motorized vehicles, electronics, machinery or some pharmaceutical products. Low-value goods in truck transport include foodstuffs, gasoline or wood. Rail trade is to 58 percent in high-value goods which are mainly motorized vehicles, basic chemicals, plastics/rubbers or base metals, while low-value goods in rail trade are cereal grains, coal or paper/print products. High-value goods are in 85 percent of cases also light goods or vice versa so that these two good categories are strongly correlated (correlation of -0.7).[24]

[22] Low value goods in air trade are mainly non-metal mineral products.

[23] Basic chemicals is the major high value good transported by ships on domestic US waterways.

[24] Appendix A.3, figure A.2 illustrates the share of heavy-weight vs. light-weight goods as a share of mode-specific trade value. The shares mirror the share of trade in high and low-value goods by transport mode (figure 1.5), highlighting the strong correlation between both good categories.

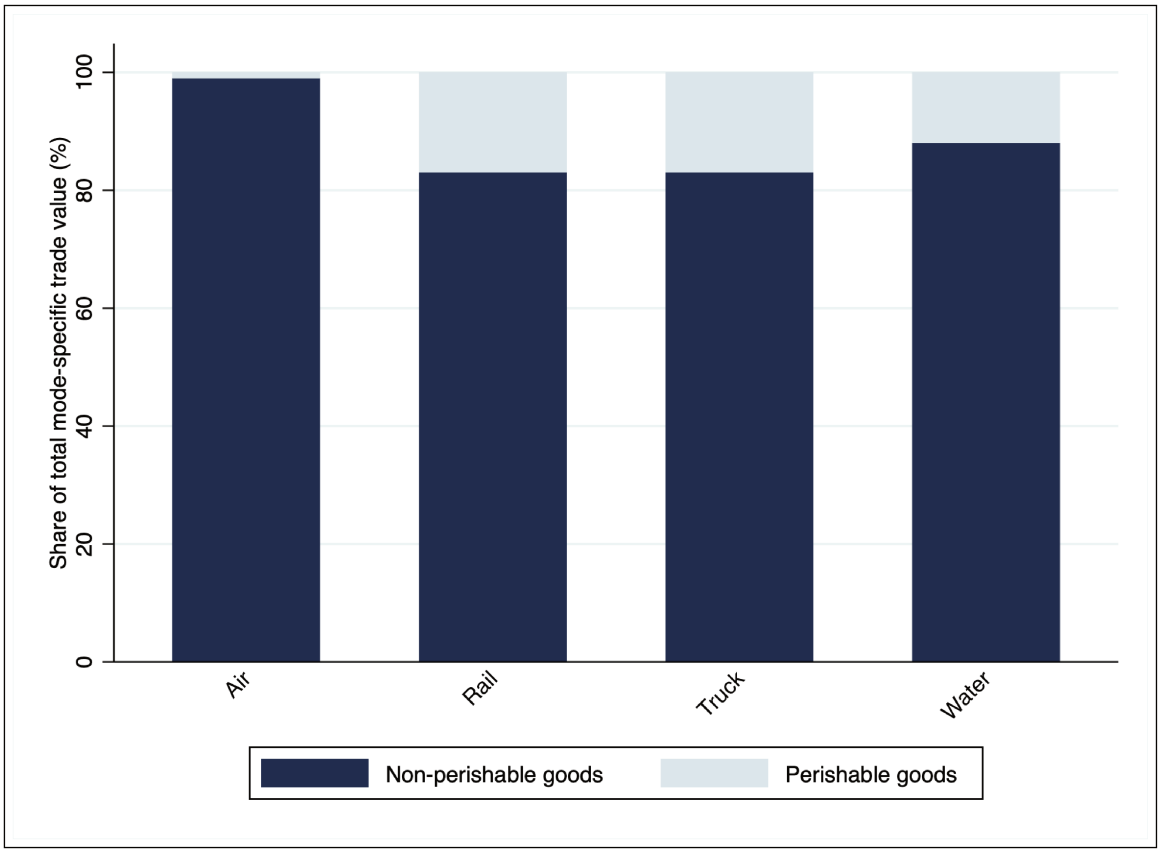
Figure 1.5 *Share of trade in high and low-value goods by transport mode*



Note: High value goods are classified in this paper as products equal or above the median unit-value (value/tons), including the following 23 good categories: Alcoholic beverages, Articles-base metal, Base metals, Basic chemicals, Chemical prods., Electronics,Furniture, Live animals/fish, Machinery, Meat/seafood, Metallic ores, Milled grain prods., Misc. mfg. prods., Mixed freight, Motorized vehicles, Paper articles, Pharmaceuticals, Plastics/rubber, Precision instruments, Printed prods., Textiles/leather, Tobacco prods., Transport equip. All other 19 good categories are low-value goods and include: Animal feed, Building stone, Cereal grains, Coal, Coal-n.e.c., Crude petroleum, Fertilizers, Fuel oils, Gasoline, Gravel, Logs, Natural sands, Newsprint/paper, Nonmetal min. prods., Nonmetallic minerals, Other ag prods., Other foodstuffs, Waste/scrap, Wood products.
Source: Author based on FAF 4 BTS.

Furthermore, air trade is concentrated in non-perishable goods (99 percent of trade value in air transport), while the other three transport modes feature a share of around 15 to 20 percent of trade in perishable goods (Figure 1.6). Perishable goods, such as food, meat/seafood as well as live animals, are sensitive to delays or inadequate means of storage that can lead to economic losses and deterioration of product quality (WTO, 2020).

Figure 1.6 *Share of trade in perishable and non-perishable goods by transport mode*



Note: Perishable goods include the following good categories: Animal feed, cereal grains, other agricultural products, other foodstuffs, live animals/fish, meat/seafood, milled grain products.
Source: Author based on FAF 4 BTS.

Table 1.6 shows summary statistics for US intranational trade flows. An average trade flow amounts to around USD 122 million with a significant difference between intra-State and inter-State trade. The average value of an intra-State trade flow is with USD 1,721 million significantly larger than inter-State trade (USD 61 million). Intra-State trade value is on average around four (rail) to 35 times (truck) the size of inter-State trade depending on the transport mode. Air transport is hardly used in intra-State trade as the data records only 864 observations (2% of total observations for air transport).

Table 1.6 *Statistics on intra-national trade and contiguous State trade*

Average trade value	**All**		**Air**		**Truck**		**Rail**		**Water**	
Intra-State trade	1,721		87		2,640		115		362	
Inter-State trade	61		16		74		33		59	
Nbr of observations	**All**		**Air**		**Truck**		**Rail**		**Water**	
Intra-State trade	12,742	4%	864	2%	8,013	3%	2,805	6%	1,060	20%
Inter-State trade	332,704		43,712		242,227		42,491		4,274	
Total	345,446		44,576		250,240		45,296		5,334	

Source: Author based on FAF 4 BTS.

1.5 Specification and results

This section presents the econometric baseline specification and in three parts the estimation results. The first set of results discusses estimates of elasticities based on routed distance and investigates the heterogeneous distance effect in intra-US trade for the four transport modes. The second set of results studies the distance effect across different groups of goods, such as high-value, heavy-weight or perishable goods by controlling for the mode of transport. The third set of results analyses the role of US State borders for different modes of transport.

1.5.1 Econometric baseline specification

To estimate the effect of mode-specific routed distances on intranational trade intensity I base my identification strategy on the variation of trade flows of the same good transported by the same mode in the same year from the same origin (destination) US State across all destination (origin) US States. In line with the structural gravity model described in section 1.3, the OLS baseline specification is as follows:

$$ln\,X_{ijkmt} = \beta_0 + \beta_1(lnDIST_{ijkmt}) + \eta_{ikmt} + \theta_{jkmt} + \epsilon_{ijkmt} \tag{1.4}$$

where X_{ijkmt} denotes the logarithm of nominal values for intranational trade from origin US State i to destination US State j of good category k transported with mode m in year t. Within the trade cost term, $lnDIST_{ijkmt}$ is the variable of interest and represents the logarithm of intranational routed distance by m between i and j in year t. As discussed in section 1.4.2, the data do not allow to track the precise address in the origin and destination US State, leading to unobserved heterogeneity in the data so that for some $ijkm$-combinations routed distances vary across panel years, therefore the subscript t in $lnDIST_{ijkmt}$. To show

the robustness of my results, I estimate the distance effect based on time-invariant distance measures as averages of $ijkm$-level distances. η_{ikmt} and θ_{jkmt} represent respectively fixed effects at the origin-good-mode-time or destination-good-mode-time level to control for the two structural multilateral resistance terms at the transport mode-level. ϵ_{ijkmt} is the standard error clustered at the *ijk*-level.

The identification strategy raises endogeneity concerns related to mode-specific trade flows (Allen and Arkolakis, 2014). For instance, governments develop rail infrastructure particularly between cities where goods are best shipped via rail. However, as discussed in section 1.2 major investment plans took place outside of the sample period (1997-2012) so that observed changes in routed distances are hardly a result of improved transport networks. Furthermore, instrumental variable estimates of intranational US distance elasticities as part of a study by Duranton et al. (2014) mitigate these endogeneity concerns.[25] The authors instrument highway distances based on the existing infrastructure in the year 2005 (which is the year closest to the study's sample year) with highway distances planned in 1947 or network distances along 1898 railroads. Their estimates based on instrumental variables do not change the estimates from the baseline specification using distances in 2005. That all of these distance measures lead to similar elasticity estimates reflect, according to the authors, the high correlation of distance across time. As such, distances based on the US infrastructure did not seem to have changed across time implying that transport routes have likely not been significantly modified in the US over time.

1.5.2 Baseline results of routed distances by transport mode

In a first step, I present the baseline results using the OLS estimator. In a second step, I discuss various functional forms since distance could have different elasticities depending on distance and this may vary by transport mode.

OLS estimates: Table 1.7 presents the estimates of the distance effect on intra-US trade. Column 1 shows the results of baseline specification 1.4 of the effect of routed distance on intranational US trade based on *ikmt*- and *jkmt*-fixed effects. The results reveal a statistically significant distance elasticity of -1.793 implying that a 1% change in routed distance leads to an average decline in bilateral trade within the US of 1.793%. The adjusted R^2 is high with 0.659 explaining more than 65% of the variance in intra-national trade.

Column 2 presents the baseline specification using great-circle distances on the same sample to compare how traditional distance measures perform. The elasticity of great-circle

[25] Duranton (2015) uses a similar instrumental approach based on colonial routes and road networks in his study about Colombia.

distance on trade is around 12% smaller with -1.581 compared to the coefficient of routed distances. The estimates are in line with the descriptive statistics highlighting that great-circle measures underestimate the distance effect since they capture the distance of a straight line between the coordinates of the origin and destination US States. In contrast, routed distances track a country's actual infrastructure network that rarely follows straight-line routes due to geographic reasons. Trade volume effects differ by 5 percentage points as doubling routed distances reduces trade on average by 71% while doubling great-circle distances reduces trade by around 66%.[26]

Column 3 shows estimates of distance elasticities by controlling for intra-State trade. The dummy on intra-State trade is positive and significant implying that trade within US States is almost two times ($exp(0.806)$) the size of inter-State trade. The result suggests domestic home bias effects in line with findings in the literature (Coughlin and Novy, 2012, 2016; Hillberry and Hummels, 2003, 2008; Wolf, 2000). The distance effect in this specification is slightly smaller with -1.673 (around -6% difference) compared to the baseline specification in column 1, although the adjusted R^2 does not increase in explanatory power.

Column 4 presents the results decomposing the elasticity of routed distance in our baseline specification (column 1) into the effect by transport mode by interacting the dummy for transport modes with routed distances. The adjusted R^2 increases slightly to 0.679. The statistically significant estimates show that routed distance by road via truck is most elastic with a coefficient of -2.150, followed in descending order (in absolute terms) by waterways with -1.001, by railways with -0.762 and by airways with -0.205. The ranking of distance elasticities by transport modes holds when limiting the sample to routes featuring all four modes (Appendix A.5, table A.7), when excluding imputed routed distances (Appendix A.5, table A.8) as described in section 1.4.2, and when using time-invariant routed distances (Appendix A.5, table A.9).

Column 5 shows estimates of mode-specific distance elasticities by controlling for intra-State trade. The ranking of mode-specific distance elasticities are in line with the results of the baseline estimation (column 4). The adjusted R^2 remains at 0.68. Interestingly, by including the intra-State dummy, the effect of road distance by truck remains relatively stable (decline in coefficient estimate by around 6%), but decreases significantly (in absolute terms) for airways by 43%, for waterways by 30% and for railways by 26%. The significant change in point estimates for some of these transport modes suggests that the intra-State effect may vary across modes – an observation already highlighted in the descriptive statistics. In

[26]Trade volume effects are derived from $\frac{X_1}{X_0} = \left(\frac{D_1}{D_0}\right)^{\hat{\beta}_{distance}}$ where X_1 and X_0 denote bilateral trade flow respectively at time 1 or 0 and D_1 and D_0 represent distance measures respectively in time 1 or 0 (Carrere et al., 2009). Based on this general formula, the trade effect amounts for routed distances to $(2/1)^{-1.793} - 1 = -71\%$.

Section 1.5.4, I therefore investigate the heterogeneous effect of domestic State borders by transport mode.

Table 1.7 *Baseline estimates (equation 1.4)*

	(1)	(2)	(3)	(4)	(5)
Dependent variable:	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$
Routed distances, miles	-1.793^a		-1.673^a		
	(0.009)		(0.009)		
Great-circle distances, miles		-1.581^a			
		(0.009)			
Air routed distance, miles				-0.205^a	-0.117^a
				(0.015)	(0.015)
Rail routed distance, miles				-0.762^a	-0.566^a
				(0.017)	(0.018)
Truck routed distance, miles				-2.150^a	-2.021^a
				(0.009)	(0.009)
Water routed distance, miles				-1.001^a	-0.713^a
				(0.046)	(0.046)
Intra-State trade dummy			0.806^a		0.904^a
			(0.051)		(0.043)
Constant	13.039^a	11.235^a	12.208^a	12.447^a	11.515^a
	(0.064)	(0.062)	(0.063)	(0.051)	(0.056)
Fixed-effects	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt
Observations	333376	333376	333376	333376	333376
Adjusted R^2	0.659	0.657	0.661	0.679	0.680

Clustered standard errors at the ijk-level are in parentheses.

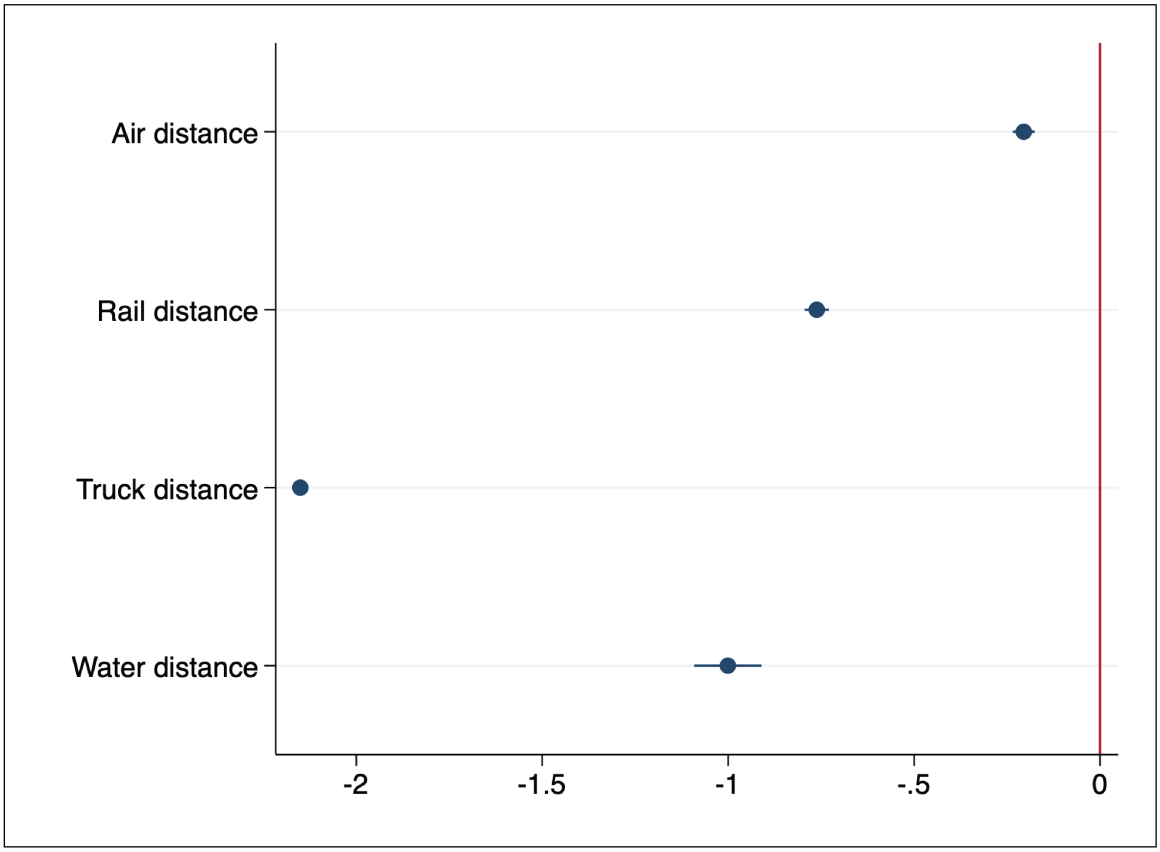
^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Notes: Years covered are 1997, 2002, 2007, 2012. All distances are in logarithm. All specifications include fixed effects (FE) as indicated in the table. Estimates of FEs and controls are omitted for brevity. In each column, 4,877 observations were dropped from the estimation as they are either singletons or separated by a fixed effect. Furthermore, 7,193 observations are small shipments so that their trade values are close to zero and fall out of the log-log regression.
Source: Author based on FAF 4 BTS.

Figure 1.7 depicts the point estimates of our baseline specification from Table 1.7 column 4 along with their confidence intervals by transport mode highlighting the significant differences in distance elasticities across modes. The findings suggest that mode-specific routed distances capture the cost of travelling via different modes of transport (Allen and Arkolakis, 2014). Reducing distance-related costs of road transport equivalent to reducing routed road distances by 10% (amounting on average to 106 miles) increases trade by truck

by around 21.5% (corresponding to an average trade value of USD 34 million).[27] For water transportation, a reduction of 10% (an average of 99 miles) in distance is associated with an increase in trade value by 10% representing on average USD 11 million. In the case of air transport, a 10% reduction in air distance (amounting on average to 103 miles) leads to an increase in intranational US trade by air of around 2.05% (amounting on average to USD 0.4 million). A 10% reduction in rail distance (amounting on average to 109 miles) increases trade by rail on average by 7.6% (an average trade value of USD 2.9 million).

Figure 1.7 *Estimates of distance elasticities by transport mode (Table 1.7, column (4))*



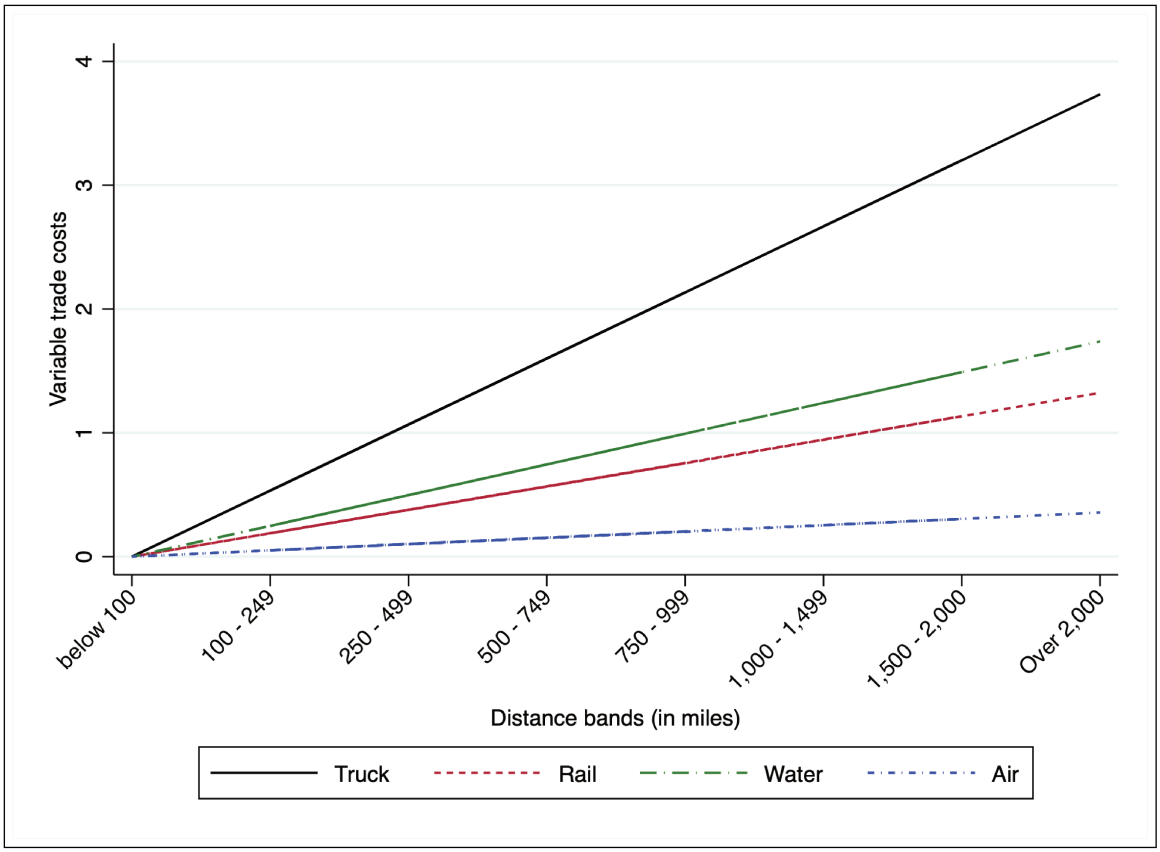
Notes: All distances are in logarithm. Dots in the graph indicate coefficients and horizontal lines the corresponding confidence intervals.
Source: Author based on FAF 4 BTS.

Translating the point estimates of the mode-specific distance elasticities from Table 1.7 column (4) into variable trade costs illustrates how transport costs for each mode evolve across distance. As detailed in Section 1.3, the structural interpretation of the distance coefficient from the trade cost function is as follows: $\hat{\beta}_{distance} = (1 - \hat{\sigma})\rho$ (Yotov et al., 2016).[28]. I derive mode-specific (variable) trade cost elasticities with respect to distance, ρ,

[27] Average trade values and miles correspond to the observations included in the estimation sample.
[28] Derived via $\beta_1(lnDIST_{ijmt}) = (1 - \sigma_k)\rho ln\, d_{ijmt}$, where σ_k should ideally be sector-specific.

by assuming the same elasticity of substitution, σ, for each transport mode and setting σ to 5 as the median reported in Head and Mayer (2014).

Figure 1.8 *Estimated (variable) trade costs (ρ) with respect to distance by transport mode*



Notes: To derive ρ for each transport mode, I use point estimates of mode-specific distance elasticities, $\hat{\beta}_m$, and I assume for all transport modes $\hat{\sigma}$ = 5 which is the median reported in Head and Mayer (2014). Mode-specific intercepts are zero as I neglect fixed costs in this illustration.
Source: Author based on FAF 4 BTS.

Figure 1.8 visualizes the derived variable trade costs across distance bands for each transport mode. Variable trade costs increase with distance significantly more for truck transport than for water, air or rail. The results do not include fixed-costs although these differ across transport modes (Rodrigue and Notteboom, 2020). As part of a study by Allen and Arkolakis (2014), the authors estimate (variable and fixed) iceberg trade costs by transport mode across distance based on a discrete choice model using the CFS of 2007. The authors' results confirm that mode-specific distances capture heterogeneity in trade costs across modes with truck trade as most elastic transport mode (in Allen and Arkolakis (2014) Figure X "Estimated trade costs", p. 116). Likewise, Duranton et al. (2014) find that distance elasticities for road trade is significantly larger (in absolute terms) than for rail trade. Importantly, both Allen and Arkolakis (2014) and Duranton et al. (2014) use trade flows

of the CFS at the level of metropolitan statistical areas (MAS) within US States. Despite geographically more aggregated trade flows, the results of this present paper are in line with the findings in these two studies. This similarity mitigates concerns related to the precision of routed distances due to unobserved heterogeneity, as discussed in subsection 1.4.2. Albeit in an international setting, results by Lux (2011) are in line with the presented findings. The author's results show the highest absolute distance elasticity for surface transport and small increases in air transport costs with longer distances.

Different functional forms: Table 1.8 shows the estimation results of the gravity model under different functional forms. First, in multiplicative form by the Poisson Pseudo-Maximum-Likelihood (PPML) estimator to address heteroscedasticity issues of trade data, as proposed in Silva and Tenreyro (2006).[29] Second, in non-parametric form using distance bins to investigate to what extent distance elasticities vary by different distance intervals.

Column 1 lists the results of the PPML estimator. The Pseudo-R^2 is high with 0.897. PPML point estimates are slightly smaller (in absolute terms) than the OLS estimates except for water transport distance whose coefficient is larger under PPML than under OLS. The higher distance estimates under OLS compared to PPML are in line with the findings in Silva and Tenreyro (2006) pointing towards the importance of Jensen's inequality in the estimation of gravity equations. Overall, the PPML results support our OLS results in table 1.7: The coefficient on truck distance remains the largest (in absolute terms) among all transport modes with an elasticity of -1.512, followed by water transport with -1.217, rail transport -0.562 and air transport -0.194 in descending order.

Column 2 shows the non-parametric estimates based on the OLS estimator using three different distance bins: i) below 500 miles, ii) equal or above 500 miles and below 1,500 miles, as well as iii) equal or above 1,500 miles. The distance effect amounts to -1.981 for routed distances below 500 miles and decreases significantly in absolute terms with increasing distances suggesting that the effect of distance on trade matters less for longer hauls. For instance, distances above 1,500 miles have the smallest trade effect with an elasticity of -0.381.

Column 3 lists the estimated elasticities across different distance bins by transport mode. This decomposition allows to investigate whether the results in column 2 are driven by the different composition of transport modes across distances, as shown in the descriptive statistics, or whether distance becomes generally less important for trade for all transport modes. For air transport, the distance effect is statistically significant for the bins below

[29] Head and Mayer (2014) suggest that if PPML (and Gamma PML) obtains significantly different results than OLS, then heteroscedasticity is a reasonable concern and OLS estimates are inconsistent.

500 miles (-0.267) and between 500 and 1500 miles (-0.210). Although the two point estimates are not statistically different they decrease slightly in absolute terms with increasing distances. Elasticities of air distances become insignificant for hauls equal or above 1,500 miles. The trade effect of rail distance is smallest for distances above 1,500 miles in line with the average results in column 2, and strongest for medium distances equal or above 500 miles and below 1,500 miles, while smallest for small hauls below 500 miles. For trade by truck, the distance effect decreases (in absolute terms) significantly with longer distances from -2.290 to -0.299 – keeping in mind that truck transport is mainly used for distances below 1,500 miles. For water transport, the distance effect decreases up to distances below 1,500 miles and increases for longer hauls equal or above 1,500 miles where the estimates are significant only at the 5%-significance level. For the last distance bin, water transport makes up only a small share of total trade via waterways (below 10 percent) and takes place particularly between New Jersey/Louisiana, Illinois/Texas (via the Mississippi River) or Ohio/Louisiana.

Table 1.8 *Different functional forms*

	(1) PPML	(2) OLS	(3) OLS
Air routed distance, miles	-0.194^a		
	(0.024)		
Rail routed distance, miles	-0.562^a		
	(0.022)		
Truck routed distance, miles	-1.512^a		
	(0.007)		
Water routed distance, miles	-1.217^a		
	(0.052)		
Routed distances, miles × Dummy: distance below 500 miles		-1.981^a	
		(0.022)	
Routed distances, miles × Dummy: distance >= 500 miles & <1,500 miles		-1.509^a	
		(0.021)	
Routed distances, miles × Dummy: distance >=1,500 miles		-0.381^a	
		(0.049)	
Air routed distance, miles × Dummy: distance below 500 miles			-0.267^a
			(0.038)
Air routed distance, miles × Dummy: distance >= 500 miles & <1,500 miles			-0.210^a
			(0.043)
Air routed distance, miles × Dummy: distance >=1,500 miles			0.104
			(0.123)
Rail routed distance, miles × Dummy: distance below 500 miles			-0.500^a
			(0.035)
Rail routed distance, miles × Dummy: distance >= 500 miles & <1,500 miles			-0.766^a
			(0.050)
Rail routed distance, miles × Dummy: distance >=1,500 miles			-0.297^a
			(0.114)
Truck routed distance, miles × Dummy: distance below 500 miles			-2.290^a
			(0.021)
Truck routed distance, miles × Dummy: distance >= 500 miles & <1,500 miles			-1.790^a
			(0.023)
Truck routed distance, miles × Dummy: distance >=1,500 miles			-0.299^a
			(0.053)
Water routed distance, miles × Dummy: distance below 500 miles			-0.633^a
			(0.095)
Water routed distance, miles × Dummy: distance >= 500 miles & <1,500 miles			-0.470^a
			(0.167)
Water routed distance, miles × Dummy: distance >=1,500 miles			-1.038^b
			(0.406)
Constant	14.877^a	2.525^a	12.968^a
	(0.038)	(0.368)	(0.100)
Fixed-effects	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt
Observations	333376	333376	333376
Adjusted R^2		0.663	0.683
Pseudo R^2	0.897		

Clustered standard errors at the ijk-level are in parentheses.

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Notes: Years covered are 1997, 2002, 2007, 2012. All distances are in logarithm. All specifications include fixed effects (FE) as indicated in the table. Estimates of FEs and controls are omitted for brevity.

Source: Author based on FAF 4 BTS.

1.5.3 Heterogeneous distance effect across good categories

Distance may matter to a different extent for different categories of goods. As Combes and Lafourcade (2005) states "the nature of the commodity makes it more or less expensive to transport", for instance due to its size, value or perishable nature. Table 1.9 therefore presents estimates of distance elasticities for different groups of goods by controlling for *ikmt* and *jkmt*-fixed effects. Column 1 shows a significantly lower (in absolute terms) distance effect for high-value goods compared to low-value goods.[30] While high-value goods have a distance elasticity of -1.573, low-value goods have an elasticity of -2.226. As distance-related transport costs make up a smaller share of trade value of high-value goods than of low-value goods an increase in transport costs for the latter one affects trade relatively more.

Column 2 shows the estimates of distance elasticities for high/low-value goods decomposed by transport modes. Except for air distance where distance elasticities are not significantly different between high- and low-value goods, the finding holds for all other transport modes that low value goods feature a significantly higher (in absolute terms) distance effect than high-value goods. Estimated distance effects for heavy-weight and low-weight goods mirror the estimates of high/low-value goods of column 1 and 2 as high (low)-value and low (heavy)-weight goods are strongly correlated (section 1.4.3). Trade of heavy-weight goods (which are frequently also low-value goods) is significantly more elastic to distance than of low-weight goods (which are generally also high-value goods). A 1% increase in routed distance is associated with a decline in trade of low-weight goods of -1.547% and of heavy-weight goods of -2.15% (Appendix A.4 Table A.6 column 1). These findings about heavy/low-weight goods hold across transport modes (Appendix A.4 Table A.6 column 2).

Column 3 presents the results of the distance effect for perishable and non-perishable goods. Trade of perishable goods reacts significantly stronger to changes in distance (coefficient of -2.118) than trade of non-perishable goods (coefficient of -1.741). Since perishable goods are particularly time-sensitive the effect of increasing distance on trade of this good category captures the additional travel time required to transport goods over a one percent

[30] High value goods are classified in this paper as products equal or above the median unit-value (value/tons), including the following 23 good categories: Alcoholic beverages, Articles-base metal, Base metals, Basic chemicals, Chemical prods., Electronics,Furniture, Live animals/fish, Machinery, Meat/seafood, Metallic ores, Milled grain prods., Misc. mfg. prods., Mixed freight, Motorized vehicles, Paper articles, Pharmaceuticals, Plastics/rubber, Precision instruments, Printed prods., Textiles/leather, Tobacco prods., Transport equip. All other 19 good categories are low-value goods and include: Animal feed, Building stone, Cereal grains, Coal, Coal-n.e.c., Crude petroleum, Fertilizers, Fuel oils, Gasoline, Gravel, Logs, Natural sands, Newsprint/paper, Nonmetal min. prods., Nonmetallic minerals, Other ag prods., Other foodstuffs, Waste/scrap, Wood products.

increase in average distance in miles.[31] Since perishable goods require special conditions for transport or fast transport, a higher price is generally charged for their transport.

Column 4 shows the estimated distance effect for perishable and non-perishable goods decomposed by transport mode. For rail and truck transport, trade of perishable goods reacts significantly stronger to changes in distance than of non-perishable goods. For rail transport the coefficients of both good categories are significantly different a the 5% significance level and for truck transport at the 1% significance level using Wald test. For air transport the coefficient for perishable goods are not statistically significant most likely because only 1 percent of air trade covers perishable goods (section 1.4.3, Figure 1.6). Although the point estimate of water transport distance for perishable goods are higher in absolute terms (-1.072) than for non-perishable goods (-0.983), the difference of both estimates is not statistically significant using Wald test.

[31] The significant difference remains if we narrow the classification of perishable goods to meat/seafood, other agricultural goods, other foodstuffs and live animals/fish.

Table 1.9 *Heterogeneous distance effect across good categories*

	(1)	(2)	(3)	(4)
Dependent variable:	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$
Routed distances × High-value goods	-1.573^a			
	(0.011)			
Routed distances × Low-value goods	-2.226^a			
	(0.017)			
Air routed distances × High-value goods		-0.204^a		
		(0.015)		
Air routed distances × Low-value goods		-0.223^a		
		(0.057)		
Rail routed distances × High-value goods		-0.582^a		
		(0.024)		
Rail routed distances × Low-value goods		-0.918^a		
		(0.023)		
Truck routed distances × High-value goods		-1.926^a		
		(0.010)		
Truck routed distances × Low-value goods		-2.582^a		
		(0.016)		
Water routed distances × High-value goods		-0.754^a		
		(0.074)		
Water routed distances × Low-value goods		-1.148^a		
		(0.059)		
Routed distances × Perishable goods			-2.118^a	
			(0.025)	
Routed distances × Non-perishable goods			-1.741^a	
			(0.010)	
Air routed distances × Perishable goods				-0.078
				(0.069)
Air routed distances × Non-perishable goods				-0.208^a
				(0.015)
Rail routed distances × Perishable goods				-0.848^a
				(0.042)
Rail routed distances × Non-perishable goods				-0.743^a
				(0.018)
Truck routed distances × Perishable goods				-2.400^a
				(0.024)
Truck routed distances × Non-perishable goods				-2.108^a
				(0.010)
Water routed distances × Perishable goods				-1.072^a
				(0.104)
Water routed distances × Non-perishable goods				-0.983^a
				(0.051)
Constant	13.003^a	12.432^a	13.044^a	12.454^a
	(0.062)	(0.050)	(0.064)	(0.052)
Fixed-effects	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt
Observations	333376	333376	333376	333376
Adjusted R^2	0.663	0.682	0.660	0.679

Clustered standard errors at the ijk-level are in parentheses.

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Notes: Years covered are 1997, 2002, 2007, 2012. All distances are in logarithm. All specifications include fixed effects (FE) as indicated in the table. Estimates of FEs and controls are omitted for brevity.

1.5.4 Estimates based on US State borders

Relating to the conclusion of the baseline results (table 1.7, column 7) in section 1.5.2, the effect of domestic US State borders on trade may vary across different transport modes as some mode-specific distance elasticities significantly change by adding a control for intra-State trade. This section therefore investigates the heterogeneous effect of domestic home bias effects by transport mode by controlling for ikt and jkt specific effects. Bilateral fixed-effects would control for distance-related trade costs, such as informational frictions, which may be higher for inter-State transactions. Yet, the additional control would absorb the intra-State dummy – the variable of interest. However, informational frictions of sellers and buyers will likely affect the mode of transport to the same extent. Table 1.10 shows the results of separate OLS estimates for each of the four modes by including a dummy for intra-State trade.

Column 1 presents the distance effect of air trade with a point estimate of -0.203 and a statistically insignificant effect of intra-State trade. The results are in line with the descriptive statistics highlighting that air trade is particularly conducted between US States rather than within US States. Also, the coefficient and standard errors are very close to the results in table 1.7 (column 6: -0.205 and SE 0.015) which exclude the dummy in the baseline results. For air trade, the results suggest that US State borders do not matter as an explanatory variable for intranational trade.

Column 2 shows the results for trade by truck. The distance effect of -1.994 is close to the point estimate in our baseline estimation including a control for intra-State trade with -2.021 and the intra-State trade dummy is statistically significant and with 1.094 close to the average home bias effect in our baseline specification (0.904 in1.7, column 7) suggesting that intranational US State borders are relevant in explaining trade conducted over roads.

Column 3 presents the estimated distance effect for rail transport. The elasticity amounts to -0.658 and is in the middle of the point estimates for rail distance in the baseline specification in table 1.7 with (-0.566) and without (-0.762) intra-State control. The coefficient of intra-State trade of 0.477 is statistically significant and below the mean effect across all transport modes with a coefficient of 0.904 in the baseline specification (table 1.7, column 7), suggesting that US State borders in rail transport matter but to a lower extent than for trade over roads or waterways.

Column 4 shows the results of the distance effect on trade over US domestic waterways. The point estimate of -0.657 is slightly lower (in absolute terms) compared to the baseline results (table 1.7, column 7) for trade by waterways (-0.713) across all transport modes and the coefficient on intra-State trade is slightly higher with 1.082 compared to the mean effect (0.904) in the baseline specification. The results suggest that State-borders matter

for domestic maritime trade and even to a higher extent compared to other transport modes. According to the descriptive statistics, 20 percent of trade value over waterways happens within US States, particularly over waterways or coasts within US States, such as in Texas, Louisiana or New Jersey. As such, State borders matter more for trade over waterways.

Overall, the results suggest that the magnitude of border effects varies across transport modes where the effect is statistically insignificant for trade over airways and strongest for trade over road by truck and over national waterways while trade by rail shows a domestic border effect in the middle range.

Table 1.10 *Estimates based on US State borders*

	(1)	(2)	(3)	(4)
	$ln\,X_{ijk,air,t}$	$ln\,X_{ijk,truck,t}$	$ln\,X_{ijk,rail,t}$	$ln\,X_{ijk,water,t}$
Air routed distance, miles	-0.203^a			
	(0.017)			
Truck routed distance, miles		-1.994^a		
		(0.009)		
Rail routed distance, miles			-0.658^a	
			(0.023)	
Water routed distance, miles				-0.657^a
				(0.079)
Intra-State trade dummy	0.019	1.094^a	0.477^a	1.082^a
	(0.086)	(0.050)	(0.069)	(0.170)
Constant	1.574^a	14.604^a	4.900^a	3.323^a
	(0.117)	(0.063)	(0.155)	(0.534)
Observations	42871	243237	43249	4019
Adjusted R^2	0.496	0.699	0.596	0.645

Standard errors clustered at the ijk-level are in parentheses.

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Notes: Years covered are 1997, 2002, 2007, 2012. All distances are in logarithm. All specifications include fixed effects (FE) as indicated in the table. Estimates of FEs and of controls are omitted from the table for brevity. Standard errors, clustered by trading pair, are shown in parentheses. ^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01. In column (1) and (2), 102 observations were dropped from the estimation as they are either singletons or separated by a fixed effect.
Source: Author based on FAF 4 BTS.

Worth repeating in this context, the data does not allow tracking the precise locations within a US State. By using raw data files of the 1997 CFS trade flows detailing 5-digit ZIP codes of origin and destination, Hillberry and Hummels (2008) show that domestic home bias effects disappear. The authors' results highlight that shipments within US State borders

are in fact not significantly greater than across States, when controlling for shipment distance at a very fine geographic grid. It would therefore be interesting to investigate whether this paper's mode-specific results still hold when considering routed distances at the 5-digit ZIP code-level.

1.6 Conclusion

The internal geography of a country plays an important role in explaining trade costs and trade patterns but has so far been less studied. The present paper investigates the effect of distance-related transport costs on intranational US trade by drawing on the gravity model of trade. A key feature of this work is the availability of routed distances in miles and trade flows that vary, unlike in the traditional trade literature, by transport mode.

The paper's findings highlight the importance of taking into account the transport sector in estimating distance elasticities as traditional distance measures, such as great-circle distances, tend to underestimate the trade effect. The transport sector is also relevant in international trade. As Krugman (1991) once stated "[...] one of the best ways to understand how the international economy works is to start by looking at what happens *inside* nations.". For future work, it would be interesting to see the effect of a more precise distance measure such as mode-specific routed distances on international trade.

The results furthermore emphasize the need to control for different categories of goods in estimating the trade effect of distance as different commodities have different transport costs related to the size, value or perishable nature of the good.

The main findings of this paper are of interest to policy makers and transport planners alike. For instance, knowledge about the heterogeneous trade-effects of mode-specific transport costs are useful in determining the best available transport-related project based on its trade-effects (Wessel, 2019). In addition, the environmental impact of different transport modes has to be taken into account in transport planning. As shown in Working Group III to IPCC (2014) and Doll et al. (2020), rail and water transport have the lowest level of CO2 emissions per ton-kilometre while air and road transport have the highest levels. A shift away from road and air transport towards rail and water transport is a necessary step towards reducing the environmental impact of the transport sector. Not to forget the necessity of improving greenhouse gas efficiency of all transport modes (ITF, 2022). Research shows that freight rates and reliability of transport services are the major determinants of mode choice in the US with truck transport featuring high reliability and shorter transit times compared to rail transport (Holguín-Veras et al., 2021). However, policy interventions aiming to alter the modal split in freight transport through e.g. subsidies, tax benefits, regulations

or infrastructure provisions have been only partially successful, as discussed in ITF (2022). A fuel tax on road transport to initiate a shift towards road seems inefficient against the background of findings in Samimi et al. (2011). The authors show that even a 50 percent increase in fuel costs would not lead to a significant shift between truck and rail transport in US freight shipments. Further work has to be done to find effective solutions to reduce the impact of transport on the environment.

Finally, an understanding of intranational transport costs are helpful to better explain export performance of firms as producers are dependent on a well developed network to transport goods to the country's point of exit. In particular developing countries often feature less-developed transport networks so that a more precise measure can capture transport-related costs in a better way than traditional distance measures.

A Appendix

A.1 Standard Classification of Transported Goods

Table A.1 *Goods description of SCTG 2-digits*

1	Live animals/fish	22	Fertilizers
2	Cereal grains	23	Chemical prods.
3	Other ag prods.	24	Plastics/rubber
4	Animal feed	25	Logs
5	Meat/seafood	26	Wood prods.
6	Milled grain prods.	27	Newsprint/paper
7	Other foodstuffs	28	Paper articles
8	Alcoholic beverages	29	Printed prods.
9	Tobacco prods.	30	Textiles/leather
10	Building stone	31	Nonmetal min. prods.
11	Natural sands	32	Base metals
12	Gravel	33	Articles-base metal
13	Nonmetallic minerals	34	Machinery
14	Metallic ores	35	Electronics
15	Coal	36	Motorized vehicles
16	Crude petroleum	37	Transport equip.
17	Gasoline	38	Precision instruments
18	Fuel oils	39	Furniture
19	Coal-n.e.c.	40	Misc. mfg. prods.
20	Basic chemicals	41	Waste/scrap
21	Pharmaceuticals	42	Mixed freight

Source: based on Statistics Canada.

Standard Classification of Transported Goods (SCTG) Codes draw on the Harmonized Commodity Description and Code System (HS) and define statistically significant categories based on transport-relevant features, such as weight, value and transport distance to be used for transport analysis (BTS (2012b)). Table A.1 shows SCTG with a description of goods.

A.2 Preparation of database

Data quality of non-contiguous US States and DC: I exclude observations involving the two non-contiguous US States Alaska and Hawaii as well as DC either as origin, intermediate stop or destination, since their data has several inconveniences: Alaska's reported domestic distance includes partly distance travelled on Canadian territory due to geographical reasons. For Hawaii around two-thirds of observations include an intermodal category of multiple transport modes typically including combinations of ship and surface modes or truck and rail, which makes it difficult to entangle the effect of individual transport modes on trade.[1] In addition, several papers highlight data quality concerns in the CFS particularly for these two US States and DC (Coughlin and Novy, 2021; Yilmazkuday, 2012) – as FAF data is based on the CFS the authors' recommendation provides another reason for excluding these two non-contiguous US States and DC from the analysis.

Modal trade shares: As shown in Table A.2, the major four transport modes make up a total of 85% in domestic trade. I exclude MMM and pipelines from the analysis because the former one does not allow investigating the effect of individual transport modes on trade, and the latter one transports very specific goods only so that modal substitutability are limited.

[1] see Center for Transportation Analysis Oak Ridge National Laboratory (2015) for more information about this intermodal category.

Table A.2 *Trade share by mode of transport: raw data*

Domestic mode	year	value domestic	percent domestic
Truck	1997	8,567,939	77.4%
MMM	1997	1,267,010	11.4%
Rail	1997	467,409	4.2%
Pipeline	1997	406,414	3.7%
Air	1997	262,193	2.4%
Water	1997	92,346	0.8%
OoU	1997	3,589	0.0%
Truck	2002	9,453,507	79.3%
MMM	2002	1,278,904	10.7%
Pipeline	2002	430,470	3.6%
Rail	2002	398,703	3.3%
Air	2002	235,884	2.0%
Water	2002	117,037	1.0%
OoU	2002	3,635	0.0%
Truck	2007	10,863,175	74.6%
MMM	2007	1,843,876	12.7%
Pipeline	2007	1,057,161	7.3%
Rail	2007	451,888	3.1%
Water	2007	178,917	1.2%
Air	2007	157,515	1.1%
OoU	2007	4,974	0.0%
Truck	2012	10,208,792	73.7%
MMM	2012	1,729,457	15.6%
Pipeline	2012	1,127,013	10.2%
Rail	2012	409,004	3.7%
Water	2012	249,152	2.3%
Air	2012	128,651	1.2%
OoU	2012	1,025	0.0%

Note: MMM stands for multiple modes and mail, and OuA for unknown transport mode.
Source: Author based on FAF 4 BTS.

Deriving intranational routed distance: I derive absolute values for *intranational* routed distance in miles from dividing ton miles by tons. All calculated distances fall in the reported distance bands. This approach leads for intranational trade flows in the raw data to around

2.3% of observations with missing *domestic* distances because either kilotons, ton-miles or both are zero.

To overcome the missing data problem, I derive mean distances through a four-steps incremental imputation procedure for each trade flow (Table A.3). In each of the four steps, I use asymmetric dyads, assuming that distances can vary between pairs ij and ji, and symmetric dyads where distances for ij are equal to distances for ji.

First, I impute domestic mean distances by *asymmetric dyad*-mode-good-year combinations (0 imputations) and *symmetric dyad*-mode-good-year combinations (0.8%); second, by *asymmetric dyad*-mode-year combinations (1.3%%) and by *symmetric dyad*-mode-year combinations (0.11%), third by *asymmetric dyad*-mode-good combinations (0.05%) and by *symmetric dyad*-mode-good combinations (0.01%); fourth by *asymmetric dyad*-mode combinations (0.03%) and by *symmetric dyad*-mode combinations (0.0003%). This imputation approach reduces the number of missing intranational distances to 2 (0.0006%) observations for intranational trade flows.

Table A.3 *Intranational trade flows: Missing domestic distances*

Imputation steps		asymmetric dyad	symmetric dyad	total dyad
A) dyad-mode-good-year	% of raw data	0	0.8%	0.8%
B) dyad-mode-year	% of raw data	1.3%	0.11%	1.4%
C) dyad-mode-good	% of raw data	0.05%	0.01%	0.1%
D) dyad-mode	% of raw data	0.03%	0.0003%	0.0%

Source: Author based on FAF 4 BTS.

The results highlight that by adding imputed observations in each step does not shift the kernel density of the entire dataset. Instead, the imputed data follows the shape of the density curve, therefore supporting the representativeness of the final dataset.

A.3 Descriptive statistics

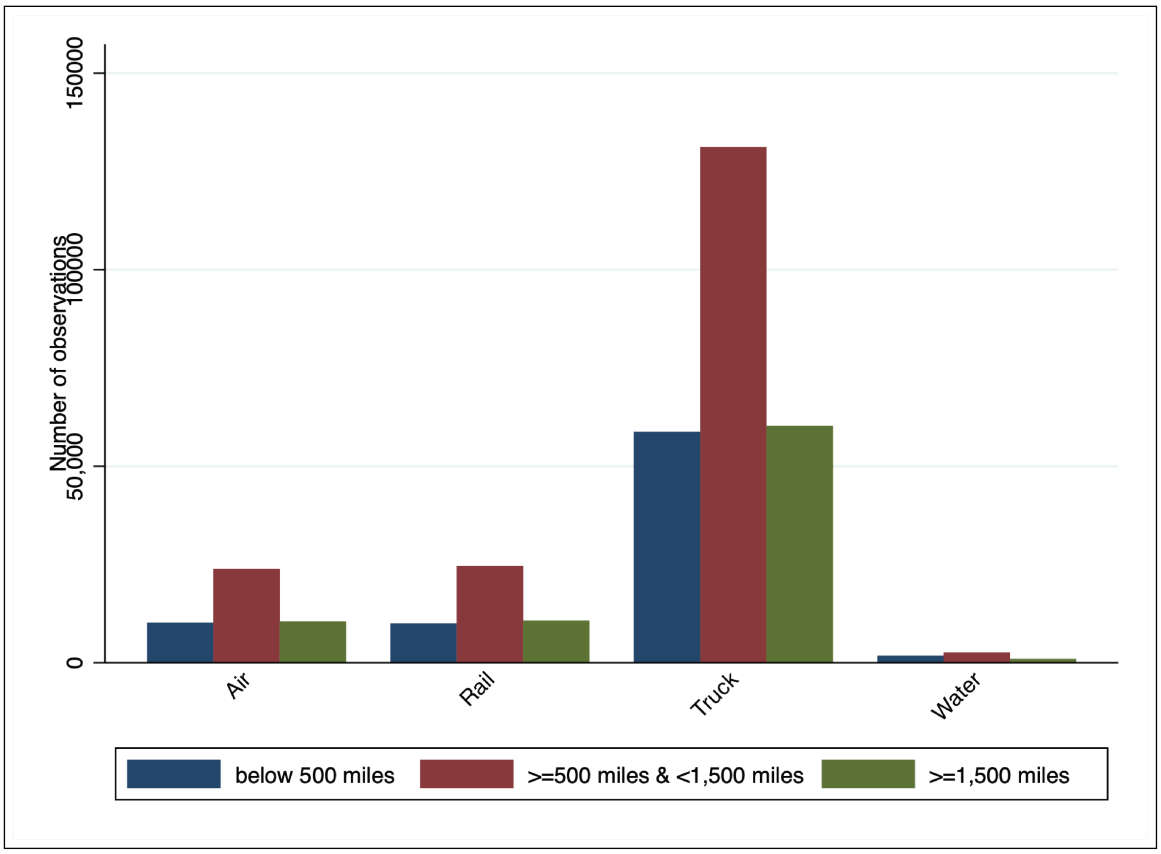
Characteristics of unbalanced panel: As the number of observations drops significantly between the panel years 1997 and 2002, I investigate the driving factor of this decline. Table A.4 shows all origin-destination pairs *(ij)* per transport mode across years. While the number of combinations remains the same for truck transport, 2,304, it declines for the remaining three transport modes. Except for truck transport, the decline in the number of observations is associated with a reduction in reported origin-destination paris, hence transport routes, and/or changes in the number of traded commodity types.

Table A.4 *Unbalanced panel: ij-combinations by transport mode across years*

year	Air	Rail	Truck	Water
1997	1993	1869	2304	466
2002	1902	1614	2304	239
2007	1773	1585	2304	271
2012	1872	1562	2304	333

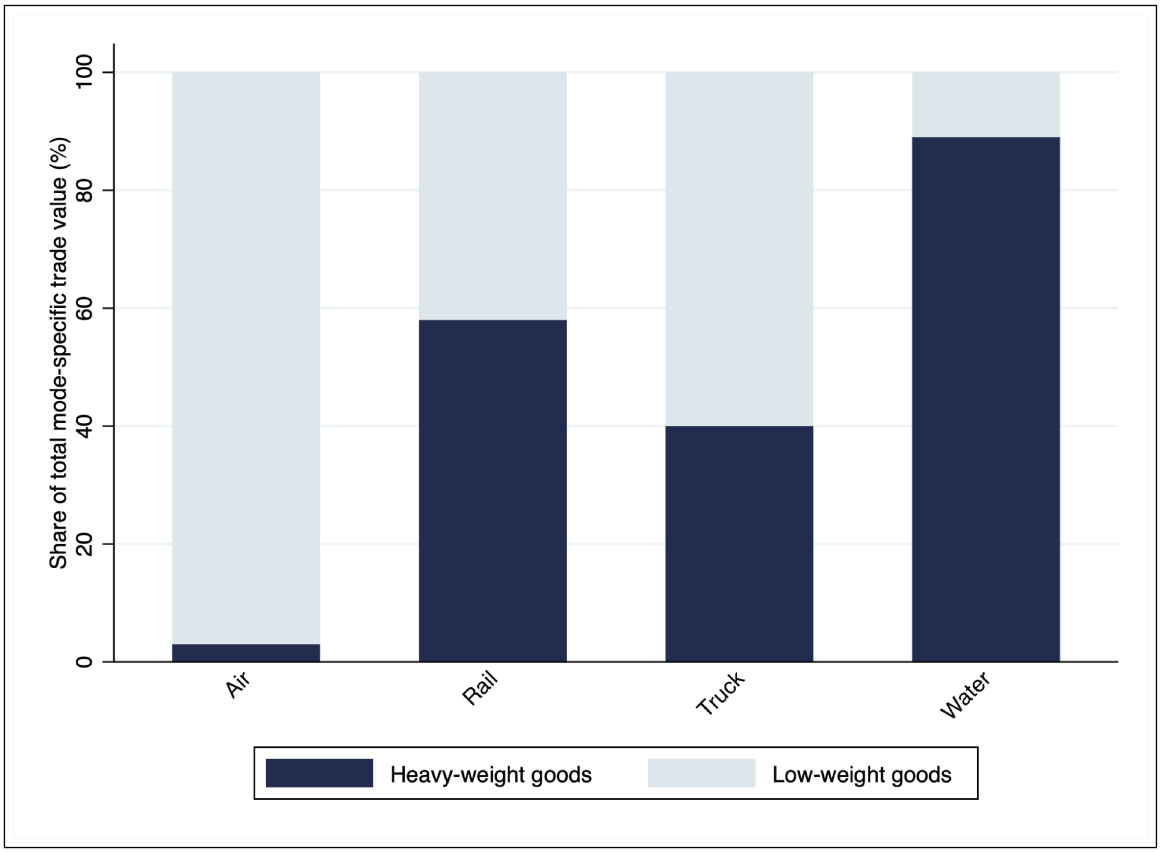
Source: Author based on FAF 4 BTS.

Figure A.1 *Observations by transport mode across distance bins*



Source: Author based on FAF 4 BTS.

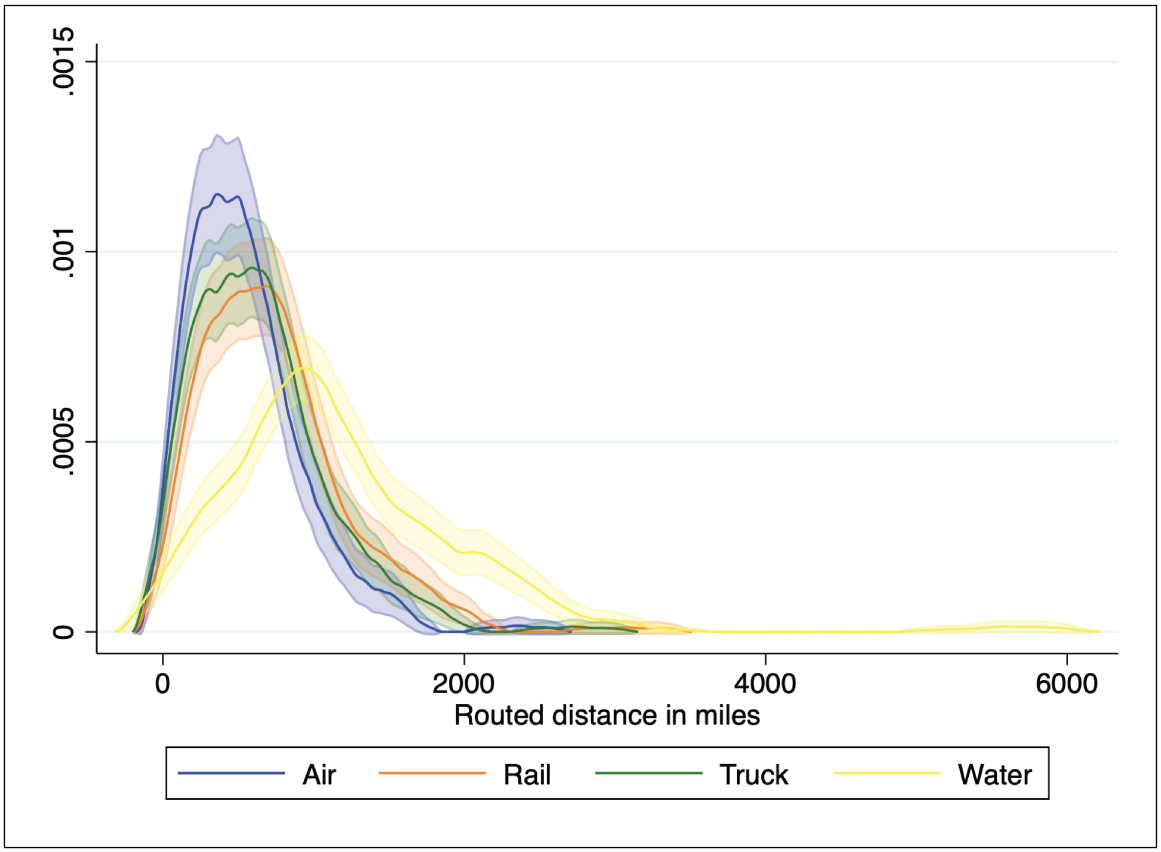
Figure A.2 *Share of trade in heavy and light goods by transport mode*



Note: Heavy goods are classified in this paper as products equal or above the mean shipment weight (in tons) by good category, including the following 21 categories: Animal feed, Base metals, Basic chemicals, Cereal grains, Coal, Coal-n.e.c., Fertilizers, Fuel oils, Gasoline, Gravel, Live animals/fish, Logs, Metallic ores, Mixed freight, Natural sands, Nonmetal min. prods., Nonmetallic minerals, Other ag prods., Other foodstuffs, Waste/scrap, Wood products.
Source: Author based on FAF 4 BTS.

Mode-specific routed distances across routes featuring all four transport modes For routes featuring all four transport modes, airways have on average the shortest distance followed by road via truck, railroads and waterways. Figure A.3 depicts kernel densities of routed distances by transport mode for routes featuring all four modes. Mode-specific distances in the kernel graph are averaged across years and goods to exclude variations in distances arising from goods and time. Yet, the distance ranking remains the same for distances of routes with all four modes averaged across *ijkt*-combinations.

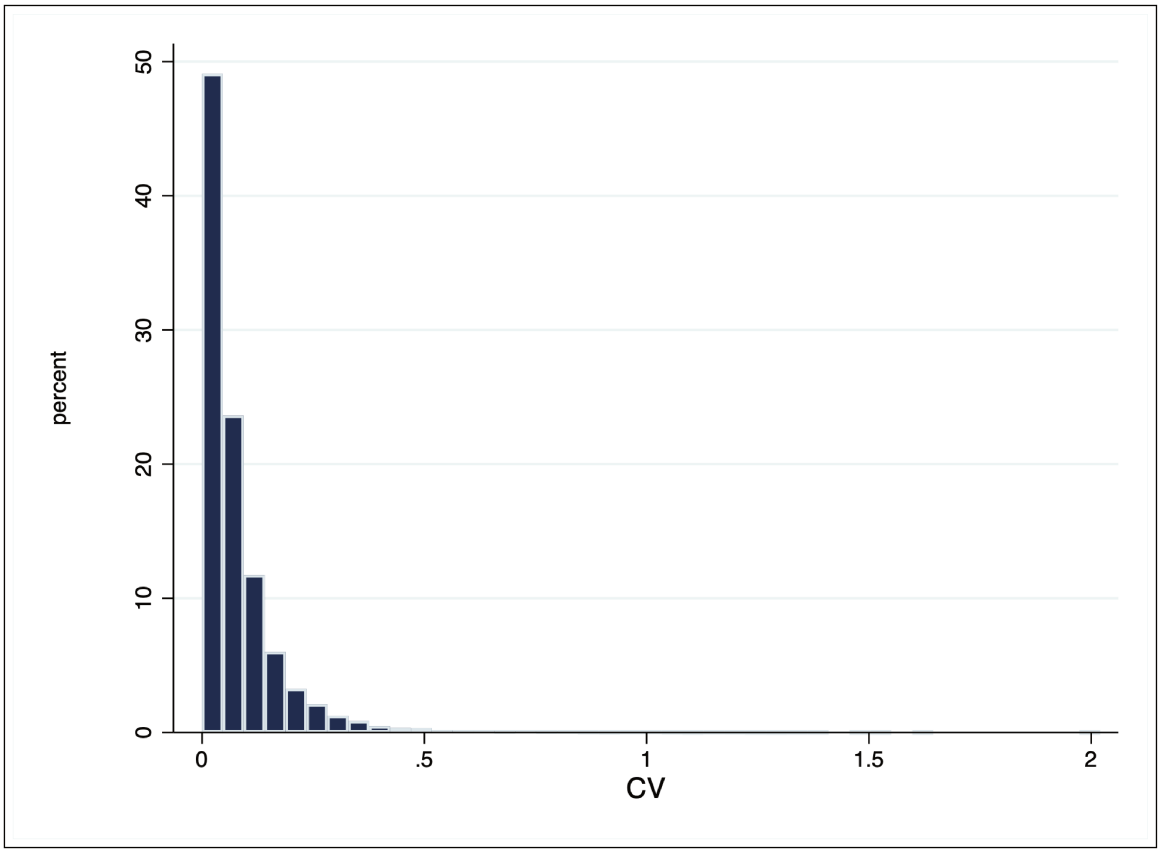
Figure A.3 *Kernel density of routed distances (ij) by transport mode with confidence bands (95-level)*



Source: Author based on FAF 4 BTS.

Differences in mode-specific routed distance across good categories: Figure A.4 displays a histogram of coefficient of variations (CV) for routed distances across goods for same origin-destination-mode-year ($ijmt$) combinations. As I derive routed distances by transport mode from ton-miles over tons for each good, the results show variation of distances across goods, all else equal. This variation implies that goods transported by the same mode between the same origin-destination pair in the same year may depart/arrive at different ZIP codes. In 99.84% of combinations, CVs are *below* 1 standard deviation. For air distances, 100% of observations are below a CV of 1. Two out of 21,922 combinations have a CV *above* 1 for truck distances, four for rail distances and 30 for water distances.

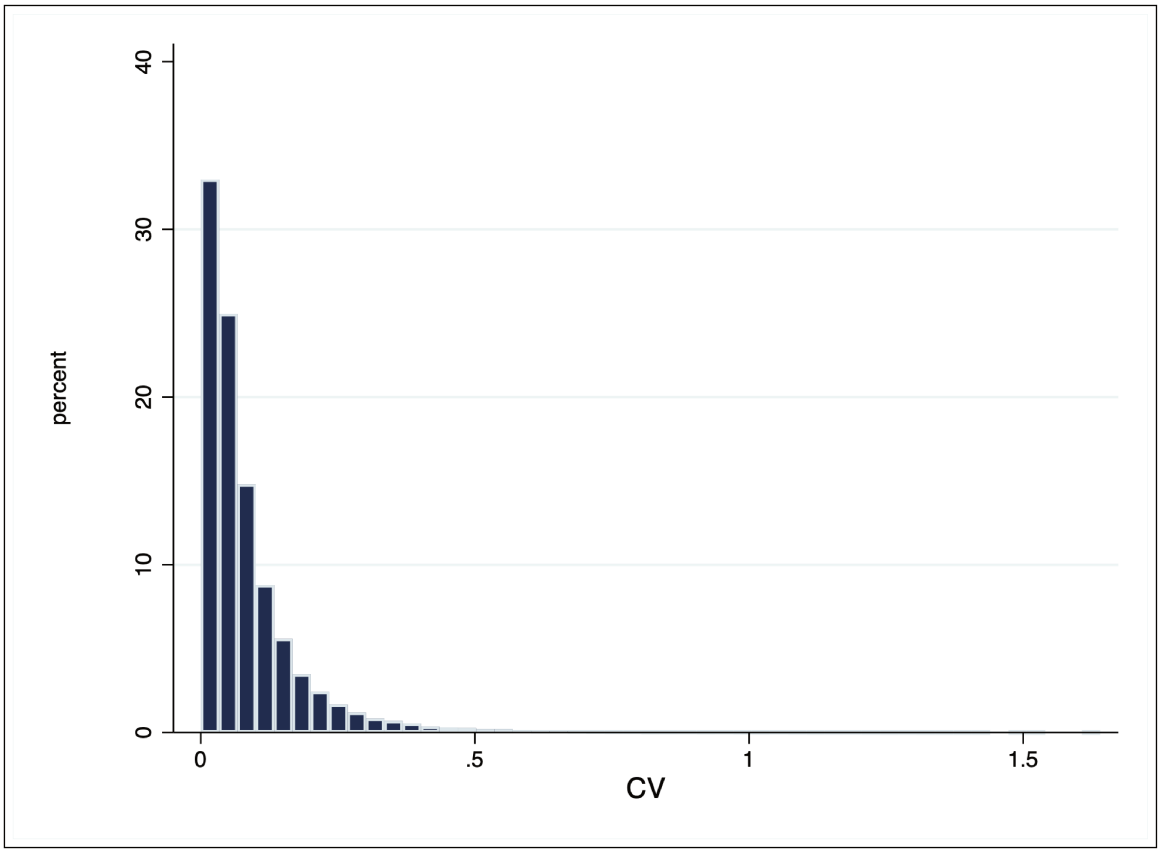
Figure A.4 *Histogram of coefficient of variation of distances across goods for same ijmt-combinations*



Source: Author based on FAF 4 BTS.

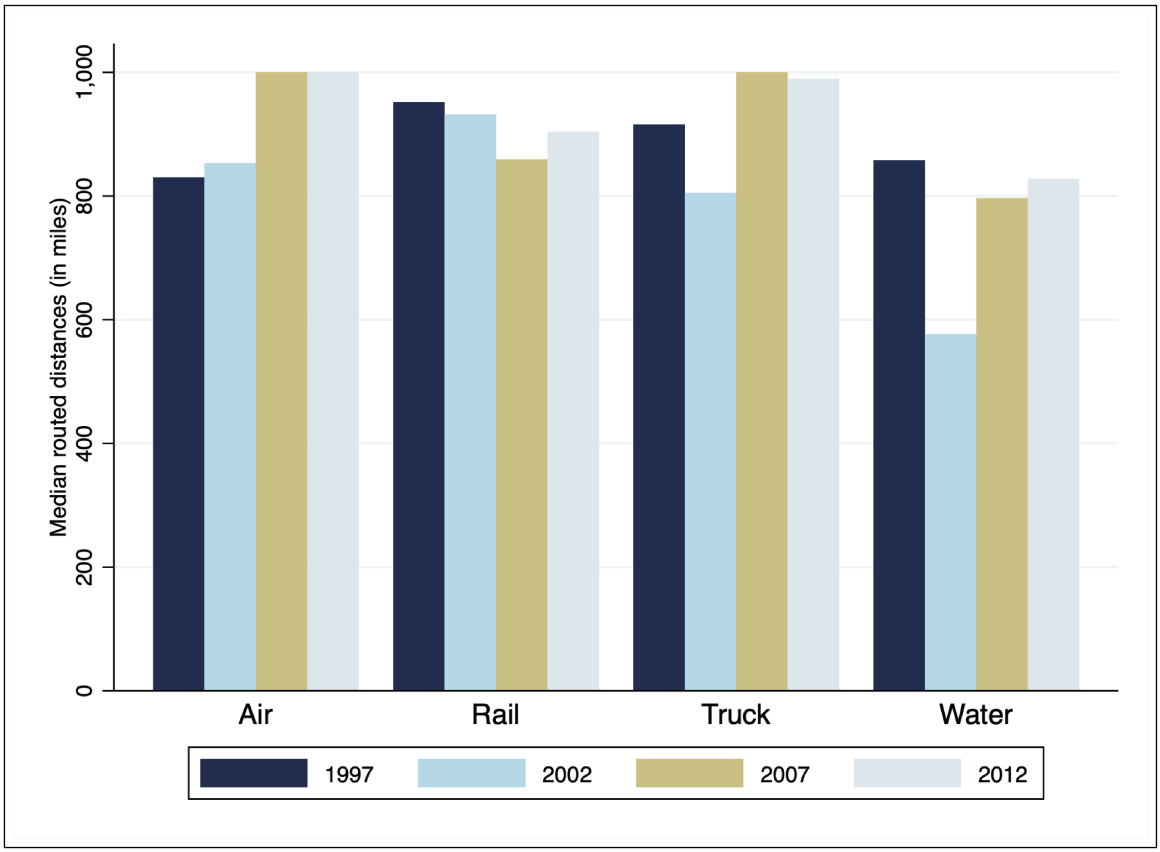
Differences in mode-specific routed distances across years: Figure A.5 depicts for each transport mode histograms of the coefficient of variation (CV) of distances for the same combinations of origin-destination-good-mode ($ijkm$) across years to investigate whether distances vary by year. Distances vary across years but by less than one standard deviation in 99.89% of combinations. For CVs above 1 (0.11% of all 91,231 combinations), the majority is associated with rail (51 combinations) and water (43 combinations) transport.

Figure A.5 *Histogram of coefficient of variation of distances across years for same ijkm-combinations*



Source: Author based on FAF 4 BTS.

Figure A.6 *Median routed distances across years by transport mode*



Source: Author based on FAF 4 BTS.

Table A.5 *Mode of routed distance across years by transport mode*

	1997	**2002**	**2007**	**2012**
Air	600	1000	1000	1000
Rail	1000	600	1000	500
Truck	1000	1000	1000	1000
Water	1000	80	1000	13

Source: Author based on FAF 4 BTS.

A.4 Supporting information for estimation results

Table A.6 *Heterogeneous distance effect: heavy weight goods*

	(1)	(2)
	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$
Routed distances × Heavy-weight goods	-2.149^a	
	(0.016)	
Routed distances × Low-weight goods	-1.547^a	
	(0.011)	
Air routed distances × Heavy-weight goods		-0.150^a
		(0.037)
Air routed distances × Low-weight goods		-0.212^a
		(0.016)
Rail routed distances × Heavy-weight goods		-0.904^a
		(0.022)
Rail routed distances × Low-weight goods		-0.531^a
		(0.025)
Truck routed distances × Heavy-weight goods		-2.507^a
		(0.014)
Truck routed distances × Low-weight goods		-1.900^a
		(0.011)
Water routed distances × Heavy-weight goods		-1.177^a
		(0.063)
Water routed distances × Low-weight goods		-0.723^a
		(0.058)
Constant	12.992^a	12.423^a
	(0.063)	(0.050)
Fixed-effects	ikmt, jkmt	ikmt, jkmt
Observations	333376	333376
Adjusted R^2	0.663	0.682

Clustered standard errors at the ijk-level are in parentheses.

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Notes: Years covered are 1997, 2002, 2007, 2012. All distances are in logarithm. All specifications include fixed effects (FE) as indicated in the table. Estimates of FEs and controls are omitted for brevity.

Source: Author based on FAF 4 BTS.

A.5 Robustness tests

Table A.7 *Estimates based on routes featuring all four transport modes*

	(1)	(2)	(3)	(4)
Dependent variable:	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$
Routed distances, miles	-1.618^a	-1.534^a		
	(0.021)	(0.024)		
Air routed distance, miles			-0.156^a	-0.063^c
			(0.034)	(0.036)
Rail routed distance, miles			-0.730^a	-0.618^a
			(0.036)	(0.038)
Truck routed distance, miles			-2.241^a	-2.142^a
			(0.022)	(0.024)
Water routed distance, miles			-0.964^a	-0.847^a
			(0.056)	(0.057)
Intra-State trade dummy		0.326^a		0.393^a
		(0.071)		(0.063)
Constant	12.001^a	11.451^a	11.838^a	11.174^a
	(0.133)	(0.151)	(0.110)	(0.133)
Fixed-effects	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt
Observations	56252	56252	56252	56252
Adjusted R^2	0.710	0.711	0.738	0.738

Clustered standard errors at the ijk-level are in parentheses.

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Notes: Years covered are 1997, 2002, 2007, 2012. All distances are in logarithm. All specifications include fixed effects (FE) as indicated in the table. Estimates of FEs and controls are omitted for brevity.
Source: Author based on FAF 4 BTS.

Table A.8 *Estimates excluding imputed routed distances*

	(1)	(2)	(3)	(4)
	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$
Routed distances, miles	-1.768^a	-1.641^a		
	(0.009)	(0.009)		
Air routed distance, miles			-0.261^a	-0.164^a
			(0.015)	(0.015)
Rail routed distance, miles			-0.765^a	-0.556^a
			(0.017)	(0.018)
Truck routed distance, miles			-2.094^a	-1.955^a
			(0.009)	(0.009)
Water routed distance, miles			-1.001^a	-0.694^a
			(0.046)	(0.046)
Intra-State trade dummy		0.844^a		0.964^a
		(0.050)		(0.042)
Constant	12.987^a	12.106^a	12.413^a	11.408^a
	(0.062)	(0.061)	(0.051)	(0.055)
Fixed-effects	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt
Observations	325654	325654	325654	325654
Adjusted R^2	0.663	0.665	0.681	0.683

Clustered standard errors at the ijk-level are in parentheses.

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Notes: Years covered are 1997, 2002, 2007, 2012. All distances are in logarithm. All specifications include fixed effects (FE) as indicated in the table. Estimates of FEs and controls are omitted for brevity.

Source: Author based on FAF 4 BTS.

Table A.9 *Estimates based on time-invariant routed distance*

	(1)	(2)	(3)	(4)
Dependent variable:	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$	$ln\,X_{ijkmt}$
Routed distances, miles	-1.814^a	-1.676^a		
	(0.009)	(0.009)		
Air routed distance, miles			-0.181^a	-0.070^a
			(0.015)	(0.016)
Rail routed distance, miles			-0.756^a	-0.528^a
			(0.016)	(0.018)
Truck routed distance, miles			-2.186^a	-2.037^a
			(0.009)	(0.009)
Water routed distance, miles			-1.195^a	-0.825^a
			(0.048)	(0.049)
Intra-State trade dummy		0.914^a		1.043^a
		(0.051)		(0.042)
Constant	13.187^a	12.234^a	12.611^a	11.523^a
	(0.065)	(0.064)	(0.051)	(0.056)
Fixed-effects	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt	ikmt, jkmt
Observations	333376	333376	333376	333376
Adjusted R^2	0.657	0.659	0.677	0.679

Clustered standard errors at the ijk-level are in parentheses.

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Notes: Years covered are 1997, 2002, 2007, 2012. All distances are in logarithm. All specifications include fixed effects (FE) as indicated in the table. Estimates of FEs and controls are omitted for brevity.
Source: Author based on FAF 4 BTS.

2 The trade effect of preferential product-specific Rules of Origin

This chapter is joint work with Julien Gourdon (CERDI) and Jaime de Melo (FERDI). Gourdon et al. (2023) is the working paper version of this article.

Abstract

Rules of Origin (RoOs) are critical components of Regional Trade Agreements (RTAs) and are designed to prevent trade deflection. While RoOs are necessary, complex RoOs may undo the benefits of RTAs. Using a novel dataset of RoOs from the World Bank's Deep Trade Agreement project, the paper investigates the trade effect of Product-Specific Rules of Origin (PSRs) across 128 RTAs for the period 1990 - 2015. Results based on a structural gravity model document wide heterogeneity across different categories of PSRs attached to preferential margins with more flexible PSRs associated with a significantly stronger trade effect compared to more restrictive ones where exporters do not have a choice among PSRs or have to satisfy multiple rules. A simulation exercise reveals that a radical simplification reform leading to the adoption of flexible PSRs providing alternative choices to prove origin would have increased global trade under RTA by on average 2.7 percent during the sample period.

Keywords: Rules of origin, Product-specific rules of origin, compliance costs.

JEL Classification: F1; F14; F15.

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List of Abbreviations

Abbreviation	**Definition**
AFTA	ASEAN Free Trade Area
ALT	Alternative rule
ASEAN	Association of Southeast Asian Nations
BACI	*Base pour l'Analyse du Commerce International*
CAFTA-DR	Dominican Republic-Central America-United States Free Trade Agreement
CC	Change of Tariff Classification at the chapter-level
CEPII	*Le Centre d'études prospectives et d'informations internationales*
CH	Change of Tariff Classification at the heading-level
COM	Combination rule
COO	Certificate of Origin
CS	Change of Tariff Classification at the subheading-level
CTC	Change of Tariff Classification
DTA	World Bank's Deep Trade Agreement Database
EBA	Everything But Arms Agreement
EXC	Exception rule
GSP	Generalised System of Preferences
HS	Harmonized System
MERCOSUR	The Southern Common Market *El Mercado Común del Sur*
MFN	Most-Favoured Nation
MLR	Multilateral Resistance terms
NAFTA	North American Free Trade Agreement
NPRoO	Non-Preferential Rules Of Origin
OECD	The Organization for Economic Cooperation and Development

List of Abbreviations

Abbreviation	**Definition**
PEM	Pan-Euro-Mediterranean Convention
PPML	Poisson Pseudo Maximum Likelihood
PSR	Product-specific rules of origin
ROF	Rules of Origin Facilitator search engine
RoO	Rules of Origin
RTA	Regional Trade Agreement
RWR	Regime-wide rules of origin
SADC	Southern African Development Community
SAFTA	Agreement on South Asian Free Trade Area
STC	Substantial Transformation criterion
TR	Technical Requirement rule
VCR	Value Content Requirement rule (or regional value content rule)
WCO	World Customs Organization
WITS	The World Integrated Trade Solution software
WO	Wholly Obtained rule

2.1 Introduction

Regional Trade Agreements (RTAs)[1] require Rules of Origin (RoO) to establish the origin requirements that products must meet to qualify for market access under preferential tariffs. These rules are intended to prevent transshipment of products with negligible regional content, e.g. through repackaging, across partners with low tariffs in a Free Trade Area (trade deflection) (Kniahin and de Melo, 2022).[2]

While RoOs are necessary, they may offset the benefits of RTAs. For instance as discussed in Angeli et al. (2020), if these rules are too complex to implement, firms may not be able to take advantage of tariff concessions. Some firms may be unable to fulfil the requirements due to limited technological or managerial capabilities, putting them at a competitive disadvantage and may force them to exit the market. Other firms may simply not utilize the preferences because the expected costs of complying with the rules significantly outweigh the associated tariff reductions. For example, consider a Vietnamese producer wishing to export cotton shirts (HS 6205.20.00) to Japan. The available options are (i) entering under the Most-Favoured Nation (MFN) regime and paying a 7.4% MFN tariff, (ii) using one of four RTAs or (iii) applying the regime of Generalised System of Preferences (GSP) and benefit from preferential tariffs conditional on complying with RoO stipulated in the agreement (Gourdon et al. (2021), figure 1). Choosing the least cost option involves search and implementation costs of those different RoO. Conceptually, the choice is easy to make: if these compliance costs are less than the corresponding tariff reduction, also called tariff preference margin – defined as the difference between the MFN tariff and the preferential tariff stipulated in the agreement – the exporter should choose to declare the exports under the preferential scheme.

Much evidence has identified the side effects of RoO, showing less trade and/or lower use of tariff preferences. RoO limit the sourcing choices of firms globally by imposing regional patterns dictated by RTAs, whereas optimisation of global value chains may call for different choices (Kniahin and de Melo, 2022). Some observers describe the result as giving preferences with one hand and taking them away with the other through RoO.[3] Researchers have advocated reforms, ranging from simplification to outright elimination of RoO.[4]

[1] We define an RTA as a reciprocal trade agreement, following the definition of the World Trade Organisation (WTO, 2023). In contrast, preferential trade agreements (PTAs) are defined as unilateral (non-reciprocal) trade agreements, such as General System of Preferences (GSP) schemes, and are not part of this paper (WTO, 2023).

[2] RoO are also necessary to confer origin, for instance for labelling or other trade-related measures like Anti-dumping, Sanitary and Phytosanitary measures. These are called 'Non-Preferential RoO' (NPRoO) which are not part of this paper. The Uruguay Round Agreement on RoO deals only with NPRoO.

[3] Recent surveys include Abreu (2016) and Kniahin and de Melo (2022).

[4] Early on, Lloyd (1993) proposed modifying the traditional assignment to a trade flow to a single country to one where assignment would be in proportion to the share of value-added originating in that country, resulting in multi-country RoO, with efficiency advantages over single-country rules. Cadot and de Melo (2008), proposed

This paper provides empirical evidence on the heterogeneous effect of different types of product-specific rules of origin (PSR) on the intensity of global trade across 128 RTAs. Product-specific rules are components of RoO including regime-wide rules of origin (RWR) covering general conditions for verification and certification of origin. While RWR are the same for all products in the same RTA, PSR, being defined at the HS6 product-level, differ across products within the same RTA and derive differences in variable compliance costs across PSR. Unlike RWR, the heterogeneity of PSR allows us therefore to derive mutually exclusive categories of PSR within the same RTA. We draw on the World Bank's Deep Trade Agreement (DTA) database that collects information on PSR and RWR of RTAs covering 181 exporter/importer countries for the period 1990-2015. The paper also relies on CEPII's bilateral trade data (BACI) and Most-Favoured Nation (MFN) tariffs from the World Integrated Trade Solution (WITS) database.

In the absence of preference utilisation rates of RTAs as dependent variable, which would be the first-best approach to measure the impact of RoO (Cadot and Ing, 2014; Inama, 2022),[5] we base our identification strategy on the variation of trade flows for the same country pair-product combination across time and indicate the presence of different types of PSRs with dummy variables (Cadot and Ing, 2016). We run a structural gravity model at the HS6 product level – at which PSRs are defined – and control for country pair-product (HS2 digit) effects, multilateral resistance terms (origin country-time, destination country-time fixed effects), level of MFN tariffs, a vector of dummies marking the presence of each category of PSRs and an interaction between the vector of PSR dummies and tariff preference margins. The interaction term is our variable of interest and measures the trade elasticity of changes in preference margins for each PSR category, thereby capturing differences in compliance costs across PSRs. We expect a stronger increase in trade for a given change in preference margin for PSR categories characterised by lower compliance costs. Our results are based on a Poisson-Pseudo Maximum Likelihood (PPML) estimator to account for heteroscedastic trade data (Silva and Tenreyro, 2006). Our control group consists of HS6 product-level trade flows across time under partners not engaged in an RTA.

Our estimates show that flexible rules allowing to choose between alternative PSRs have the strongest positive impact on trade value when controlling for changes in preference margins. On the other hand, adopting stricter rules like imposing combinations of different

an elimination of RoO requirements for 'nuisance tariffs' and a simplification in criteria. Hoekman and Inama (2018) observed some convergence across non-preferential Rules of Origin and argue for RTA members to agree on equivalence regimes for RoO. Mavroidis (2018) argued for abolition.

[5]The lack of systematic data on preference utilisation rates imposes challenges on the evaluation of the effects of PSRs as they cannot be directly associated with the corresponding amount of trade realized under a specific RTA. However, preference utilisation rates are only available for some years for RTAs involving the EU, US, Japan and Canada.

rules annihilate the positive trade effect of preference margins. Simulation-based estimates suggest that a simplification of PSRs would be associated with larger bilateral trade flows at the product level. A simulation of a radical simplification reform that leads to the adoption of flexible rules allowing for alternative choices increases global trade under RTA by 2.7 percent on average during the sample period. To our knowledge, this analysis is the first documented evidence of trade effects of different categories of PSRs across the quasi-full range of worldwide RTAs.

The paper is structured as follows. Section 2.2 presents evidence in the literature on the effect of RoO on the utilisation of tariff preferences and trade flows. Section 2.3 describes the distribution of PSRs across 128 RTAs covered in the paper explaining assumptions used to classify these rules in sufficiently broad categories to be amenable to statistical analysis. Section 2.4 presents the final dataset and descriptive statistics. Section 2.5 outlines our empirical strategy and estimation results. Section 2.6 presents our simulation results under a simplification of PSRs. Section 2.7 concludes and suggests avenues for future research.

2.2 Related literature

The literature most closely related to our work documents the effect of Rules of Origin (RoO) on the utilisation of tariff preferences and trade flows.[6]

A large number of empirical evidence draws on preference utilisation rates – the share of total eligible trade value that has received preferential duty rates at the time of customs clearance – and determine three major factors of utilisation: the extent of tariff reductions approximated by the preference margin (i.e. MFN tariff - preferential tariff), the value of exports and the restrictiveness of RoO. Preference margins approximate the extent of benefits in terms of unpaid duties, while RoO may generate compliance costs (Hakobyan, 2015).

Exporters will face costs of complying with RoO to be able to benefit from preferential tariffs and may therefore not use the preferences if these costs outweigh the associated tariff reductions. Compliance costs of rules of origin are of fixed and variable nature (Brenton, 2003; Kniahin and de Melo, 2022; Lendle et al., 2016). Fixed costs are related to the necessity to change production processes, such as finding new suppliers or understanding the RoO requirements, as well as capital investments to prove compliance through documentation (e.g. with expensive accounting software visualizing the geographical distribution of imported

[6]There is also a stream of literature (unrelated to our work) examining the effect of RoO on sourcing patterns of intermediate inputs from non-RTA partners (third market effects of RoO). Conconi et al. (2018) estimate that RoO on final goods significantly reduced imports of intermediate goods from third countries. Cadestin et al. (2016) measure for 25 RTAs in Latin America a decline in imports of intermediate goods from non-RTA members of on average 23.5 percent.

inputs from different origins) (Brenton, 2003; Lendle et al., 2016). Fixed costs furthermore include administrative costs that are related to obtaining the certificate of origin (COO) for each transaction regardless of the product's export value (Hayakawa et al., 2019). In the case of fixed costs, preference utilisation rates should increase with trade values because obtaining preferences would be beneficial for high export volumes resulting in significant duty savings (Kniahin and de Melo, 2022; Lendle et al., 2016). Findings suggest a positive relationship between the value of exports and preference utilisation rates, hinting towards fixed costs of RoO (Brunelin et al., 2019; Bureau et al., 2006; Hakobyan, 2015; Lendle et al., 2016; Nilsson, 2016).[7] Keck and Lendle (2012) estimate administrative (fixed) costs related to RoO between USD 14 and USD 1,500 for preferential trade agreements of Australia, Canada, the EU and the US. Albert and Nilsson (2016) find average fixed costs based on transaction-level data of between EUR 20 and EUR 260 for EU exports to Iceland. Hayakawa (2011) estimate tariff-equivalent fixed costs of 3 percent of final product prices on average across worldwide Free Trade Agreements. Anson et al. (2005) derive ad-valorem equivalent total compliance costs for NAFTA of 6 percent, offsetting the average preference margin, where administrative costs amount to about 47 percent of the preference margin. In a case study on a South African retailer ("Shoprite"), Gillson (2012) describes that the company spends USD 5.8 million per year on fixed costs (e.g. filing certificates, obtaining import permits) to comply with RoO under the Southern African Development Community (SADC) to secure USD 13.6 million in duty savings. Krishna et al. (2021) find that fixed costs of documentation decrease over time with the experience of the firm to obtain preferential tariffs.

Variable costs of RoO, as a percentage of production value, are associated with increased production costs due to origin requirements obliging producers to source inputs from more expensive suppliers or to produce the input by themselves at higher costs (Hayakawa et al., 2019; Keck and Lendle, 2012). In the case of variable compliance costs, the utilisation of preferences will vary with the level of preference margins. Keck and Lendle (2012) empirically test the determinants of preference utilisation and find a positive effect of the extent of preference margins (capturing variable costs) and the volume of exports (capturing fixed costs), as well as a negative impact of the restrictiveness of rules of origin. The positive relationship between preference margins and preference utilisation has been empirically

[7] Likewise, Nilsson (2011) finds that low EU import values under unilateral preferential trade agreements of the EU are associated with significantly lower preference utilisation rates where flows of less than EUR 10,000 reduce preference utilisation rates by almost 50% in comparison to preferential import flows of above EUR 1 million. Manchin and Pelkmans-Balaoing (2007) show that preferential imports are positively affected only at very high preference margins with around 25 percentage points, suggesting high administrative costs of complying with the RoO stipulated in the Association of Southeast Asian Nations (ASEAN) Free Trade Area (AFTA). The authors do not include measures of different types of RoO as they are only interested in the effect of different bins of preference margins on AFTA trade flows.

shown in a number of further work, such as by Ayele et al. (2022); Cadot and Ing (2016); Candau et al. (2004); Carrère and de Melo (2015). Cadot et al. (2014b) conclude in their study on Colombia's trade preferences to Argentina, Peru and Uruguay that the major compliance costs of RoO are variable costs of sourcing locally rather than fixed costs of compliance.

Francois et al. (2006) estimate average compliance costs of RoO at 4 percent of trade value and Cadot et al. (2006) found trade-weighted averages of these costs to be 6.8 percent ad-valorem equivalent for NAFTA and 8 percent for the EU. Further indications on the magnitude of compliance costs are, for instance by Manchin (2006) who analyses the use of preferences under the Cotonou agreement. The author estimates a minimum value of 4 percent in the difference between preferential and third country tariffs (i.e. preference margins) in order for exporters to have incentives to request preferences.

However, these cost estimates are averages that do not capture variation of compliance costs across different types of RoO, reducing the relative tariff savings obtained through preferential treatment (Hakobyan, 2015). For instance, Hayakawa et al. (2016) estimate (fixed and variable) compliance costs using Thai customs-level data. The authors highlight that value content rules entail lower variable compliance costs as they are relatively business-friendly in adjusting input sourcing while they incur high documentation costs (fixed costs) by reporting invoices and contract documents for each input to prove origin. Carrère and de Melo (2015) estimate compliance costs of the main origin rules in NAFTA using a non-parametric revealed preference approach. First applied by Herin (1986), the idea behind this approach is that preference margins reveal the upper bound of compliance costs for products with utilisation rates of 100 percent, while preference margins of products with zero utilisation inform about the lower bound.[8] The authors conclude that compliance costs of NAFTA provisions are least for the change in tariff classification rule, followed by combined rules including value content requirements and are highest for combined rules including technical requirements.[9] Studies looking at a simplification of regime-wide RoO – which are the same for all products part of a specific RTA – lead to higher preference utilisation (Brunelin et al., 2019; de Melo and Portugal-Perez, 2014; Sytsma, 2022) and increased export values (Tanaka and Fukunishi, 2022). For instance, Sytsma (2022) exploits a natural experiment and estimates compliance costs of the RWR on double-transformation in the textiles sector to be three-quarters of the preferential margin.

[8] Cadot et al. (2006) also draw on the revealed preference approach to estimate compliance costs of RoO for NAFTA and the EU's PANEURO system, and Anson et al. (2005) for NAFTA.

[9] The authors document in table 4 that the change in chapter rule leads to compliance costs of around 3.5% of trade value and a value content rule in combination with a change in subheading or change in heading of around 3.8%, while combination rules including a technical requirement, such as a change in subheading plus a technical requirement of around 11.4%.

The literature also documents a negative relationship between the degree of *restrictiveness* of RoO and preference utilisation rates and/or trade values (Ayele et al., 2022; Cadot et al., 2006; Keck and Lendle, 2012). In earlier attempts to derive differences in the *restrictiveness* of product-specific rules of origin (PSR) in NAFTA, Estevadeordal (2000) developed a qualitatively ordered index that is based on an observation rule (ad-hoc judgment)[10] and that ranks PSRs from 1 to 7. This synthetic index has been detailed over time[11] and adjusted in various studies, such as in Anson et al. (2005); Ayele et al. (2022); Cadot et al. (2006); Cadot and Estevadeordal (2006); Carrère and de Melo (2015). Although a definition of restrictiveness is not clearly provided in the work, Estevadeordal (2000) explains that products under a slow tariff liberalisation programme (measured by the number of years stipulated in the agreement until products obtain zero preferential tariffs) are associated with more restrictive PSR – whose degree of *restrictiveness* or *stringency* is measured by Estevadeordal's developed ordinal index for provisions under NAFTA. The paper furthermore suggests that the restrictiveness index captures the degree of protection of a specific good through the associated PSR category.[12] Harris (2007) defines restrictiveness as "[...] the extent to which non-originating inputs are precluded from use in the production of originating goods." (Harris, 2007, p.41) and states that this concept of restrictiveness is highly correlated with the effects of RoO on raising production costs of compliance.

A small stream of work looks at the effect of RoO on trade values mainly due to the lack of available data on preference utilisation rates, as it is the case in our work that takes a global view. Cadot and Ing (2016) investigate the trade-inhibiting effect of different categories of PSR in the Association of Southeast Asian Nations (ASEAN) Free Trade Area (AFTA) by using the variation of trade flows across country pairs and products. The authors' findings suggest that RoO nullify around a quarter of the effect of preference margins in ASEAN's trade. The paper documents the most trade-inhibiting effect of ASEAN's PSR for the Wholly Obtained (WO) rule, the Textile Rule and combinations of rules (COM). Augier et al. (2005) exploit a quasi-experiment through changes to Europe's regime-wide RoO in 1997 where the diagonal cumulation rule has been relaxed in its restrictiveness without changing the level

[10] Harris (2007) states in his paper's introduction that the indices are based "solely on inference and ad-hoc judgments".

[11] Suominen (2004) modifies this observation rule for PSRs that do not involve a change in tariff classification (Estevadeordal et al., 2007, for a summary) and Harris (2007) develops the ranking further by incorporating rules that allow for alternative choices, and Kelleher (2012) extends the index by Harris (2007) by including regime-wide rules of origin.

[12] "A more sophisticated interpretation of this result is the existence of a "substitution" post-liberalization effect. Once tariffs have been completely phased out, the origin requirements will still remain, thereby implying that the degree of "protection" attached to the rules will remain in place: products that are relatively more protected (slow liberalization, high initial tariffs) will still be subject to more restrictive rules.", page 16 in Estevadeordal (2000).

of preference margins. Using a difference-and-differences approach, the authors conclude based on their preferred control group that the regime-wide RoO reduced bilateral trade between 7.4 to 22.1 percent. Kelleher (2012) investigates the trade effect of an extended restrictiveness index across 15 preferential trade agreements and documents a negative effect of PSR restrictiveness on intra-PTA trade flows.

Our work is most closely related to Cadot and Ing (2016) and Kelleher (2012) both using trade flows as dependent variable to investigate the effect of PSR. Our empirical baseline specification is in the spirit of Cadot and Ing (2016), while our extended specification draws on the indirect effect of PSR as in Kelleher (2012) who uses an interaction term between a RoO index and preference margins. The author argues that this indirect effect shows that for strict RoO, firms do not avail of preference margins as the relative compliance costs of strict PSR offset the tariff reductions – he empirically documents this relationship in a sample split for primary goods and highly processed goods. In our approach, we attempt to capture differences in compliance costs of different types of PSR through differences in the trade elasticity of preference margins across PSR categories. In other words, we decompose the trade elasticity of preference margins by PSR category and argue that PSR types that are less costly (easier) to comply with will have a higher elasticity (thereby exploiting the tariff reductions) than PSRs that are more costly (more difficult) to comply with. Our work is also related to Carrère and de Melo (2015) in ranking the degree of restrictiveness of PSRs in terms of the different effect of compliance costs on trade or preference utilisation.

In contrast to the literature on *restrictiveness* indices of RoO, we refrain from assigning an ordinal index to each category of PSR, preferring to keep comparisons by broad groups of PSRs across the large sample of RTAs. For one reason, this approach allows us to empirically capture the trade effect of each PSR category separately and relating it to the role of compliance costs as a percentage of trade values, subsequently deriving our "own" definition of *restrictiveness* according to a ranking of the point estimates. For another reason, it allows us to carry out simulations of changes in PSRs.

2.3 Classification of product-specific rules of origin

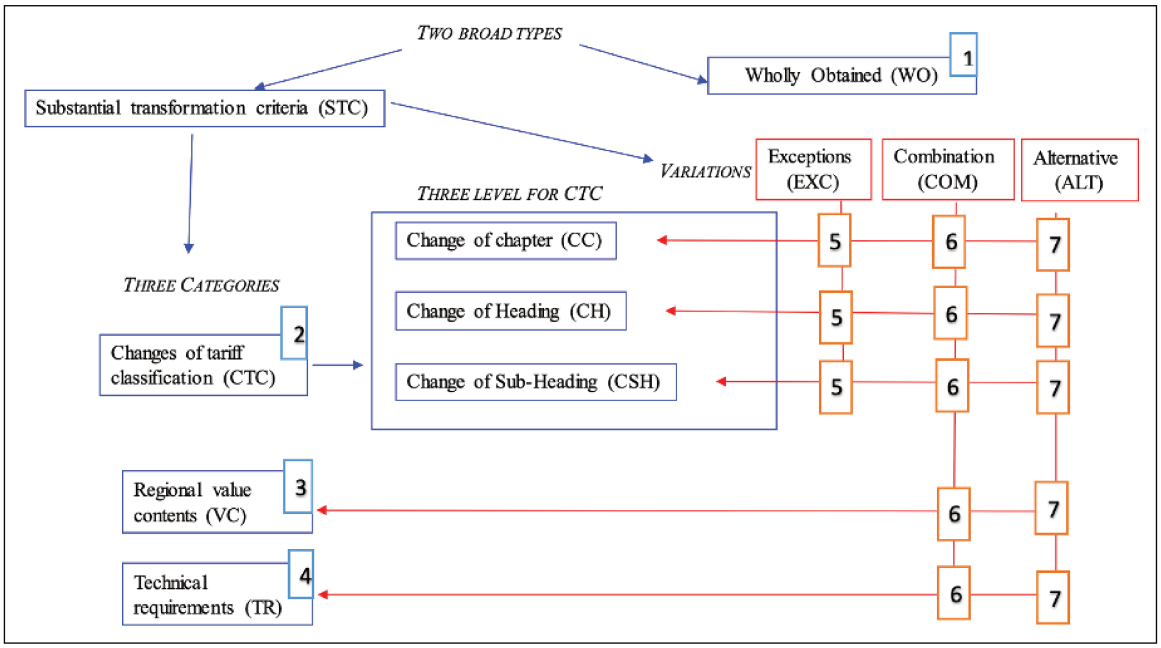
RoO are classified under two categories in the World Bank's Deep Trade Agreement (DTA) database (Angeli et al., 2020):[13] product-specific rules of origin (PSRs) and regime-wide rules (RWRs). RWRs cover general conditions for qualification under the preferential regime

[13]The data were obtained from an administered questionnaire. Appendix B.1 lists these questions (mostly YES/NO) and describes how the answers are translated into 17 mutually exclusive PSR categories in Appendix Table B.1.

and certification requirements. While both general conditions and certification requirements vary across RTAs, differences across RWRs are much less than for PSRs which are the focus of this paper. Furthermore PSRs, being defined at the HS6 level are non-overlapping at the product-RTA level whereas the RWRs are not unique at the HS-level.[14] Non-overlap is important since the objective of this paper is to use observed trade flows at the same HS6 level under different PSRs to estimate differences in compliance costs across PSRs.

Figure 2.1 illustrates the two types of criteria used to identify origin of a product and how these criteria are mapped into seven mutually exclusive PSR categories as subsequently described in table 2.1.

Figure 2.1 *Criteria and mapping of product-specific rules of origin*



Source: Authors based on Cadot and Ing (2016); Gourdon et al. (2021).

First, the Wholly Obtained (WO) criterion specifies that the country of origin of a product is the country where the commodity has been wholly produced (or grown, harvested or extracted for non-manufactured products). In this case, the origin requirement is met if a product or commodity does not use any foreign components or materials. Second, the Substantial Transformation criterion (STC) specifies that the country of origin is the country where the last substantial transformation took place, and this transformation must be sufficient to give its essential character to a commodity. "Substantial transformation" is

[14]Gourdon et al. (2021) discuss the frequency of RWR for 378 RTAs in the Rules of Origin Facilitator (ROF) database taking six RTAs (SADC, SAFTA, ASEAN, MERCOSUR, PEM, NAFTA) as examples of RTAs in the main families of RTA recognized by the World Customs Organization (WCO).

further identified by three additional criteria: Change of Tariff Classification (CTC), Value Content Requirement (VCR), or a Technical Requirement (TR).

According to the Change of Tariff Classification (CTC), a product can be considered to have achieved substantial transformation by undergoing a change in the HS tariff classification: the exported good must have a different tariff classification from any imported input to change a product into a different product category. Figure 2.1 shows that this category is further broken down by the level of aggregation at which the change in tariff classification must occur: at the Chapter (CC), Heading (CH), or Subheading (CS) levels.

Under the Value Content Requirement (VCR), the exported good must include a minimum percentage of the value of regionally (i.e among RTA members) produced inputs.

Under the Technical Requirement (TR), the exported good must have undergone specified manufacturing or processing operations, such as a chemical reaction, which are deemed to confer origin of the country in which they were carried out.

The ST criterion is further complemented by several composite rules (variations on the right-hand side of figure 2.1). First, the three STC categories are used in existing trade agreements as stand-alone or in combination with other criteria (COM), or as alternative criteria (ALT). Second, exceptions (EXC) can be attached to a particular CTC requirement, generally prohibiting the use of non-originating materials from a particular HS chapter, heading or subheading for goods supposed to qualify via CTC.

Table 2.1 lists the seven mutually exclusive categories we designed for our empirical analysis. These categories reflect decisions not to disaggregate CTC according to sub-levels (i.e. CC, CH, CS) as well as to group all types of combinations into one group (COM), all types of alternatives into one group (ALT) and all rules with an exception to CTC into one group (EXC). These 7 categories enter separately in the regressions reported in section 2.5.

Table 2.1 *Construction of seven groups of mutually exclusive PSR categories*

4 stand-alone rules:	**3 composite rules:**
[1] WO: Wholly obtained	[5] EXC: Any rule with a CTC and an exception
[2] CTC: Change in tariff classification	[6] COM: rules with combination (‘and’) criteria (without exception in CTC)
[3] VCR: Value content requirement	[7] ALT: rules with alternative (‘or’) criteria (without exception in CTC)
[4] TR: Technical requirement	

Notes: Numbering in parenthesis relates to the PSR in figure 2.1.

2.4 Data

This section describes the preparation of the final sample and provides descriptive statistics.

2.4.1 Data preparation

We use trade data at the level of origin country *(i)*, destination country *(j)*, HS6 product *(k)* and year *(t)* from CEPII's BACI database that is based on UN COMTRADE but reconciles direct and mirrored data. We take six steps to prepare the sample for the descriptive statistics and econometric estimates.[15] First, we exclude countries with export values below the 25^{th} percentile to remove small countries (e.g. small islands). Second, the sample excludes exporting countries that sold a certain product to a certain country (*ijk*-combinations) for less than six years within the sample period to omit occasional exports (Fontagné et al. (2015)). Third, we restrict the panel period to six 5-years intervals starting in 1990 to let trade flows enough time to adjust to changes in trade policies, as suggested by Anderson and Yotov (2016); Baier and Bergstrand (2007); Trefler (2004). Fourth, we exclude trade flows below 1,000 USD. These small flows make up only 0.003 percent of total sample trade value but represent 13.5 percent of total sampling observations. Fifth, we drop observations for which MFN tariffs are already zero prior to the implementation of the RTA. In these cases, preferences are void. Sixth, we exclude observations that are part of RTAs but without PSR, hence, without preferences. These products were excluded from negotiations about tariff concessions and account for around 5 percent of the sample. The final sample represents around 68 percent of global imports (excluding intra-EU trade) on average across years.

Applied MFN tariffs are from the the World Integrated Trade Solutions (WITS) database. In our empirical specification (section 2.5), we approximate the extent of tariff reductions by the difference between the MFN tariff and the preferential tariff (preference margins). Unfortunately, WITS does not report preferential tariffs for 63 percent of the tariff lines needed for the analysis.[16] We therefore decide to assume preferential tariffs of zero (full liberalisation) – an assumption also adopted in other studies.[17] Assuming full liberalisation means setting the preferential tariffs to zero $\left(tar_{jkt}^{PREF} = 0\right)$ so that tariff reductions measured by the preference margin equals the MFN tariff for all products part of RTAs:[18]

[15] For further information on the reduction steps see table B.2 in appendix B.2.

[16] See appendix B.2, figure B.1 for a distribution of preferential tariffs available in WITS.

[17] See for instance, Cadot and de Melo (2008); Cadot and Ing (2016).

[18] In turn, this means for our control group, that trade outside of an RTA is carried out under the MFN tariff so that no tariff reductions are possible and, as a consequence, the preference margin equals zero.

$$Preferential margin_{ijkt} = \frac{\left(1+tar_{jkt}^{MFN}\right)-\left(1+tar_{jkt}^{PREF}\right)}{\left(1+tar_{jkt}^{PREF}\right)} = tar_{jkt}^{MFN} - tar_{jkt}^{PREF} = tar_{jkt}^{MFN}$$

In our large sample, the assumption of full liberalisation will, in some instances at least, result in an over-estimate of the preferential margin because the reduction of preferential tariffs is over a phase-out period, ranging between immediate elimination up to generally 10 years (Estevadeordal, 2000). However, Espitia et al. (2020) report that only 3.2 percent of global imports (including both MFN and preferential) in 2016 are subject to preferential tariffs above zero and below the MFN tariff.[19] As a result, in some cases, our approach will overestimate actual preference margins.

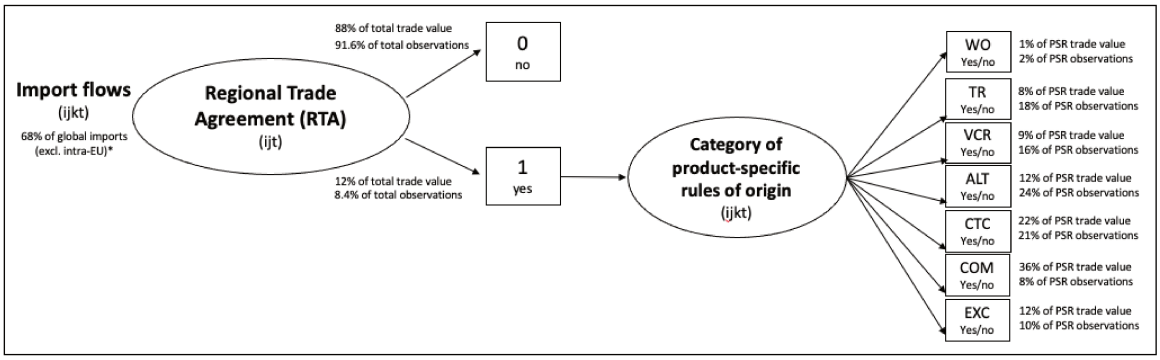
2.4.2 Descriptive statistics

Our final dataset covers around 15 million observations over 181 exporters *(i)*,135 importers *(j)*, 5,018 HS6 products *(k)*, and six 5-years intervals *(t)* starting in 1990. Figure 2.2 describes the structure of the final dataset. The data covers import flows which either are outside of an RTA and trade under MFN tariff as they have no option to obtain a preferential tariff (on average 88 percent of total trade value and 91.6 percent of total observations), or are part of an RTA and therefore can obtain a preferential tariff (on average 12 percent of total trade value and 8.4 percent of total observations) conditional on fulfilling the origin requirement stipulated for the product.

Under a given RTA between a pair of *ij*-countries, each bilateral trade flow falls under one of the seven PSR categories (i.e. WO, TR, VCR, ALT, CTC, COM, EXC). Within the same RTA, different HS6 products will typically have PSRs in different categories. For example, for all countries that have signed the CAFTA-DR agreement, trade under HS6 product 8207.19 (rock drilling or earth boring tools) falls under the PSR category CTC which needs to be fulfilled to obtain a preferential tariff (if not fulfilled the firm exports under MFN tariff). HS6 product 854419 (insulated electric conductors) was allocated a PSR category COM. These PSR categories do not change over time once the RTA has been signed.

[19]The authors report in their study national tariff line level data for 2016 covering 97 percent of world trade at the HS6 level. For further information about the distribution of preferential tariffs in the authors' study, see appendix B.2, figure **??**.

Figure 2.2 *Final data structure*



Notes: In *ijkt*, *i* stands for exporter, *j* importer, *k* HS6-product, *t* panel year. ∗indicates the average across all sample years. PSR categories: WO = wholly obtained; TR = technical requirement; VCR = value content requirement; ALT = alternative ('or'); CTC = change in tariff classification; COM = combination ('and'); EXC = exception.
Source: Authors.

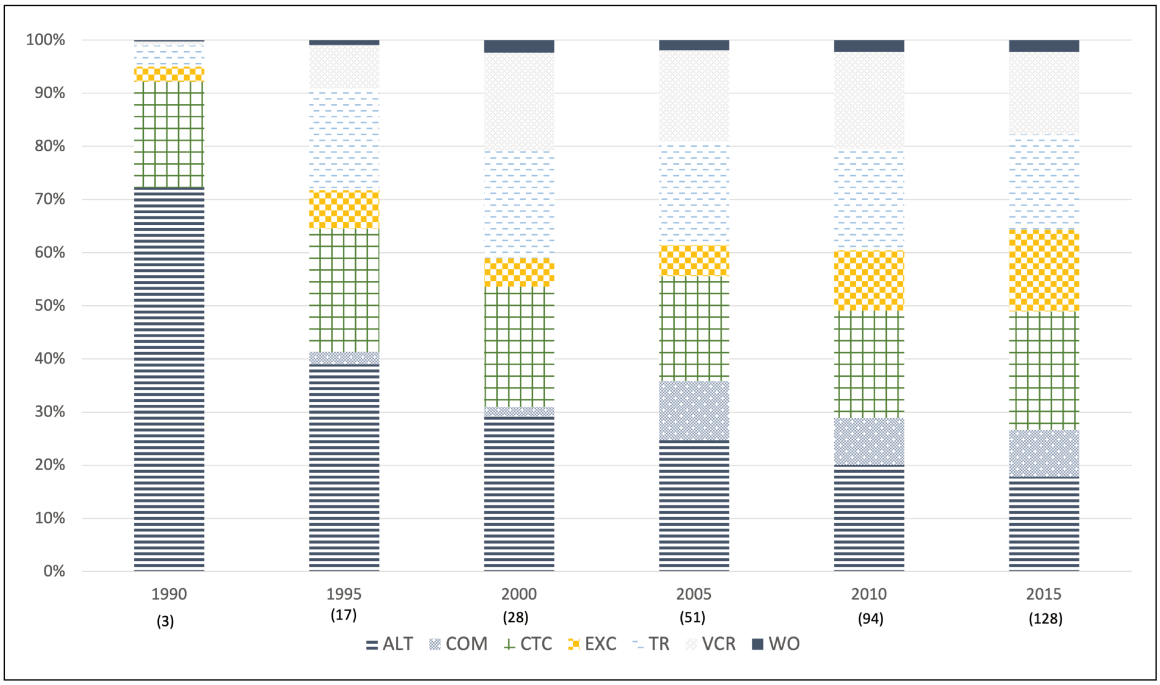
For the PSR sample, the lowest share of trade value (1 percent) and observations (2 percent) are reported for the WO requirement (percentages indicated on the right-hand side in figure 2.2). TR, VCR, ALT and EXC have relatively low shares in observations compared to their shares in trade value suggesting that these rules mostly apply to low-value products. The contrary is found for the COM category which reports 36 percent of trade value but only 8 percent of observations, suggesting that this rule is mainly applied to high-value goods.

Figure 2.3 shows the growth in the number of RTAs over the panel in each of the six periods with the changing composition of categories of PSRs. Focusing on the period 1995-2015 with a significant number of RTAs, the following shifts in the distribution on PSRs are observed: (i) the share of flexible rules (ALT) diminished by one half; (ii) the share of value content requirements (VCR) doubled; (iii) the share of technical requirements (TR) and exceptions (EXC) fell; (iv) the share of wholly obtained (WO) remained constant. Overall, except for WO which is by far the least used PSR, the distribution of PSRs is fairly evenly distributed around the other categories. Prima facie, these observations over the period 1995-2015 suggest two opposite trends since (i) is an indication of a shift towards more restrictive rules while (iii) suggests a shift towards less restrictive rules.[20]

In our sample, a percentage value is reported for about 60 percent of PSRs with a VCR. About a quarter of VCRs with available values require a VCR of 40 percent with the rest being about equally distributed below and above this value.

[20]The share of trade value across PSR categories is shown in Appendix table B.2.

Figure 2.3 *Frequency distribution of PSR categories over the sample period*



Notes: Number of RTAs in parenthesis below year.
Source: Authors.

Figure 2.4 shows the distributions of preference margins for all seven PSR categories,[21] highlighting that PSRs are fairly evenly distributed across preferential margins over the entire sample. Interestingly, a larger share is present for the WO category at higher preferential margins, this means above 20 percent, compared to all other PSR categories. The distribution of widely spread observations (outliers) are concentrated in the VCR and TR categories. The largest share of observations is located between preference margins above 5 percent and below or equal to 20 percent.[22]

The distribution of observations of PSRs across HS2 sections shows that the WO rule is mainly concentrated in *Vegetables* (50 percent of all observations of WO) and *Animal products* (around 27 percent), followed by the *Food* sector (around 18 percent). The estimates of the WO rule will therefore mainly be driven by observations within these three sectors. The CTC rule is mostly present in *Metals* (around 22 percent), *Chemicals* (10 percent) and *Wood products* (9 percent). Interestingly, most of the VCR, TR, ALT and COM rules are present

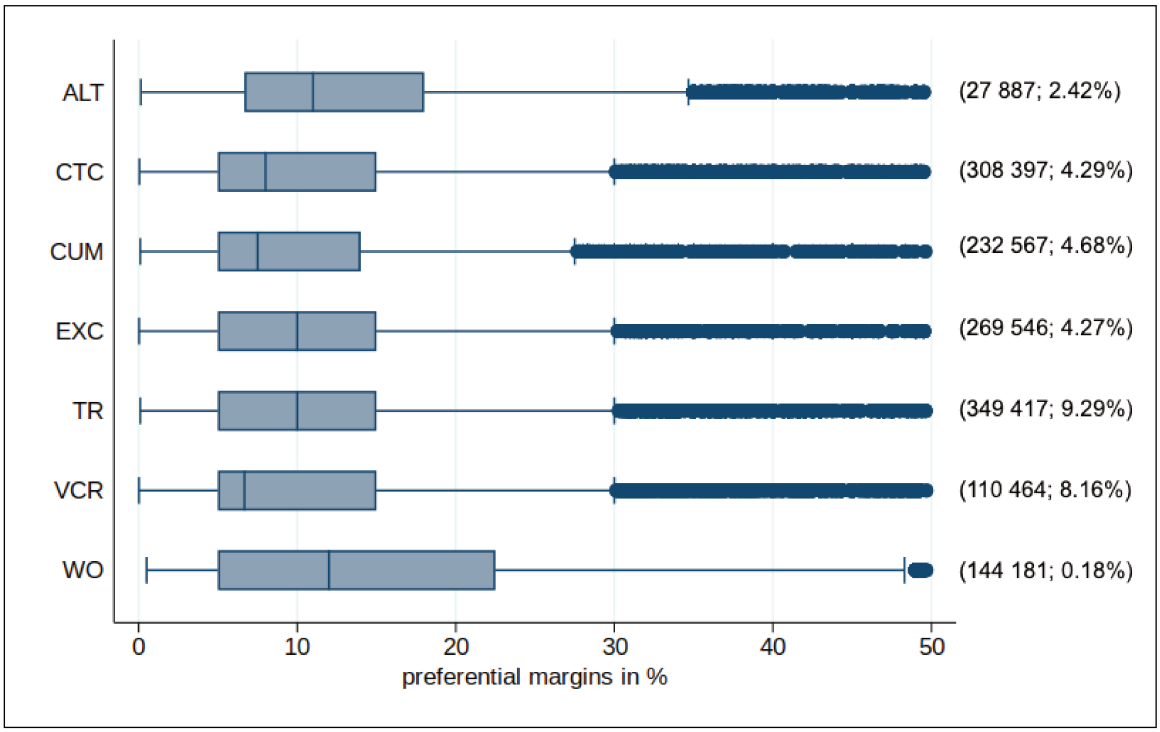
[21] Due to lack of available data, preferential margins are calculated from preferential tariffs from WITS under the assumption of full tariff liberalisation.

[22] In appendix B.3, figures B.3 and B.4 display the frequency distributions of PSR categories across seven bins of preferential margins for respectively 1995 and 2015 and shows a stable right skewed distribution over the sample.

particularly in the Textiles and Machinery/electrical sectors. The EXC rule is concentrated in the Textiles (around 34 percent) and Metals (13 percent) sectors.[23]

Animal products or *Vegetables* feature a similar distribution of PSR categories, with WO rules (23 percent of all sector observations for Animal products, 17 percent for Vegetables), CTC (20 percent, 23 percent) and TR (15 percent, 12 percent) rules. The sectors on *Food*, *Mineral products* or *Chemicals* predominantly feature CTC or TR rules, while the *Machinery/electrical* and *Transportation* sectors have each the highest number of sector observations under the VCR rule. Overall, the CTC and ALT rules are the most prominent rules in a large number of sectors.[24]

Figure 2.4 *Whisker plots of preferential margins (in %) by PSR category*



Notes: Numbers in parenthesis indicate the number of observations and percentages of total observations classified as outliers. Preferential margins above 50 percent are excluded from the figure (amounting to 1.2 percent of observations in the treatment group). Each whisker plot shows the distribution of preferential margins in the range of the 25^{th} and 75^{th} percentiles. The black line in each plot indicates the median of the preferential margins. The lines extending from the plots are respectively the upper and lower adjacent values located above the percentiles. The dots outside of the lines are outliers.
Source: Authors.

[23] Appendix B.3 provides the distribution of PSR categories across HS2 sections in table B.5.
[24] Appendix B.3 provides the distribution of PSR categories by HS2 sections in table B.4.

2.5 Econometric analysis

This section describes our empirical specification and presents the results of the estimated effect of different categories of product-specific rules of origin (PSR) on the intensity of bilateral trade by controlling for tariff preference margins.

Empirical specification

Our sample consists of bilateral imports from origin *i* to destination *j* of HS6 product *k* in panel year *t* where *ijkt*-combinations are either not part of an RTA and hence are assumed to trade under MFN-tariffs (control group), or are part of an RTA between countries *ij* in year *t* (treatment group) (see data structure in figure 2.2).

To estimate the trade effect of product-specific rules of origin (PSR) attached to tariff preference margins, we base our empirical strategy on the theoretical gravity structure derived from the demand-side by Anderson and van Wincoop (2003) (see appendix B.4).[25]

Baseline specification: We start by estimating the following baseline specification in the spirit of Cadot and Ing (2016) but in a panel data setting:[26]

$$X_{ijkt} = exp[\beta_0 + \beta_1 ln\,(1 + tar_{jkt}^{MFN}) + \beta_2 I_{ijt}^{RTA} + \beta_3 \left(I_{ijt}^{RTA} \times ln\,(1 + tar_{jkt}^{MFN})\right) + \sigma_{ijs} + \eta_{it} + \theta_{jt}] + \epsilon_{ijkt} \quad (2.1)$$

where $i = 1, \ldots, 135$; $j = 1, \ldots, 181$; $k = 1, \ldots, 5018$; $t = 1990(5)2015$.

X_{ijkt} is the trade value of HS6 product *k*, between origin *i* and destination *j* in panel year *t*. Coefficient (β_0) is the constant measuring the average trade value of the control group. $ln\,(1 + tar_{jkt}^{MFN})$ is the logarithm of the applied MFN tariff ($ln(1 + \frac{MFN_{jkt}}{100})$) on product *k* defined by the destination country for all origin countries (Most-Favoured Nation rule). Corresponding coefficient (β_1) measures the tariff elasticity and captures the response of bilateral trade flows to a percentage change in MFN tariff.

The dummy variable

[25] As discussed in Cadot et al. (2014a), Novy (2013) shows that the gravity equation originates from three families of micro-founded trade models: Demand side with love of variety (Anderson and van Wincoop, 2003); supply side where productivities (Eaton and Kortum, 2002) or firms ((Chaney, 2008; Melitz and Ottaviano, 2008) are drawn from a distribution. See also the discussion in Yotov (2022) on the different theories leading to the gravity model of trade.

[26] See also Anderson and Yotov (2016) exploiting time-variation within the same ijk-combination to detect the trade effect of FTA membership, and Olivero and Yotov (2012) for gravity estimations using panel datasets.

$$I_{ijt}^{RTA} = \begin{cases} 1 & \text{if i and j are members of the same RTA in year t} \\ 0 & \text{otherwise} \end{cases}$$

indicates whether *i* and *j* belong to the same RTA, so that coefficient (β_2) measures the average change in trade following the entry into force of an RTA (treatment group) relative to the change in trade experienced by countries outside of an RTA (control group of non-agreement countries).

$I_{ijt}^{RTA} \times ln\,(1 + tar_{jkt}^{MFN})$ is an interaction term between RTA membership and the MFN tariff. The corresponding coefficient, (β_3), therefore captures the trade effect of a change in tariff-preference margins in an RTA $\left(I_{ijt}^{RTA} \times ln(1 + tar_{jkt}^{MFN})\right)$. As discussed in section 2.4, we set the preferential tariff to zero so that tariff reductions measured by the preference margin are approximated by the MFN tariff.

A set of fixed effects controls for omitted confounding factors: σ_{ijs} represent bilateral country-product fixed effects (ijs-level) to exploit variation in trade flows within combinations of the same origin-destination-HS section (HS2-product level) across time.[27] These fixed effects also account for endogeneity concerns due to reverse causality since signing an RTA and thereby offering preferential tariffs seems more likely with economies that are already a significant trading partner with the liberalizing economy (Baier and Bergstrand, 2007). These controls, furthermore, will absorb all bilateral time-invariant trade cost determinants, such as bilateral distance. Bilateral fixed-effects *(ij)* are shown to capture bilateral trade costs much better than an approximation by a set of bilateral gravity variables traditionally selected in empirical work (Agnosteva et al., 2019; Egger and Nigai, 2015). According to Egger and Nigai (2015), by using a set of traditional gravity variables the estimation bias arises from country-specific structural parameters that depend in a non-linear way on all trade costs which are only partly measured by the chosen parameters. Residual trade costs, that are not captured by the parameters, are included in the error term which is then correlated with the parameters – a correlation that would bias the results (Egger and Nigai, 2015).

Non-observable outward and inward Multilateral Resistance (MLR) terms in our panel dataset are captured by η_{it} and θ_{jt} (Anderson and van Wincoop, 2003; Baldwin and Taglioni,

[27] Ideally, we would exploit variation in bilateral trade flows of a specific good at a given time (*ijkt*) that is once traded without the possibility of obtaining a preferential tariff and that is once traded with the option of benefiting from a preferential tariff when the origin requirement attached to a PSR was fulfilled. Then, we would be able to observe which of these conditions lead to higher trade intensity. However, the data at hand does not allow exploiting such an experiment because trade data at the *ijkt*-level are too aggregated to distinguish between these conditions through, for instance, preference utilization rates.

2006; Olivero and Yotov, 2012).[28] As these fixed-effects capture any time-varying origin-time and destination-time specific characteristics, they also absorb the size terms $Y_{i,t}$ and $E_{j,t}$ in the gravity equation. ϵ_{ijkt} is the error term clustered at the treatment level, ijs, (Huntington-Klein, 2021).

Extension to heterogeneous effects of PSRs: In a second step, we decompose the effect of the stand-alone RTA membership dummy into the effect of each of the seven PSR categories as in specification 2.2.

$$X_{ijkt} = exp[\beta_0 + \beta_1 ln\,(1 + tar_{jkt}^{MFN}) + \beta_3 \left(I_{ijt}^{RTA} \times ln\,(1 + tar_{jkt}^{MFN})\right) + \sum_{l=1}^{7} \beta_{4l} r_{ijkl} + \sigma_{ijs} + \eta_{it} + \theta_{jt}] + \epsilon_{ijkt} \quad (2.2)$$

$$r_{ijkl} = \begin{cases} 1 & \text{if rule } l \text{ applies to product } k \text{ in the agreement between } i \text{ and } j \\ 0 & \text{otherwise} \end{cases}$$

where *l* is a set of dummies for each of the seven PSRs (ALT, CTC, WO etc.) that apply to a specific HS6 product *k* in an RTA between *i* and *j*. Coefficients β_{4l} capture the effects of the presence of different categories of PSRs on trade flows. To identify all seven categories of PSRs in the estimations individually, we drop in this specification the stand-alone dummy on RTA membership ($\beta_2 I_{ijt}^{RTA}$).

Extension to heterogeneous trade elasticity of preference margins by PSRs: In a last step, we decompose the effect of preference margins by PSR category to capture differences in variable compliance costs. The lower the compliance costs of a specific PSR category, the stronger should be the positive trade effect of an increase in preference margins. We estimate the following empirical specification:

$$X_{ijkt} = exp[\beta_0 + \beta_1 ln\,(1 + tar_{jkt}^{MFN}) + \sum_{l=1}^{7} \beta_{4l} r_{ijkl} + \sum_{l=1}^{7} \beta_{5l} r_{ijkl} \times ln\,(1 + tar_{jkt}^{MFN}) + \sigma_{ijs} + \eta_{it} + \theta_{jt}] + \epsilon_{ijkt} \quad (2.3)$$

[28] Note that setting the MLR fixed effects at the product-level (*jkt*, *ikt*), as in Anderson and Yotov (2016); Larch and Wanner (2017), would absorb the explanatory variable of interest, MFN tariff, which is also defined at the *jkt*-level.

We add the coefficient β_{5l} which represents an interaction term between the set of the seven PSR dummies and the tariff preference margins (which equal the MFN tariff, see section 2.4) to estimate the heterogeneous trade effect of preference margins by PSR category. To identify the trade elasticity of the preference margin for all seven PSR categories individually, we drop the explanatory variable on β_3 (which would otherwise be the reference category of the interaction term).

All estimates are over 5-year intervals starting in 1990. This gives trade flows enough time to fully adjust to the implementation of RTAs (Anderson and Yotov, 2016; Baier and Bergstrand, 2007; Heid et al., 2017; Trefler, 2004).

We use the Poisson Pseudo Maximum Likelihood (PPML) estimator to account for heteroscedasticity of trade data (Silva and Tenreyro, 2006). The trade literature proposes to include unrealized trade between countries in a specific year to exploit information revealed in zero trade flows (Silva and Tenreyro, 2006; Yotov et al., 2016). However, the universe of zero trade flows is very large in this sample[29] so that we face significant computational challenges. We do not believe that this constraint will affect our research goal as we are primarily interested in the trade effect of PSRs on the value of exports, this means the intensive margin, rather than the probability of exporting, hence the extensive margin. We therefore maintain our unbalanced panel of non-zero trade flows and apply the PPML estimator.

Furthermore, due to data limitations we are not able to include intra-national trade flows as suggested in Bergstrand et al. (2015),[30] so that our estimates tend to be upward biased. By omitting intranational trade, we do not account "for any possibly declining trends in unobservable bilateral fixed and variable trade costs that may have increased international relative to intranational trade" (Bergstrand et al., 2015).

Estimation results

Table 2.2 reports the estimation results. Column 1 explores the effect of membership in an RTA relative to all other trade flows under MFN. The coefficient estimate (β_2) is insignificant indicating that RTA membership alone does not result in a significant increase in bilateral trade flows. The trade elasticity to a change in MFN tariffs in the control group is negative and significant, $(\beta_1 = -2.216)$, implying that a 1% increase in MFN tariff is associated with a significant decline in bilateral trade value of around 2.2%. Importantly, for RTA members, an increase in tariffs is an increase in the tariff preference margin and has a positive effect $(\beta_3 = +1.457)$ since products under an RTA are on average less affected by changes in MFN

[29] A total of 735 688 980 observations for a rectangular panel of 135 importers $\times$ 181 exporters $\times$ 5 018 goods $\times$ 6 years.

[30] Intranational trade data, that is currently available, covers 170 industries (Borchert et al., 2021) which is too aggregated to match our HS6-categories.

tariffs due to the option to export under preferential tariffs (conditional on the PSR). The results suggest that the effect of preferential treatment of RTAs is primarily realised through tariff concessions captured in the preference margin (β_3), while other RTA particular benefits, such as simplified customs procedures, captured in the RTA dummy are insignificant.

Column 2 decomposes the RTA dummy into the seven PSR categories. The coefficient on the preference margin remains positive with $\beta_3 = 1.396$ compared to column 1. To identify all seven categories of PSRs in the estimation, we drop in column 2 the stand-alone dummy on RTA membership ($\beta_2 I_{ijt}^{RTA}$), see specification 2.2. Trade flows are significantly smaller under the large group of trade flows with a change of tariff classification (CTC) compared to trade flows under MFN tariff (control group). All other categories are insignificant.

Column 3 decomposes the effect of changes in the preferential margin on bilateral trade flows across the PSR categories by interacting changes in the preferential margin with each of the seven PSR categories, (β_{5l}). An increase in the MFN tariff significantly reduces bilateral trade for the control group with an elasticity of ($\beta_1 = -2.21$) which remains stable across specifications. Importantly, within the RTA sample, the estimates are heterogeneous, suggesting that a change in preference margin by 1% leads to a change in trade significantly different across the 7 categories. The positive response is strongest under the ALT rule (2.934) followed by WO, TR, CTC and COM while EXC and VCR are insignificant. In other words, the effect of changes in preference margins under the ALT category is significantly stronger than under the WO category. However, the control group may include trade flows under non-reciprocal RTAs also subject to PSRs – whose information is not included in the dataset. In column 4, we therefore exclude bilateral trade flows of partner countries that are part of a non-reciprocal RTA. The point estimates of the coefficients on the MFN tariff (β_1) and the trade elasticity of the preference margins by PSR category (β_{4l}) are slightly stronger in magnitude. These elasticities with associated 5% confidence intervals are reported in figure 2.5. The pattern remains where the trade elasticity of preference margins is stronger for PSRs with choice (ALT) while PSRs requiring meeting several criteria (COM) have the lowest effect, and the EXC and VCR rules are statistically insignificant. Overall, the positive trade effect of tariff concessions of goods in RTAs is particularly strong for products under the ALT category.

Table 2.2 *Results: full sample*

	(1)	(2)	(3)	(4)
Dependent variable X_{ijkt}	All	All	All	w/o unilateral PTAs
β_1 : MFN tariff (log)	-2.216***	-2.216***	-2.214***	-2.326***
	(0.299)	(0.299)	(0.299)	(0.314)
β_2 : if RTA=1	-0.073			
	(0.068)			
β_3 : RTA * MFN tariff (log)	1.457***	1.396***		
	(0.340)	(0.338)		
ALT dummy		-0.088	-0.185	-0.195*
		(0.112)	(0.129)	(0.116)
CTC dummy		-0.390***	-0.404***	-0.411***
		(0.118)	(0.137)	(0.146)
CUM dummy		0.180	0.207	0.188
		(0.258)	(0.265)	(0.262)
EXC dummy		-0.207	-0.193	-0.212
		(0.185)	(0.232)	(0.239)
TR dummy		0.088	0.049	0.033
		(0.128)	(0.139)	(0.140)
VCR dummy		0.291	0.420	0.364
		(0.267)	(0.319)	(0.321)
WO dummy		0.187	0.116	0.003
		(0.296)	(0.325)	(0.264)
ALT dummy * MFN tariff (log)			2.394***	2.438***
			(0.876)	(0.895)
CTC dummy * MFN tariff (log)			1.584***	1.747***
			(0.601)	(0.590)
COM dummy * MFN tariff (log)			0.963*	1.080*
			(0.556)	(0.570)
EXC dummy * MFN tariff (log)			1.199	1.371
			(0.924)	(0.920)
TR dummy * MFN tariff (log)			1.804***	1.986***
			(0.526)	(0.534)
VCR dummy * MFN tariff (log)			-0.068	0.162
			(1.245)	(1.227)
WO dummy * MFN tariff (log)			1.905***	2.071***
			(0.361)	(0.352)
Constant	9.697***	9.692***	9.692***	9.714***
	(0.018)	(0.019)	(0.019)	(0.020)
Fixed-effects:	it, jt, ijs	it, jt, ijs	it, jt, ijs	it, jt, ijs
No. of observations	15,086,003	15,086,003	15,086,003	14,590,914
Pseudo R^2	0.551	0.551	0.551	0.557

Notes: PPML estimates. Standard errors, in parentheses, are clustered at the treatment level (ijs, origin-destination-HS2 product), (Huntington-Klein, 2021).

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

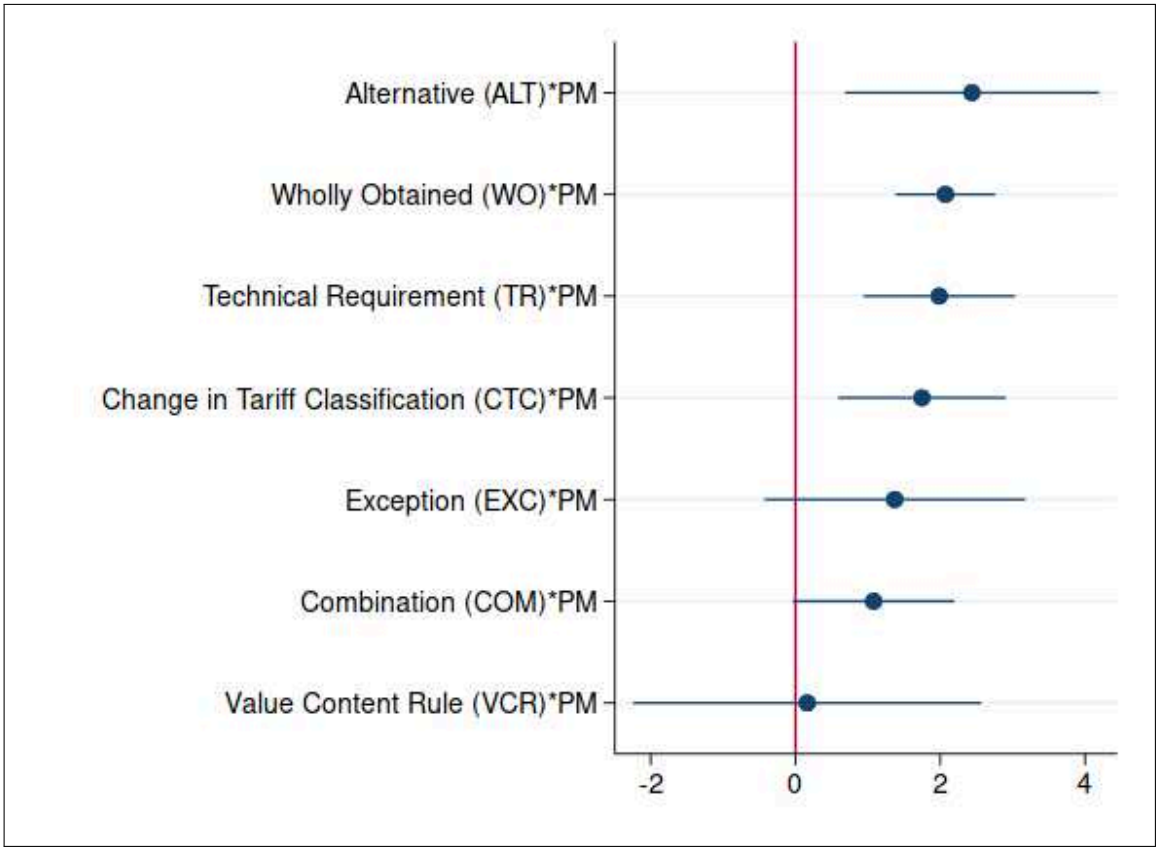
Column 1 examines the effects of MFN tariffs on bilateral trade flows in the RTA group relative to all other trade flows under MFN.

Column 2 decomposes the effect of an RTA (beyond the preference margin) into the effects across PSR categories.

Column 3 decomposes the effect of the preference margin by PSR category through interactions between PSR dummy * MFN tariff (log) to capture variable compliance costs across PSRs.

Column 4 is based on a sample excluding trade flows of partner countries that are part of unilateral PTAs and replicates the specification of column 3.

Figure 2.5 *PSR responses to an increase in preferential margin*



Notes: The figure reports the coefficients with confidence interval at the 95%-level on the interaction term β_{4l} in table 2.2, column 4. Note that those coefficients crossing the red line (EXC, VCR) are not significantly different from the effect of the control group to a change in MFN tariff. The control group in the full sample are trade flows under MFN (excluding trade flows of partner countries with non-reciprocal RTAs).
Source: Authors.

To sum up, the results in table 2.2 suggest that flexible PSRs where exporters have a choice among PSRs respond more strongly to an increase in the preference margin than all other (less flexible) PSR categories. This suggests that variable compliance costs (in % of trade value) are significantly lower for the ALT category than for all other PSR categories.[31] PSR categories with a low trade elasticity of preference margins would be stricter as the costs of complying offset the tariff reductions reflected in the preference margin.

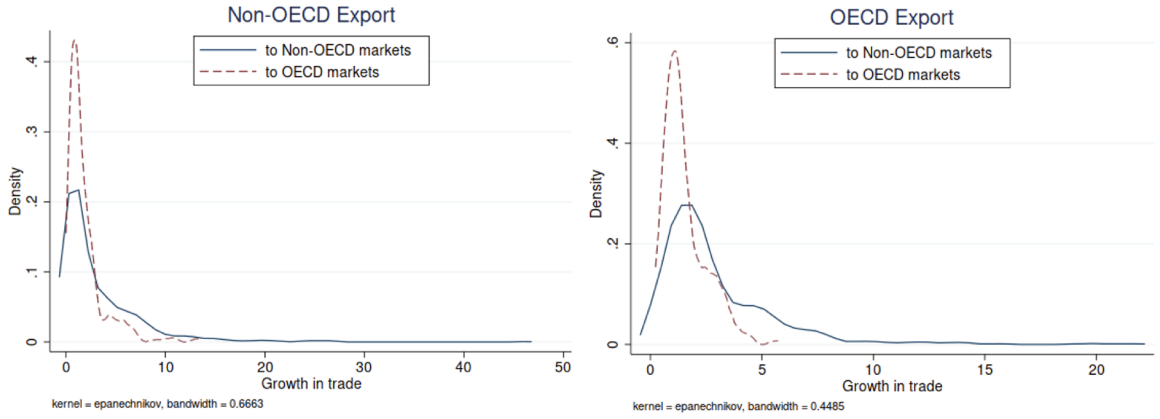
[31] Medalla and Balboa (2009) argue in line with our findings, notably that the alternative rule where an export can choose among different rules would be the most liberal RoO, while the most restrictive rule would be one that stipulates a combination of several rules to comply with.

2.6 Simulation of trade effects from moving to a flexible PSR category

To quantify the trade effect of simplifying PSRs, we use our preferred estimates from table 2.2, column 4, of the full sample excluding from the control group all partner countries that are part of a non-reciprocal trade agreement. We simulate a scenario in which observations with *restrictive* PSR categories, namely EXC, COM, TR, WO, CTC and VCR, adopt the alternative rule, ALT, one of the most *flexible* PSR rules. This amounts to replacing in equation 2.1 for the full sample the estimated coefficient values for each of the restrictive PSR for observation *ijkt* with the corresponding ALT coefficient, keeping the original preferential margin attached to each *ijkt*-combination (Appendix B.5 provides details of the simulation).

Adopting the more flexible ALT rule in the analysed RTAs would increase bilateral trade under RTA on average by 2.7% during the sample period. Figure 2.6 plots the densities of simulated trade growth separately for OECD and non-OECD exports for all pairs of countries under RTAs when adopting the ALT rule across the board. Both densities are right-skewed. The average effect on the intensive margin of trade is highest for non-OECD exports to non-OECD countries (increase in trade by 3%) and OECD exports to non-OECD countries (2.9%), followed by non-OECD exports to OECD countries (1.86%) and OECD exports to OECD countries (1.5%). The simulation results suggest that the trade effect is generally stronger for accessing to non-OECD markets, where preferential margins are higher on average due to higher MFN tariffs.[32]

Figure 2.6 Density of simulated trade growth under RTA (based on full sample), average pair-year



Source: Authors.

[32]Summary statistics across country groups during the sample period show average MFN tariffs for OECD partners of 5.6%, for non-OECD partners of 12.5%, for OECD to non-OECD partners of 10.9% and for non-OECD to OECD partners of 6.1% (Appendix table B.6).

2.7 Conclusion

Rules of origin are necessary provisions in preferential trade agreements to ensure that a product fulfils origin requirements to benefit from preferential treatment and to avoid trade deflection. Yet, the existing literature emphasizes the non-negligible compliance costs associated with product-specific rules of origin (PSRs). Empirical evidence points towards adverse effects of these rules on bilateral trade and calls for simplification.

This paper systematically explores the effect of PSRs on the intensity of bilateral trade across 128 regional trade agreements and investigates heterogeneity across seven mutually-exclusive categories of PSRs. The work exploits the World Bank's Deep Trade Agreement database (DTA) covering information on rules of origin at the HS6-level over the period 1990 to 2015. To our knowledge, this is the first documented evidence of trade effects of different categories of PSRs across the quasi-full range of worldwide RTAs.

The empirical results are based on a structural gravity model. Controlling for the level of preferential margins, our results show that rules allowing to choose between alternatives have the strongest positive impact on trade value while stricter rules imposing combinations of different rules have the lowest effect. These results are relevant in the context of trade policy negotiations. In defining PSRs in RTAs, policy makers may want to consider moving from strict PSR categories, thus from those associated with higher variable compliance costs, towards more flexible ones. Our simulation of a radical simplification reform that leads to the adoption of alternatives of rules shows an increase in global trade under RTA by 2.7 percent on average during the sample period.

Future work can extent our work in several ways. First, due to data constraints on preference utilization rates of PSRs, this work draws on trade data from CEPI's BACI. However, once data becomes available, it would be interesting to investigate the effect of these seven mutually-exclusive PSR categories on the utilization of preferences. Second, an extension of this work could incorporate the effect of PSRs in non-reciprocal trade agreements, such as the Everything-But-Arms (EBA) agreement, to investigate whether the trade effect differs from PSRs in reciprocal agreements. Third, should a comprehensive database on preferential tariffs become available, future work could derive more precisely tariff reductions attached to PSRs as approximated by preferential margins. Since phase-out periods certainly play an important role in the extent of preferential tariffs as well as the evolution of MFN tariffs, preferential margins would capture such dynamics to a better extent. Fourth, a future avenue for our work could be an analysis of the heterogeneous trade effect of regime-wide rules of origin (RWR) and to what extent these different RWR influence compliance costs of PSR.

B Appendix

B.1 Categorizing PSR

Below is the questionnaire used to categorize the PSRs described in Angeli et al. (2020). The square-bracketed terms below refer to the corresponding variables in the Angeli et al. (2020) dataset available in the WB Deep Trade agreement database. Examples are listed in boxes.

Does the agreement contain product-specific Rules of Origin? [SR psr]
The WTO Rules of Origin Agreement and the WCO Kyoto Convention[1] recognise two basic criteria for determining origin: wholly obtained and substantial transformation, classification of which is discussed in the following.

I. Wholly obtained:
The wholly obtained (WO) criterion specifies that the country of origin of a product is the country where the commodity has been wholly produced (or grown, harvested or extracted for non-manufactured products). In this case, the origin requirement is met if a product or commodity does not use any foreign components or materials.
Is the product's origin defined as wholly obtained? [SR who]

[1] The International Convention on the Simplification and Harmonization of Customs Procedures.

Example from EFTA-Central America (2014), Annex I on Rules or Origin and Methods of Administrative Cooperation, Article 2: Origin Criteria:
For the purposes of this Agreement, a product shall be considered as originating in a Party if:

a) it has been wholly obtained in a Party, in accordance with Article 3 (Wholly Obtained Products);

b) the non-originating materials used in the working or processing of that product have undergone sufficient working or processing in a Party, in accordance with Article 4; or

c) it has been produced in a Party exclusively from materials originating in one or more Parties.

II. Substantial transformation:

The substantial transformation criterion specifies that the country of origin is the country where the last substantial transformation took place, and this transformation must be sufficient to give its essential character to a commodity.

Is the product's origin defined through substantial transformation criteria? [SR stc]

Example from Russian Federation-Serbia (2006), Article 4(1): Criterion of sufficient processing (treatment): Product is considered to be subjected to sufficient processing or treatment in one of the States Parties, if such a product is processed or treated and the value of used in this process materials (raw materials, semi-finished and finished goods), originating from other countries (other than States Parties), or the value of materials of unknown origin does not exceed 50 percent of exported goods' value.

Furthermore, three distinct sets of criteria are used to express "substantial transformation":

1. Change of tariff classification (which can be at the Chapter (CC), Heading(CH), or Subheading level(CS));
2. Value Content Requirement (VC). Note that different methodologies are used to compute the threshold, depending on whether the focus is on the originating or the non-originating materials;
3. Technical Requirement (TR) such as a chemical reaction.

According to the value content (VC) criterion, the exported good must reach a threshold percentage value of produced inputs either locally or among RTA members.

Is the product's origin defined through a value content requirement? [SR vcr]

Example from South Asian Free Trade Agreement (2012), Product Specific Rules Under SAFTA Rules of Origin, Explanatory Notes(4): The Domestic Value Added (DVA) in percentage shall mean the minimum value addition in the Exporting Contracting State, calculated as per the following formula: DVA equals (FOB value of the export product less the value of non originating materials) $\times$ 100 FOB value of the art. product.

For the VC entry, one additional sub-entry is distinguished, with respect to the reference values:

Illustration of VC thresholds from the Transpacific Partnership (2019), I Annex 3-D (Product-Specific Rules of Origin) 87.07: No change in tariff classification required for a good of heading 87.07, provided there is a regional value content of not less than:

a) 35 per cent under the build-up method; or

b) 35 per cent under the net cost method; or

c) 45 per cent under the build-down method.

Alternatively to the VC criterion, a product can be considered to have undergone substantial transformation by undergoing a change in tariff classification (CTC): the exported good must have a different tariff classification from any imported inputs to change a product into a different product category. The CTC rule is based on the harmonized system (HS), and the change can be specified at either the chapter level (HS2, with 99 categories), the heading level (HS4, with over 1,000 categories) or sub-heading (HS6, with over 5,000 categories).

Is the product's origin defined through a change in tariff classification? [SR ctc]

This category can be further broken down by the level of aggregation at which the change in tariff classification must occur:

Is the product's origin defined through a change in chapter? [SR cc]

Example on the Transpacific Partnership (2019), Annex 3-D (Product-Specific Rules of Origin) 05.01 - 05.11: A change to a good of heading 05.01 through 05.11 from any other chapter.

Is the product's origin defined through a change in heading? [SR ch]

Example from the Transpacific Partnership (2019), Annex 3-D (Product-Specific Rules of Origin) 1208.90: A change to any other good of subheading 1208.90 from any other heading.

Is the product's origin defined through a change in subheading? [SR cs]

Example from the Transpacific Partnership (2019), Annex 3-D (Product-Specific Rules of Origin) 0801.32: A change to a good of subheading 0801.32 from any other subheading.

The distribution of CTCs across the three categories retained in the sample is : CH=71%; CC=15%; CS=14%.

In the technical requirement (TR) criterion, the exported good must have undergone specified manufacturing or processing operations which are deemed to confer origin of the country in which they were carried out.

Is the product's origin defined through a technical requirement? [SR tr]

Example from the Transpacific Partnership (2019), Annex 3-D (Product-Specific Rules of Origin): Notwithstanding the applicable product-specific rules of origin, a good of chapter 27 that is the product of a chemical reaction is an originating good if the chemical reaction occurred in the territory of one or more of the Parties.

III. Variations:

Combinations and alternatives: Those three criteria are used in existing trade agreements as stand-alone or in combination with other criteria, or as alternative criteria.

Do two or more origin criteria apply cumulatively? [SR com]

Example from the Transpacific Partnership (2019), Annex 3-D (Product-Specific Rules of Origin) 1901.20: A change to a good of subheading 1901.20 containing more than 30 per cent by dry weight of rice flour from any other chapter, provided that the value of non-originating rice flour of subheading 1102.90 does not exceed 30 percent of the value of the good.

Do two or more origin criteria apply alternatively? [SR alt]

Example from the Transpacific Partnership (2019), Annex 3-D (Product-Specific Rules of Origin) 1515.19: A change to a good of subheading 1515.19 from any other chapter; or No change in tariff classification required for a good of subheading 1515.19, provided there is a regional value content of not less than 40 percent under the build-down method.

Exceptions: Exceptions can be attached to a particular CTC requirement, generally prohibiting the use of non-originating materials from a particular HS subheading, heading, or chapter for goods supposed to qualify via CTC, and thereby making the requirement more restrictive.

Are one or more HS codes or product groups explicitly excluded from being used as inputs for originating goods? [SR ctc exc]

Example from the Transpacific Partnership (2019), Annex 3D (Product-Specific Rules of Origin) 1102.90: A change to a good of subheading 1102.90 from any other chapter, except from heading 10.06.

Mapping to seven PSR categories: From the answers to those 12 questions, Angeli et al. (2020) constructed 17 mutually exclusive PSR categories, see Table B.1. The choice is built around five rules:

- Composite rules are distinguished according to whether the presence of multiple criteria relax the rule by giving more choice (i.e. 'or' rules) or make the rule stricter ('and' rules). For example, the PSR [CTH and RVC 40%] is not the same as PSR [CTH or RVC 40%]. Therefore, the rule was separated into two alternative sub-rules so that the two PSRs are classified separately.
- No differentiation across VC rules according to the required percentage of originating materials since percentages are not available across all.
- We group in the same category the combination of a CTC with a TR or with a VC rule.
- We group in the same category the alternative of a CTC with a TR or a VC.
- We group in the same category the exception even if there are alternatives or combination rules included in the exception.

Table B.1 *Mapping of PSRs categories in Angeli et al. into the 7 categories*

17 categories in Angeli et al. (2020)	Mapping into 7 categories	Distribution (percent)	
		1995	2015
1 WO	1: WO	0.5	1.9
2.CC	2: CTC	3.3	4.3
3. CH	2: CTC	13.3	15.1
4. CS	2: CTC	4	3.2
5. VC	3: VC	6.7	15.4
6. TR	4: TR	21.4	17.2
7. CC with EXC	5: EXC	2.4	3.1
8. CH with EXC	5: EXC	3.8	10.3
9. CS with EXC	5: EXC	0.5	0.3
10. CC and TR/VC	6: COM	0.6	1.6
11. CH and TR/VC	6: COM	1.9	2.1
12. CS and TR/VC	6: COM	0.4	0.1
13. TR and VC	6: COM	0.2	7
14. CC or TR/VC	7: ALT	0.8	1.8
15. CH or TR/VC	7: ALT	36.8	13.2
16. CS or TR/VC	7: ALT	1.2	2.6
17. TR or VC	7: ALT	0.1	0.3
Number of trade flows under PSR		105.038	345.337
Number of PTAs		17	128
VCR<40%		0.0	3.0
VCR=40%		11.0	66.7
VCR>40%		89.0	30.3

Source: Authors.

B.2 Dataset preparation

This annex describes the sample used in the text resulting from the six steps described in table B.2. First, we exclude exporting countries with a total export value by destination country below the 25^{th} percentile. Second, we keep only bilateral exports for a product if it is traded at least three times during the sample period. This excludes occasional exporter flows (Fontagné et al., 2015). Third, we restrict the panel period to six 5-years intervals starting in 1990 to let changes trade flows to adjust for changes in trade policies, as suggested by Anderson and Yotov (2016); Baier and Bergstrand (2007); Trefler (2004). Fourth, we exclude trade flows below 1,000 USD. These small flows make up only 0.003% of total sample trade value but represent 13.5% of total sample observations. Fifth, we drop observations for which MFN tariffs are already zero prior to the implementation of the PTA. In these cases, preferences are void. Sixth, we exclude observations that are part of PTAs but without PSR likely to represent products excluded from tariff negotiations.

Table B.2 shows the sample size at each step. The sample is reduced by 19% from excluding trade flows with less than 5 years worth of data and another 13% from excluding trade flows of less than USD 1,000. Taking data at 5-year intervals reduces further the sample by close to 80%. Remaining exclusions only reduce the sample marginally, notably the exclusion of products with no PSRs once it is recognized that 23% of those correspond to trade flows with zero applied MFN tariffs. These observations relate to products that were excluded from negotiations of tariff concessions.

Table B.2 *Data coverage resulting from sample selection*

Steps	**Sample period**	**Nbr of countries**	**Nbr of products**	**Change in nbr of observations**	**Nbr of observations**	**Change in trade value**	Trade value (in billion USD)
Raw data	1990-2015	181	5,018		121,224,927		156,580
exclude small exporters (<25 percentile)				-1.2%	119,820,171	-0.2%	156,324
exclude if <=5 years of observed trade				-18.7%	97,435,976	-1.7%	153,721
data at 5 years intervals	1990, 1995, 2000, 2005, 2010, 2015	**135 exporters, 181 importers**		-77.6%	21,803,233	-77.7%	34,280
exclude trade flows<1000 USD				-13.5%	18,854,670	-0.003%	34,279
exclude if MFN=0 & PSR=1				-2.4%	18,393,110	-6.1%	32,171
exclude products in RTA without PSR*				-5.0%	17,480,272	-9.7%	29,061
Final data	1990, 1995, 2000, 2005, 2010, 2015	**135 exporters, 181 importers**	5,018		17,480,272		29,061

Notes: *22.8% of those products (207,790 observations) are in an RTA with a zero applied MFN tariff. Changes in number of observations and in trade value are from each step.
Source: Authors.

The final data sample represents around 68 percent of global imports (excluding intra-EU trade) on average across years (Table B.3).

Table B.3 *Import value in final sample as share of global imports*

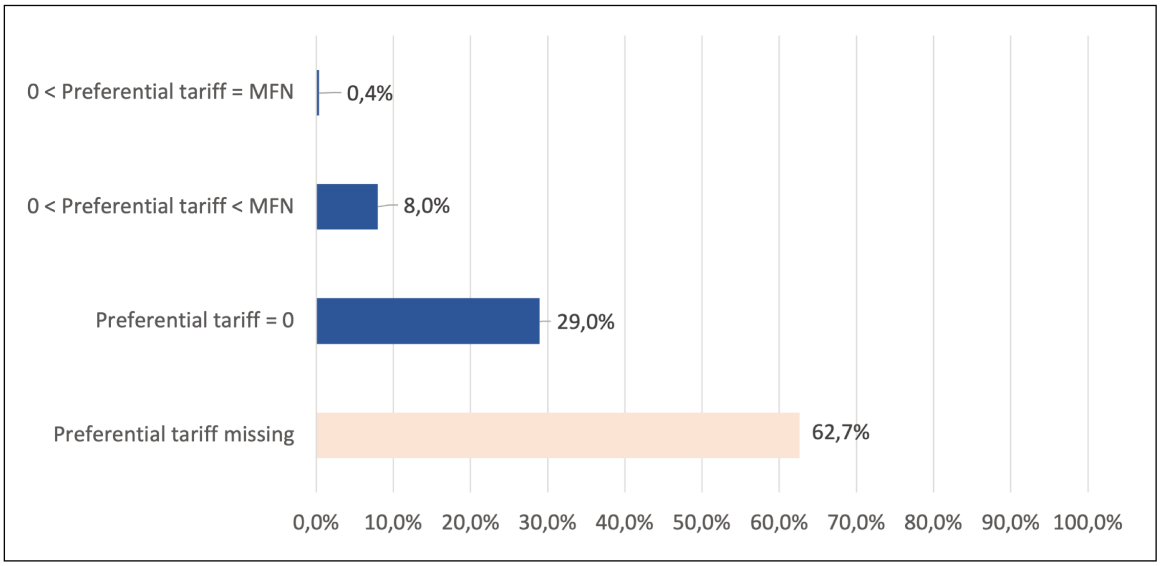
Year	Global imports excl. intra-EU trade (WITS)	Final sample imports	%
1990*	2,300,003,514	1,138,170,208	49%
1995	3,557,836,193	2,909,374,138	82%
2000	4,937,452,035	3,763,072,935	76%
2005	7,898,848,827	5,483,828,681	69%
2010	11,700,417,627	7,986,584,799	68%
2015	12,553,474,443	7,780,723,234	62%
Average			68%

Notes: Data in 1,000 USD. *For the year 1990, we use global import values in SITC from WITS instead of HS nomenclatures because in 1990 trade data was mainly based on STIC rather than HS nomenclatures.
Source: Authors.

In practice, FTA negotiations result in the reduction of applied bilateral tariffs over a period, often 10 years, with a large chunk of reductions taking place at the end. (Espitia et al., 2020, figure 1.7, p. 54) report national tariff line code data for 2016 covering 97 percent of world trade at the HS6 level. They report that PTAs have brought an extra 28 percent of global imports to zero tariffs with only 5.5 percent of imports under PTAs subject to positive tariffs. However, they report that nearly one quarter of tariff lines with MFN tariffs over 15 percent are excluded from preferential liberalization.

Espitia et al. (2020) report applied bilateral tariff data for 141 countries for 2016 and for others for a prior year. Their data does not extend to earlier years. Therefore, applied bilateral tariffs are taken from WITS where available and a preferential margin equal to the MFN tariff has to be calculated for the remainder. Figure B.1 shows that preferential tariffs from WITS are missing for 63% of the tariff lines in our sample (approximately the same percentages are obtained for import-weighted tariffs). Faced with this situation, we have assumed an applied bilateral tariff of zero for all flows, implying a preferential margin equal to the MFN tariff.

Figure B.1 *Distribution of preferential tariffs by category of MFN of final sample, all sample years*



Source: Authors.

B.3 Descriptive statistics

Table B.4 shows the distribution of PSR categories by HS sections and table B.5 across HS sections over 1990-2015. Looking at HS categories, all categories, except textiles, machinery and transportation have over 10 percent of their RoO fulfilled by a CTC criterion and the ALT category accounts for over 20 percent of RoO for seven sectors and only animal products have less than 10 percent of sectors with some choice. TR requirements are concentrated in plastics, textiles, and transportation.

Turning to the distribution of PSRs across HS sections, textile and machinery/electrical rely on a large array of PSRs. Textiles, the subject of many studies a large array of relatively evenly distributed PSRs: threshold content requirement (VCR), technical requirements (TR), exceptions (EXC) but also a relatively large share of choices (highest share of ALT across HS). Chemicals and machinery/electrical stand out with a large share of CTC at the subheading level.

Table B.4 *Distribution of PSR categories by HS sections (average over 1990-2015)*

HS section | PSR category	WO	CTC	VCR	TR	ALT	CUM	EXC	*CC*	*CH*	*CS*	
Animal products	**22.8**	**20.1**	4.5	**15.4**	9	3.3	4.9	*12.3*	*7.4*	*0.3*	100
Vegetables	**17**	**23.3**	4.7	**12.9**	11.9	4.8	2.1	*10.4*	*11*	*1.9*	100
Foodstuffs	5	**21.2**	6.5	13.3	**16.5**	3.3	13.1	*7.4*	*11.9*	*1.9*	100
Mineral products	0.9	**22.1**	8	15.4	**21.8**	6.7	3	*3.8*	*18.2*	*0.1*	100
Chemicals	0	**16.7**	12.9	14.4	**27**	6.1	6.2	*0.5*	*10.5*	*5.7*	100
Plastic/rubbers	0.1	14.5	16.7	**17.9**	**21.5**	8.6	6.3	*0*	*12.4*	*2*	100
Raw hides, skins, leathers	0.1	**31**	2.8	7.6	**18.3**	2.8	6.4	*7.6*	*22.9*	*0.4*	100
Wood products	0.1	**30.9**	6.7	10.5	13.1	3.9	4	*2.3*	*25.8*	*2.8*	100
Textiles	0.3	7.8	11.7	**23.2**	**22.9**	7.6	18.6	*2.5*	*5.3*	*0*	100
Footwear/headgear	0	**20.4**	9.8	11.2	**17.6**	4.8	15.8	*2.3*	*13.1*	*5*	100
Stone/glass	0	**25.7**	8	12.1	**16.8**	5.3	6.3	*4.6*	*20.3*	*0.9*	100
Metals	0	**27.4**	4.8	**10.5**	**16.7**	5.4	7.9	*3*	*23.3*	*1.1*	100
Machinery/electrical	0.2	8.5	**30.8**	**19.8**	**20.8**	5.8	5.6	*0*	*4.6*	*3.8*	100
Transportation	**0**	8.6	**27.2**	**19.5**	**19.2**	11.3	5.6	*0.1*	*6.4*	*2.1*	100
Miscellaneous	0	**17.2**	15.5	11.5	**25.3**	9.2	4	*2*	*9.9*	*5.3*	100

Source: Authors.

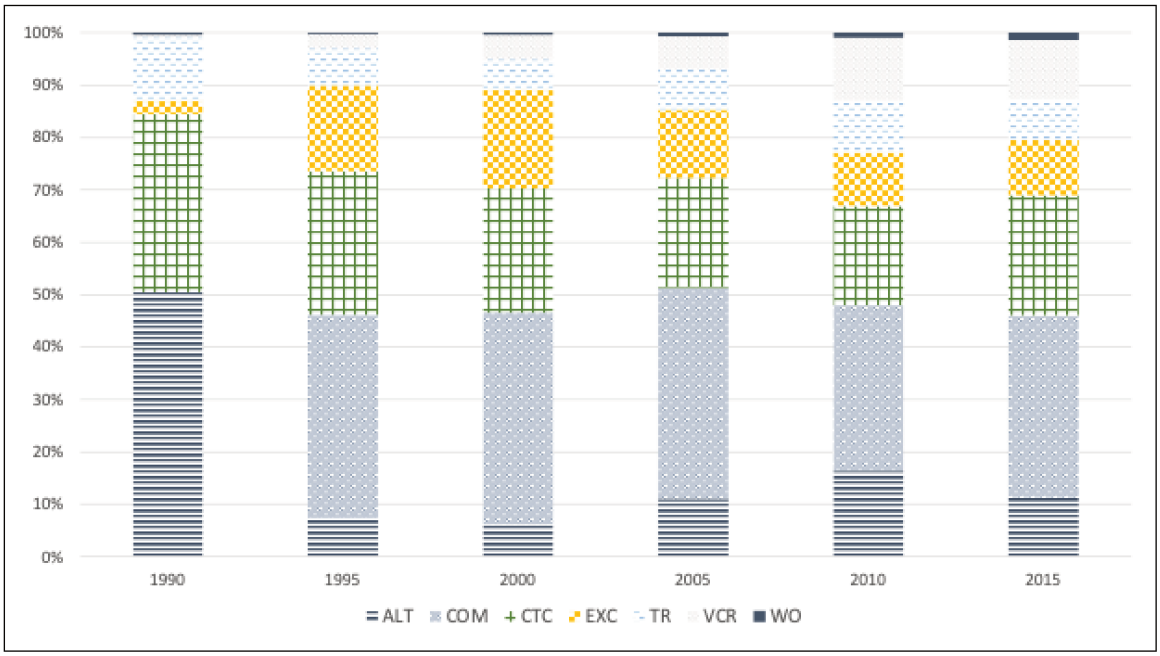
Table B.5 *Distribution of PSR categories across HS sections (average over 1990-2015)*

HS section | PSR category	WO	CTC	VCR	TR	ALT	CUM	EXC	*CC*	*CH*	*CS*
Animal products	**26.8**	2.2	0.7	1.9	0.9	1	1.2	*8.7*	*1.2*	*0.3*
Vegetables	**50**	6.5	1.7	4.1	2.9	3.7	1.2	***18.4***	*4.4*	***3.7***
Foodstuffs	**17.6**	7.1	2.9	5.1	4.9	3.1	9.4	***15.8***	*5.7*	*4.4*
Mineral products	0.7	1.6	0.8	1.3	1.4	1.3	0.5	*1.7*	*1.9*	*0*
Chemicals	0	**10.3**	10.5	10.1	**14.7**	10.6	8.3	*1.8*	*9.3*	***25***
Plastic/rubbers	0.3	5.5	8.3	7.6	7.1	9.1	**5.1**	*0.1*	*6.7*	*5.4*
Raw hides, skins, leathers	0.1	2.7	0.3	0.8	1.4	0.7	1.2	*4.3*	*2.9*	*0.3*
Wood products	0.3	9.4	2.7	3.6	3.5	3.3	2.6	*4.5*	*11.2*	*5.9*
Textiles	2.2	6.6	**13.1**	**22.3**	**17**	**18.1**	**33.6**	*13.6*	*6.4*	*0.1*
Footwear/headgear	0	2.2	1.4	1.4	1.7	1.5	3.7	*1.6*	*2.1*	*3.8*
Stone/glass	0.1	7	2.9	3.7	4	4	3.7	*7.9*	*7.9*	*1.7*
Metals	0.4	**21.8**	5.1	9.4	11.6	12	**13.4**	*14.9*	***26.5***	*6*
Machinery/electrical	1.3	6.9	**33.1**	**18.2**	**14.8**	**13.2**	9.8	*0.1*	*5.3*	***22***
Transportation	0	1.5	6.3	3.9	2.9	5.5	2.1	***0.1***	*1.6*	*2.6*
Miscellaneous	0.1	8.7	10.3	6.6	11.2	**13**	4.4	*6.4*	*7.2*	*18.8*
	100	100	100	100	100	100	100	*100*	*100*	*100*

Source: Authors.

Figure B.2 shows the share of trade value across the seven PSR categories by year.

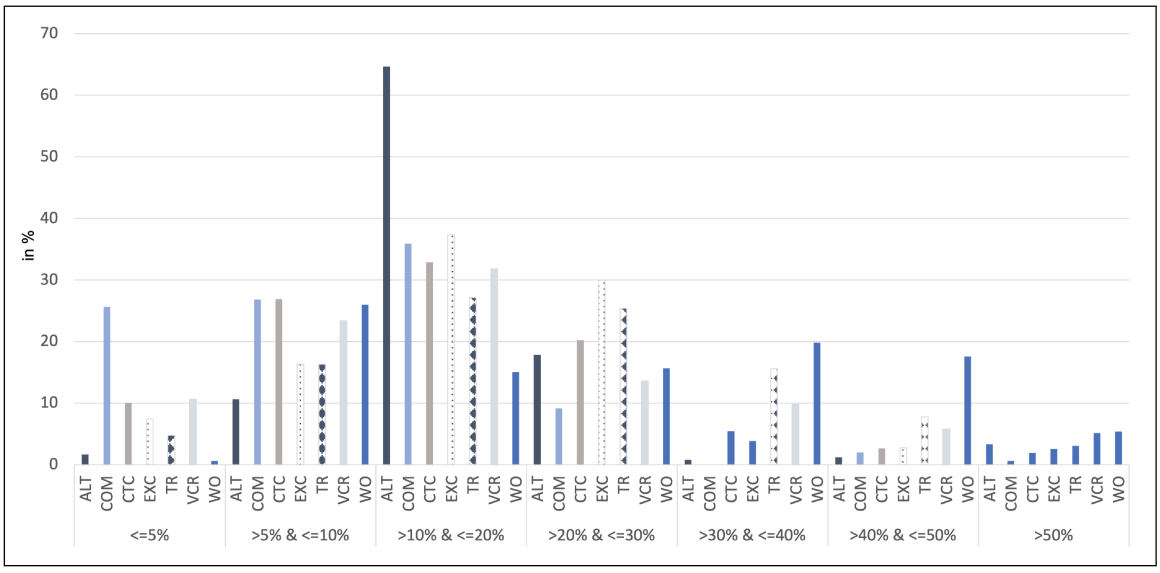
Figure B.2 *PSR categories as share of trade value*



Source: Authors.

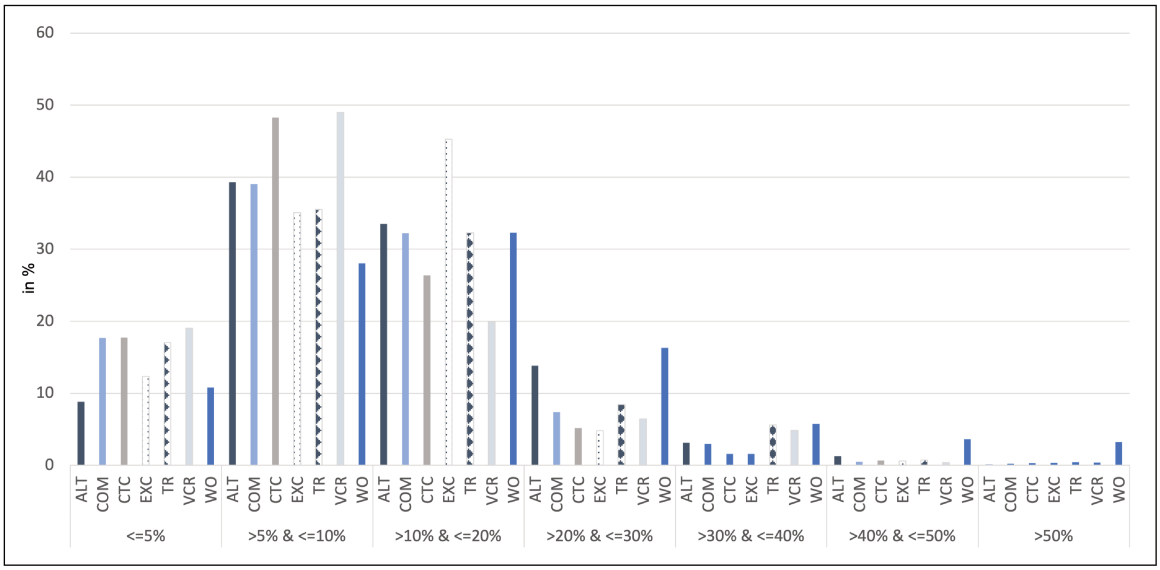
Figures B.3 and B.4 shows the frequency distributions of the PSR categories across 7 bins of preferential margins for 1995 and 2015. The largest share of observations is located between margins above 5 percent and below or equal to 20 percent and is gradually decreasing afterwards. Distributions are relatively similar overall. The distribution is flatter in 2015 than 1995. The flexibility (ALT) category is concentrated in the 10 percent to 20 percent range.

Figure B.3 *Frequency distribution of preferential margins across PSR categories by bins, 1995*



Source: Authors.

Figure B.4 *Frequency distribution of preferential margins across PSR categories by bins, 2015*



Source: Authors.

Table B.6 gives summary statistics of MFN tariffs in the final sample by group of country for export-import partners.

Table B.6 *Summary statistics of MFN tariff across country groups*

	count	mean	sd	min	max
OECD to OECD: MFN tariff	2,215,980	5.6	9.8	0.0	835.9
non-OECD to non-OECD: MFN tariff	4,158,378	12.5	16.2	0.0	3,000.0
OECD to non-OECD: MFN tariff	6,187,037	10.9	14.5	0.0	3,000.0
non-OECD to OECD: MFN tariff	2,560,888	6.1	8.9	0.0	835.9

Source: Authors.

B.4 Gravity equation

Our empirical work is based on the theoretical gravity structure derived from the demand-side by Anderson and van Wincoop (2003) and that is separable by sectors (Anderson and Yotov, 2016; Larch and Wanner, 2017):

$$X_{ij,t}^k = \underbrace{\frac{Y_{i,t}^k E_{j,t}^k}{Y_t^k}}_{\text{size term}} \underbrace{\left(\frac{t_{ij,t}^k}{\Pi_{i,t}^k P_{j,t}^k} \right)^{1-\sigma_k}}_{\text{trade cost term}}$$

where $X^k_{ij,t}$ denotes bilateral trade flows of good category k from origin country i to destination country j in year t. In the size term, $E^k_{j,t}$ indicates total expenditures for k in j from all origin countries, $Y^k_{i,t}$ are total sales of k from i to all destination countries, and Y^k_t is total output of k. The trade cost term consists of bilateral trade costs ($t^k_{ij,t}$), and the two structural inward ($P^k_{j,t}$) and outward ($\Pi^k_{i,t}$) multilateral resistance (MLR) terms (Anderson and van Wincoop, 2003). $\sigma_k > 1$ denotes the elasticity of substitution of the same good across different locations.

Log-linearizing the gravity model and expanding it with an additive error term ($\epsilon^k_{ij,t}$) leads to the following empirical specification (Yotov et al., 2016):

$$lnX^k_{ij,t} = lnY^k_{i,t} + lnE^k_{j,t} - lnY^k_t + (1-\sigma_k)ln\,t^k_{ij,t} - (1-\sigma_k)ln\Pi^k_{i,t} - (1-\sigma_k)lnP^k_{j,t} + \epsilon^k_{ij,t} \tag{B.1}$$

We apply a Poisson-Pseudo Maximum Likelihood (PPML) estimator with fixed effects leading to the following equation:

$$X_{ijkt} = exp[\beta_0 + \beta\tau_{ijkt} + \eta_{ikt} + \theta_{jkt}] + \epsilon_{ijkt} \tag{B.2}$$

where τ_{ijkt} indicates bilateral trade costs and the fixed effects η_{ikt} and θ_{jkt} account for the MLR terms ($P^k_{j,t}$) and ($\Pi^k_{i,t}$) and furthermore absorb the size terms $Y^k_{i,t}$ and $E^k_{j,t}$.

The trade cost term, τ_{ijkt}, in our baseline specification (2.1) consists of the following components:

$$\tau_{ijkt} = exp[\beta_1 ln\,(1 + tar^{MFN}_{jkt}) + \beta_2 I^{RTA}_{ijt} + \beta_3 \left(I^{RTA}_{ijt} \times ln\,t^{MFN}_{jkt}\right) \tag{B.3}$$

where $ln\,(1+tar^{MFN}_{jkt})$ is the logarithm of the applied MFN tariff ($ln(1+\frac{MFN_{jkt}}{100})$) on product *k* defined by the destination country for all origin countries (Most-Favoured Nation rule). I^{RTA}_{ijt} is a dummy variable indicating the presence of an RTA between country paris ij in year t. $I^{RTA}_{ijt} \times ln\,t^{MFN}_{jkt}$ is an interaction term between RTA membership and the MFN tariff. Our estimation strategy needs some adjustment in the formulation of the specification as the MFN tariff, a unilateral tariff, is defined at the jkt-level so that we are not able to include jkt-level fixed effects. We therefore decide to capture the MLR terms via η_{it} and θ_{jt}. We also add a control for bilateral country HS2-product effects (σ_{ijk_2}) to account for the traditional bilateral trade cost variables, such as bilateral distance, and product-specific effects. Our baseline specification is as follows:

$$X_{ijkt} = exp[\beta_0 + \beta_1 ln\,(1 + tar_{jkt}^{MFN}) + \beta_2 I_{ijt}^{RTA} + \beta_3 \left(I_{ijt}^{RTA} \times ln\, t_{jkt}^{MFN}\right) + \sigma_{ijk_2} + \eta_{it} + \theta_{jt}] + \epsilon_{ijkt} \quad \text{(B.4)}$$

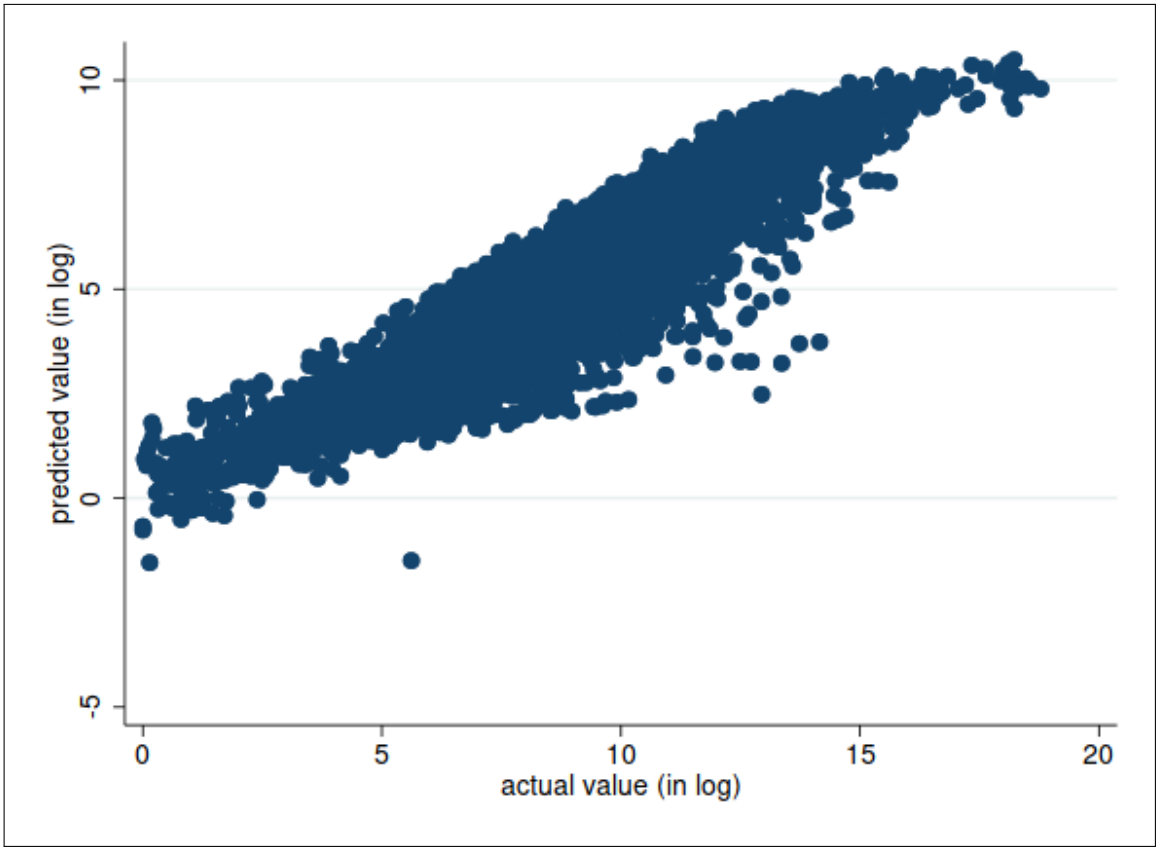
B.5 Simulation of simplification of PSR

Description of simulation steps: To quantify the trade effect of simplifying PSRs, we proceed as follows. We draw on our results based on equation 2.1 and presented in table 2.2, column 5. First, we predict the average trade value for each *ijkt*-combination with our model, based on the following equation:

$$\begin{aligned}\hat{X}_{ijkt} = {} & \hat{\beta}_0 + \beta_1 ln\,(1 + tar_{jkt}^{MFN}) + \hat{\beta}_{ALT} D_{ijkt}^{ALT} + \hat{\beta}_{VCR} D_{ijkt}^{VCR} + \hat{\beta}_{CTC} D_{ijkt}^{CTC} + \hat{\beta}_{WO} D_{ijkt}^{WO} \\ & + \hat{\beta}_{TR} D_{ijkt}^{TR} + \hat{\beta}_{COM} D_{ijkt}^{COM} + \hat{\beta}_{EXC} D_{ijkt}^{EXC} + \hat{\gamma}_{ALT} D_{ijkt}^{ALT} ln\,(1 + tar_{jkt}^{MFN}) \\ & + \hat{\gamma}_{VCR} D_{ijkt}^{VCR} ln\,(1 + tar_{jkt}^{MFN}) + \hat{\gamma}_{CTC} D_{ijkt}^{CTC} ln\,(1 + tar_{jkt}^{MFN}) \\ & + \hat{\gamma}_{WO} D_{ijkt}^{WO} ln\,(1 + tar_{jkt}^{MFN}) + \hat{\gamma}_{TR} D_{ijkt}^{TR} ln\,(1 + tar_{jkt}^{MFN}) \\ & + \hat{\gamma}_{COM} D_{ijkt}^{COM} ln\,(1 + tar_{jkt}^{MFN}) + \hat{\gamma}_{EXC} D_{ijkt}^{EXC} ln\,(1 + tar_{jkt}^{MFN}) \\ & + \hat{\sigma}_{\hat{ijk_2}} + \hat{\eta}_{it} + \hat{\theta}_{jt} + \hat{\epsilon}_{ijkt} \quad \text{(B.5)}\end{aligned}$$

To see the predictive power of our PPML model, figure B.5 plots the predicted trade values (in log) from our model on the y-axis and the observed ones (in log) on the x-axis (*ijt*). The predicted values include the estimated constant and all fixed effects.

Figure B.5 *Predicted versus observed trade value for country pairs, 1990-2015*



Source: Authors.

Second, we simulate a scenario in which observations with restrictive PSR categories, notably EXC, COM, TR, WO, VCR and CTC, adopt one of the most flexible PSR types, in our case the alternative rule (ALT category). To do so, we set the interacted coefficient of restrictive PSR of observation *ijkt* to the ALT coefficient, keeping the original preferential margin attached to each *ijkt*-combination. Equation B.6 represents the simulated trade value once observations with a restrictive PSR adopt ALT rules.

$$\hat{X}_{ijkt} = \hat{\beta}_0 + \beta_1 ln t_{jkt}^{MFN} + \hat{\beta}_{ALT} D_{ijkt}^{ALT} + \hat{\beta}_{VCR} D_{ijkt}^{VCR} + \hat{\beta}_{CTC} D_{ijkt}^{CTC} + \hat{\beta}_{WO} D_{ijkt}^{WO} + \hat{\beta}_{TR} D_{ijkt}^{TR} + \hat{\beta}_{COM} D_{ijkt}^{COM} + \hat{\beta}_{EXC} D_{ijkt}^{EXC} + \hat{\gamma}_{ALT} D_{ijkt}^{ALT} ln t_{jkt}^{MFN} + \hat{\gamma}_{ALT} D_{ijkt}^{VCR} ln t_{jkt}^{MFN} + \hat{\gamma}_{ALT} D_{ijkt}^{CTC} ln t_{jkt}^{MFN} + \hat{\gamma}_{ALT} D_{ijkt}^{WO} ln t_{jkt}^{MFN} + \hat{\gamma}_{ALT} D_{ijkt}^{TR} ln t_{jkt}^{MFN} + \hat{\gamma}_{ALT} D_{ijkt}^{COM} ln t_{jkt}^{MFN} + \hat{\gamma}_{ALT} D_{ijkt}^{EXC} ln t_{jkt}^{MFN} + \sigma_{\hat{ijk}_2} + \hat{\eta}_{it} + \hat{\theta}_{jt} + \hat{\epsilon}_{ijkt} \quad \text{(B.6)}$$

3 US maritime cabotage: An economic assessment of the Jones Act policy

This chapter is joint work with Joaquim José Martins Guilhoto (University of São Paulo, Brazil). Parts of this work are based on the policy paper Gourdon and Guilhoto (2019).

Abstract

The US Jones Act obliges intra-US seaborne trade to be conducted on US built, US owned, US crewed and US flagged vessels, thereby protecting the domestic US shipbuilding industry and artificially inflating domestic shipping prices. This study simulates the effects associated with a hypothetical abolition of the Act on the US economy and highlights the up- and downstream industries that are most affected by the policy. Our work is based on a novel version of OECD's Inter-Country Input-Output (ICIO) database that has been disaggregated to the level of the US shipbuilding industry and captures dynamics in ship production in 2018 between 46 industries and 67 countries. The simulation results are based on a static multi-country input-output model and reveal losses for the US service sector, but economic gains for the US food industry, agriculture products sector, pharmaceuticals sector, electronics industry and petroleum products sector.

Keywords: Cabotage, Jones Act, Shipping, Shipbuilding, Trade policy, Domestic trade, Input-Output models.

JEL Classification: F10, C67, R15, R48.

3.1 Introduction

"Cows flying first class" has made headlines in an article describing how Hawaiian cattle ranchers send their cows to the US mainland by airplanes due to inflated shipping rates and unavailable ships in domestic US waterborne transport (Fitzgerald and Mulligan, 2020). Similar anecdotal stories, such as about lumber products or road salt (Bergstresser and Melitz, 2017), go back to a more than a century old US cabotage law that significantly restricts foreign participation in domestic US maritime trade and ship construction. The Merchant Marine Act of 1920 requires that all goods transported between two US ports be carried on ships that have been built in the US, are registered under a US flag, are crewed with US citizens or US permanent residents, and are owned by US citizens (Cato Institute, 2018). This cabotage law, still in place as of today, has since been known as the *US Jones Act*.[1]

The Act has repeatedly been in the focus of debates in the US Senate[2] and has become part of international trade negotiations, such as the Transatlantic Trade & Investment Partnership (ECSA, 2014; European Commission, 2017) or the OECD's Shipbuilding Agreement (European Commission, 1995). Policy makers, unions and the civil society are split over the effectiveness of this cabotage policy. Supporters of the Jones Act emphasize its original purpose that goes back to national security concerns after the country's significant war losses in World War I (Bergstresser and Melitz, 2017; Grennes, 2018). By supporting employment and work conditions for American shipbuilders and seamen, proponents argue that the policy ensures a viable US Merchant Marine Fleet that is capable of assisting in times of war or national emergency (Bergstresser and Melitz, 2017; Grennes, 2018).[3]

However, studies show significant economic side-effects of this policy (Francois et al., 1996; Olney, 2020; US ITC, 2002). In an international comparison, the US ranks first in terms of restrictiveness of its maritime transport industry among OECD economies (Olney, 2020; World Economic Forum, 2013). The US Jones Act also ranks second of the most costly US import restraints just after quantitative restrictions imposed in the US textile and apparel sector (US ITC, 2002). The Act's

[1] The Jones Act allows a merchant cargo vessel not eligible for US coastwise trade to discharge foreign import cargo loaded at a foreign place, and load export cargo for discharge at a foreign place. In turn, this implies that the Jones Act prohibits a merchant cargo vessel not eligible for the coastwise trade to load and subsequently discharge the same cargo between domestic US places (US Department of Homeland Security, 2017, § 4.80 "Vessels entitled to engage in coastwise trade") (based on exchanges with Michael N Hansen "President at Hawaii Shippers Council"). For instance, international trade is not affected by the Act if transport is required to stop to unload foreign goods in New York and continues to Florida to unload the remaining import cargo, as long as the foreign shipping company does not load cargo in New York to subsequently discharge it in Florida.

[2] For instance, the US government repeatedly suspended the US Jones Act as it was hindering disaster relief work in the wake of hurricanes in 2005, 2012 and 2017 (Bergstresser and Melitz, 2017). In 2017, Senator John McCain introduced several bills to permanently abolish the US Jones Act's restrictions but without success (McCain, 2017a,b). In 2020, the Senate passed an amendment introduced by Congressman John Garamendi to enforce the Jones Act for offshore renewable energy production (Garamendi, 2020).

[3] Yet, a report by the US Congressional Research Service suggests that the US navy is actually dependent on foreign-built ships for the deployment of military assets ("sealifts") as the US Department of Defense considers leasing in this context as "the most cost-effective option" (Bergstresser and Melitz, 2017; O'Rourke, 2010).

restrictions drive up ship prices and water transport costs, and thereby restrict domestic trade (Frittelli, 2019; Olney, 2020; US ITC, 2002).

This study contributes to the public debate by simulating the effects of a hypothetical abolition of the Act on the US economy and its up- and downstream industries. Our work is based on a novel version of OECD's latest Inter-Country Input Output (ICIO) data that has been disaggregated to reflect the structure of the US shipbuilding industry. The rich ICIO structure captures dynamics in ship production between 46 industries and 67 countries in 2018. The general equilibrium analysis is based on a static comparative input-output (IO) model measuring changes in economic activity (i.e. GDP) in the target sector of the US policy, such as shipbuilding or maritime transport services, the US economy and up- or downstream sectors before price changes materialize.

The Jones Act requirements affect the US economy through different channels which we exploit in our simulation. First, the policy imposes a local content requirement ("US built criteria") for the production of ships to be eligible to operate in the Jones Act fleet. The requirement stipulates that a vessel is considered as being built in the US if all major components of the ship hull and superstructure are fabricated in the US and the ship is entirely assembled in the US (Frittelli (2019); Appendix C.1). The requirement constraints shipbuilders from freely deciding to purchase inputs from domestic or foreign suppliers under profit maximisation considerations. Our analysis reveals that US built ships are around four times more expensive than comparable ships available on the international market. Second, increased capital costs of ships, insurance costs arising from US flag registration, costs associated with US ownership obligation (i.e. tax payments) and labour costs resulting from the requirement of US nationality of the crew lead to increased shipping prices, which in turn increase the final price of goods. Findings in the literature suggest that the policy's requirements lead to shipping rates that are around three times higher than those of foreign shipping firms (US Marad, 2011).

We investigate separately the effect of three shocks associated with an abolition of the Act on output (GDP) of the target's sectors' up- and downstream industries: i) reductions in domestic shipbuilding output, ii) reductions in domestic water transport services and iii) reductions in domestic water transport costs.

First, with the abolition of the Act, shipping companies are free to purchase cheaper and more competitive ships on the international market, thereby reducing demand for domestically produced US ships. Our results reveal an output multiplier of 1.8 implying that for each reduction in shipbuilding output by 1,000 USD the US economy will experience an additional reduction in GDP by 800 USD. The strongest output effect is observed in ship repair, as fewer ships will be repaired in the US building yard. Overall, the US services sector is most affected, including wholesale and retail trade as well as professional, scientific and technical activities, such as legal services, accounting and engineering.

Second, the abolition of the Act implies liberalising domestic water transport services where firms are free to contract foreign maritime service providers which are significantly cheaper and more competitive than US domestic firms. We simulate the effect on GDP of a reduction in output in the US water transport sector. Our results show an output multiplier of 2.2 implying that a reduction in output of domestic water transport services by 1,000 USD will lead to an additional reduction in US

GDP by around 1,200 USD. Most affected US up- and downstream industries include the financial and insurance sector, legal, accounting or engineering services as well as postal and warehousing activities.

Third, liberalising the US water transport sector increases competition between domestic and cheaper foreign shipping firms, thereby reducing domestic shipping rates. Lower freight rates reduce unit production costs, leading to an increase in demand for goods using domestic water transport services. The US food sector will benefit the most from lower shipping rates, followed by wholesale trade and agriculture products, pharmaceuticals, computer, electronics and optical equipment as well as petroleum products.

While our study is based on a static IO model, most of the previous quantitative work on the US Jones Act apply Computable General Equilibrium (CGE) models which describe the behaviour of and linkages between producers and consumers in an economy and estimate welfare effects associated with policy changes, economic shocks or natural disasters (Burfisher, 2021; Hu et al., 2014; Koks et al., 2016; Rose and Guha, 2004). For instance, Hufbauer and Elliott (1994) find economic gains of around 1.1 billion USD from waving the Jones Act law in 1990. Similarly, Francois et al. (1996) perform an applied general equilibrium model to estimate the effects of a hypothetical abolition of the Act on the US economy in terms of welfare, production, trade and employment. The authors' results suggest welfare costs of Jones Act restrictions of around 3 billion USD in 1989. Moreover, the US International Trade Commission (ITC) has a long series of reports investigating the economic effects of significant US import restraints with a chapter on the Jones Act (US ITC, 1993, 1995, 2002). In their latest available report using a static CGE model for 1999, the economic gains of an abolition of the Act amount to around 656 million USD. Gains amount to 261 million USD if the liberalisation includes only the domestic built-requirement (US ITC, 2002).

Yet, CGE models are often considered as *black boxes* assuming non-linear relationships through their demand and supply elasticities, which makes it difficult to understand the interconnections between the variables under consideration. In contrast, our static IO model requires fewer assumptions on non-linear relationships and allows us to study different impacts separately due to its linear nature. On that basis, governments have information on the sectors most affected by the policy change in the short-term to support structural change with adequate public measures.

In contrast to the precedent papers, our model also integrates international trade flows with US domestic sectors so that the impact on the overall US economy considers spill-over effects on foreign economies and the feedback loop from these economies on the US, thereby taking into account the role of global value chains.

Furthermore, since the publication of antecedent studies on the Act, time has past, so did the distribution of shipbuilding activity in the world with Asian economies significantly rising in power. The rich data structure of OECD's ICIO data captures these dynamics in 2018 at the level of the domestic US shipbuilding industry. OECD's ICIO framework allows an assessment of the policy's effects in terms of output, final demand, and value added on the US shipbuilding and shipping industry as well as on other sectors of the US economy.

Exceptions to input-output or CGE models on the Jones Act are by Swisher and Wong (2015) and Olney (2020). Swisher and Wong (2015) build a multi-modal network model of the US transport system and find economic savings in shipping costs of around 1.91 billion USD per year from repealing the Act, where the Los Angeles-Long Beach area saves the most. Their model furthermore reveals an increase in usage of maritime shipping services by about 24%. Olney (2020) is the only work, to our knowledge, that estimates econometrically the effect of the Act on domestic trade. By using an instrumental variable approach, the study's results show that an exogenous 10% decline in Jones Act-eligible ships due to foreign competition in shipbuilding reduces US domestic water shipments by on average 2.7% relative to imports. The effect is stronger (6.8%) for coastal US States as they have the possibility to substitute with imports from abroad on cheaper foreign ships. The author concludes that since domestic water transport is onerous due to the Jones Act restrictions, domestic water shipments decrease and imports increase for coastal US States while trade via other modes increases mostly for non-coastal US States.

Although econometric and transport models have their own advantages, such as their predictive power, they lack the ability to provide estimates at the more granular level to capture the ripple effects of the policy change throughout the economy (Koks et al., 2016). Instead of comparing a net impact of the policy changes, we investigate the effects on the structure of the US economy in the short-term, thereby highlighting the down- and upstream industries most affected in each scenario.

The paper is structured as follows. Section 3.2 provides a review of studies on the economic effect of localisation based policies to which we count domestic (local) built requirements and restrictions on the domestic service sector. As the Jones Act policy consists of a domestic built obligation in addition to restrictions on foreign participation in the water transport service sector, the review will help with a better understanding of the effects expected from a hypothetical abolition of the policy. Section 3.3 describes the cabotage policy's two target sectors which are the US commercial shipbuilding and shipping industries. Section 3.4 presents OECD's Inter-Country-Input-Output (ICIO) database and outlines the methodology of our static input-output model. Section 3.5 presents the simulation results. Section 3.6 concludes.

3.2 Literature on localisation based policies

This section reviews the literature on localisation based policies to which we count both local content requirements (LCRs) and restrictions in maritime service sectors through cabotage laws.[4] The review aims to provide a better understanding of these policies' goals and effects that have been documented in ther literature.[5]

[4]Stone et al. (2015) cover both local content requirements and cabotage laws restricting foreign inputs in domestic waterborne trade under the term "localisation barriers to trade". Throughout the paper we use the terms local content requirements and localisation based policies interchangeably.

[5]This section is mainly based on Gourdon and Guilhoto (2019).

Policy makers usually draw on various forms of local content policies with the belief that such measures will generate economic and social benefits to the domestic economy. The most widely promoted policy objectives attached to such government measures are threefold: generating domestic employment, supporting local ownership requirements for strategic industries and enhancing competitiveness of the target industry in the global market (Deringer et al., 2018). The first two goals are often promoted by supporters of the US Jones Act as the US domestic shipbuilding and shipping industries are considered as strategic and important sectors for military purposes (Bergstresser and Melitz, 2017; Grennes, 2018).

Yet, most studies on LCRs highlight the long-run inefficiencies that arise in the economy as a result of the policy. By implementing an LCR the target sector is required to source (a part of) its inputs domestically. Absent the policy, companies are able to freely decide to purchase from domestic or foreign firms under profit maximization considerations so that their observed intermediate input use and sourcing pattern would be based on optimal allocation at given prices. Firms are, however, obliged to purchase less competitive and more expensive intermediate inputs domestically than they could acquire on the international market. The policy results in the intended increase in output of the local upstream sectors, increasing welfare, but only in the short-term. In the long-term, the higher prices of domestically procured components will increase the price of the final good and, as a result, the quantity sold will decline as will domestic welfare.[6]

For instance, Dixon et al. (2018) found that the "US Buy American Act" offers domestic manufacturing industries only a small level of protection against import competition. The authors show that the Act results in other sectors of the economy having around 360 000 fewer jobs than would have been the case if the Act were to be abolished. Using a model of successive oligopoly in up- and downstream industries, Belderbos and Sleuwaegen (1997) find that LCRs have anti-competitive effects and generally fail to increase domestic welfare. Although Veloso (2006) argues that under the assumption of positive spill-over effects moderate LCRs might be welfare-enhancing, he concedes that too high LCRs can have significant detrimental effects on the economy. According to the author, which effect dominates depends not only on the price elasticity of demand for the final goods, but also on the price elasticity of intermediate goods used in its production and their degree of tradability.

At the sectoral level various studies discuss the role and outcomes of LCRs, such as on the oil and gas industry (Anouti et al., 2013; Hufbauer et al., 2013), automobile (Hufbauer et al., 2013; Veloso, 2006), renewable energy (Bahar et al., 2013; Hufbauer et al., 2013), heavy vehicle (Deringer et al., 2018) or health care sector (Hufbauer et al., 2013).

[6]Which effect dominates depends on the degree the target industry is already fulfilling the LCR (i.e. to what extent the LCR is binding for the target industry). For instance, if the current domestic content in inputs is 60% and the LCR is 50%, the policy will have no effect on the composition of foreign and domestically produced intermediate inputs (Stone et al., 2015). Furthermore, economic outcomes depend on how sensitive the intermediate good production reacts to changes in its output price (i.e. demand elasticity of intermediate goods) and how sensitive final good production is to changes in intermediate good prices (i.e. demand elasticity of final goods) (Veloso, 2006).

Findings, furthermore, suggest that LCRs can result in an inefficient allocation of resources by distorting the principle of comparative advantage, a reduction in competition for the target industry, a decline in product quality by inhibiting access to technologically-advanced inputs, as well as corruption and favouritism if the policy design is opaque (Hufbauer et al., 2013; Weiss, 2016). Hufbauer et al. (2013) argue that the objectives of LCRs, such as building up a competitive industry through stronger industrial links, supplier's creation and backward linkage can hardly be obtained. According to the authors, LCRs often isolate high-cost producers from global competition and innovation, and result in insufficient incentives for R&D investments. In general, they observe that stronger domestic linkages are created when foreign firms find competitive partners in the domestic economy.

Economic effects of LCRs beyond the target sector have been documented by Stone et al. (2015). The study differentiates between the impact on intermediate inputs and final demand, and examines the decline in trade with third countries. The analysis shows that although final goods are affected by the LCR, around 80% of the decline in trade arises from the policy's effects on intermediate products. Households and other non-LCR targeted sectors are only able to mitigate the losses inflicted by the policy by shifting from local to international markets — a development such a protectionist measure initially tried to hamper (Stone et al., 2015). The results illustrate the policies' overall negative impact on trade by restricting imports and reducing exports. Furthermore, LCRs increase prices for firms and consumers. In the short term, the industry output in the target sector may increase but only at the expense of other related industries, offsetting the benefits by negative side effects.

3.3 US domestic maritime sector

The US domestic maritime sector is regulated by the US Merchant Act of 1920 in Section 27, commonly known as *Jones Act*. The policy's requirements affect directly the domestic shipbuilding sector through its domestic built requirement and the domestic shipping sector through the obligations on domestic employment, ownership and flag registration (see Appendix C.1 for more details about the Jones Act's requirements to engage in domestic shipping). This section describes the US commercial shipbuilding and shipping industries in more detail, as our model simulates the abolition of the policy as an external shock on these two target sectors for the year 2018.

3.3.1 US commercial shipbuilding

The commercial shipbuilding industry in the US counts 154 private yards that are active in shipbuilding. An additional 300 private yards focus on ship repair and maintenance, and are inactive in shipbuilding although in practice they are capable of building ships (MARAD, 2021a). For 2018, MARAD (2021a) estimate revenues of around 5.65 billion USD from commercial shipbuilding and repair in the US.[7]

[7] 26.9 billion USD of total private US shipbuilding industry whereof around 21 percent are from commercial shipbuilding and repair activity in the US, and the remaining share comes from military shipbuilding and repairs which is excluded from the Jones Act (MARAD, 2021a).

However, not all of these shipyards produce Jones-Act compliant ships and repair activity is excluded from the policy. Therefore, shipbuilding revenues that can be associated with the policy in 2018 are significantly lower. With Jones-Act compliant ships we refer in the context of ship production to ships that fulfil the local content requirement where the majority of inputs are domestically sourced and the ships are entirely assembled in the US.

We wave together data from different sources to derive an estimate of shipbuilding revenues associated with the construction of Jones-Act compliant ships in 2018. In this way, we simulate a reduction in output (proxied by revenues) in domestic shipbuilding associated with an abolition of the local built requirement of the policy since shipping firms are allowed to purchase cheaper and more competitive ships from abroad. We focus in our simulation exercise on ocean-going ships, such as tankers, containerships and bulk carriers. The reason is that US shipbuilders would face severe competition from Asia on ocean-going vessels in case of an abolition of the Act, while US shipbuilders are seen as efficient and competitive in the construction of smaller boats serving inland waterways, such as barges or tugs (Cato Institute, 2021a; Frittelli, 2017).

The US Maritime Administration (MARAD, 2021b) reports that US shipbuilders produced three Jones-Act eligible containerships in 2018. The database of the UK-based shipbroker Clarksons Research (2022) confirms the production of these three ships in 2018 that are reported under their unique ship identifier, known as International Maritime Organisation (IMO) number. The largest of these ships was sold at a price of around 209 million USD, while price data for the two other ships are not available.[8] Assuming a sales price of 209 million USD for each of these three ships – although two of them are smaller vessels – our first estimate of total revenues for the production of Jones-Act compliant ships amounts to around 627 million USD in the US in 2018.

A similar dimension in sales value of Jones-Act ships is confirmed by the US Bureau of Economic Analysis BEA (2021) and US ITC (2002). BEA (2021) report in their June version of satellite account data for the US marine economy, gross output for commercial shipbuilding (other than barges or military ships) of 618 million USD in 2018. Output figures are quite stable across a six years period with an average of 617 million USD for 2014-2019.[9] In their CGE model, US ITC (2002) estimate a shock of 503 million USD for a reduction in US shipbuilding output associated with Jones-Act ships in 1999.[10] In light of the supporting figures from other US reports, we are confident of assuming (rounded) 620 million USD in gross output for the production of Jones-Act compliant ships in 2018.

The Cato Institute (2021a,b) highlights that the commercial shipbuilding industry makes up only a tiny share of the US shipbuilding industry's output. We estimate that only 11% of US commercial

[8] One fully-cellular containership called *Daniel K. Inouye* of 51,400 deadweight tons, 260 meters LOA, priced at 209 million USD, built by Philly Shipyard and operated by Matson Inc.. Two Ro-Ro/Containerships called *TAINO* and *El Coqui* both of around 26,000 deadweight tons, 220 meters LOA with unpublished price data, built by VT Halter in Pascagoula and operated by Crowley Liner Services Inc..

[9] In current USD gross output amounts to 621 million USD (average of 628 million USD for 2014-2019).

[10] Although ITC's assumed gross output is related to the US market twenty years ago, the comparison gives an indication about the value dimension we should expect for Jones-Act ship production in the US.

shipbuilding output in 2018 materialise from the production of Jones-Act compliant ships.[11] The lion's share coming from repair activity or construction of non-ocean going ships, such barges, tugs or passenger ships, which are excluded from the Act.

If the US Jones Act did not exist, domestic commercial shipping companies would be free to purchase ocean-going ships from the international market. The major three economies specialized in the production of ocean-going vessels are currently China, Japan and South Korea. According to data from Clarksons Research (2022), a containership of comparable size (52,000 deadweight tons) and type (fully-cellular containership) with diesel 2-stroke power engine and similar overall hull length (230 meters length overall) was produced for 43 million USD in 2017 at Jiangsu New Shipyard in China. Compared to the US production, this ship was sold five times cheaper than the US price (43 million USD compared to 209 million USD). Roll-on/roll-off containerships (Ro/Ro containerships) that are produced in China in 2016 and 2017, and are twice the size of the US produced ship (55 deadweight tons instead of 26 deadweight tons) were sold at 85 million USD.[12] Ships produced in South Korea of similar size (around 27,000 deadweight tons) but in the pure Ro/Ro category were sold at 93 million USD[13], and in the fully-cellular container category at 55 million USD;[14] if produced in China the price is noted at 24 million USD.[15] We decide to take an average of these three prices to derive a valuation of the import price for two Ro/Ro containerships produced in Asia, resulting in an estimate of 57 million USD per Ro/Ro containership.[16] Based on this calculation, we estimate a total import value of the three ships from Asia at around 160 million USD[17], which is on average around four times cheaper than prices of comparable ships produced in the US in 2018.

3.3.2 US domestic shipping

The US domestic shipping sector reports operating revenues of around 14.2 billion USD for the year 2018 (BTS, 2022). This amount includes transport activities on inland waterways as well as coastal maritime routes and Great Lakes. US ITC (2002) argues that US shippers serving inland markets are considered as efficient and foreign service providers who engage in international shipments will therefore hardly compete on inland waterways. We therefore focus in our work only on the revenues generated by US service providers on coastal waterways, US islands and Great Lakes, amounting to around 7.9 billion USD in 2018 (BTS, 2022). Note that a fleet of almost 100 Jones-Act vessels generated these revenues in 2018 (Marad, 2018). According to Frittelli (2019), the ocean-going

[11] Taking 5.65 billion USD including repair activity from figures reported by MARAD (2021a) and assumed production of Jones-Act compliant vessels in 2018 of 620 million USD.

[12] Ship names are *Atlantic Sea, Sun, Sail, Sky* and are owned by *Atlantic Cont Line*.

[13] Ship names are *Delphine* and *Celine* and are owned by CLdN Cobelfret.

[14] Ship names are *Dole Caribbean* and *Dole Atlantic*, and are owned by *Dole Fresh Fruit*.

[15] Ship names are *Ubena*, *Ulanga* and *Seatrade Orange*, they are owned by *John T. Essberger* and *Seatrade Groningen.*

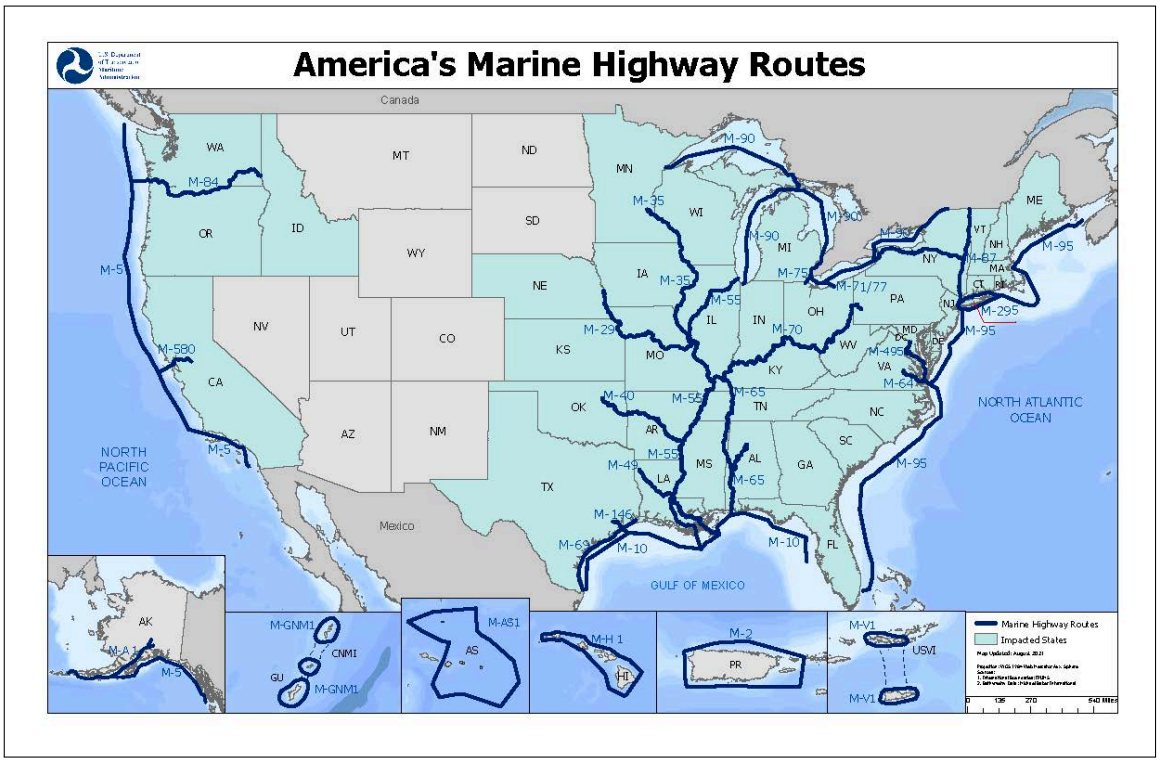
[16] This estimate seems realistic as it makes up around two-thirds of the price of the double-sized Ro/Ro containership produced in South Korea.

[17] Rounded figure for 2* 57 million USD + 43 million USD.

Jones-Act fleet primarily serves routes between the US mainland to Alaska, Hawaii and Puerto Rico. These routes evidently do not offer many alternative transport modes, such as trucks or railways.

Figure 3.1, depicts the US marine highway routes. We focus on coastal shipping and Great Lakes maritime trade, since US shippers are considered competitive on inland waterways, and US shipbuilders seem efficient in the construction of boats serving those inland waterways. An abolition of the law tends to affect mostly coastal routes, such as between Florida and Texas or those in the East and West coast and around Puerto Rico and Hawaii, as well as Great Lakes situated at the Canadian border to Ontario, such as in Michigan or New York.

Figure 3.1 *US inland waterways*



Source: Marad (2021).

In the absence of the US Jones Act, domestic freight transport will be open to more competitive foreign shipping firms, unless domestic service providers are able to restructure their cost structure to compete with foreign competitors. Lack of modernisation increases the average age of the Jones-Act fleet, leading to serious security concerns and inflated costs in the domestic US shipping sector (Frittelli, 2019). According to data from 2010 (US Marad, 2011), shipping costs of foreign service providers are at least three times cheaper than of US service providers due to lower capital and

operating costs related to crew, ownership and ship registration. In 2018, the cost differential is assumed to have increased by 25%.[18]

3.4 Data and Methodology

This section presents OECD's Inter-Country Input Output (ICIO) database and methodology for our simulation exercise. It provides background information on Input-Output (IO) models and describes the basic Leontief model in a national setting followed by an expansion to an inter-country model which we apply in our simulation about the US shipbuilding industry.

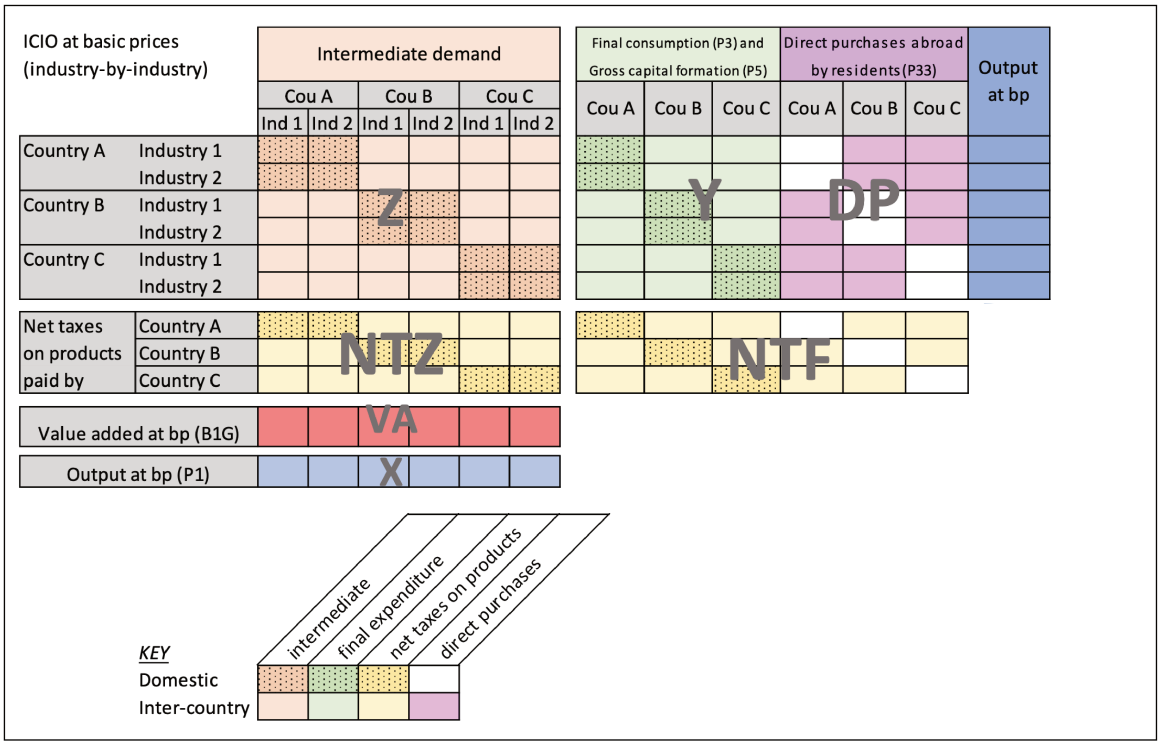
3.4.1 OECD's Inter-Country Input Output (ICIO) database

Our simulations are based on the 2021 version of OECD's Inter-Country Input-Output (ICIO) database which covers supply and demand linkages between 45 industries and 67 countries across the years 1995 and 2018 (OECD, 2021). The ICIO data is publicly available and uses revision 4 of the International Standard Industrial Classification (ISIC). ICIO tables provide indicators of output, value added and final demand of goods and services that are domestically produced, imported or exported. As such, the data provides an ideal framework to investigate the effect of changes in the Jones Act policy on different parts of the economy and their interlinkage. The data allows analysing the structure of the US economy and relationships of production and consumption for intermediate and final goods as well as services within and between economies.

Figure 3.2 illustrates a 3-country, 2-industry example of an ICIO table. The ICIO data structure provides a domestic and international view of intra-country and inter-country inter-industry flows of intermediate and final goods and services (OECD, 2021). As described in a paper on global value chains in the shipbuilding industry (Gourdon and Steidl, 2019), in the part of the table on intermediate demand (highlighted in orange), each of the cells represent the value of a transaction between an upstream industry (output), denoted in the row, and a downstream industry (input) in a specific country shown in the columns. The additional part on the right of intermediate demand (highlighted in green) represents the use of outputs for final consumption of household goods or capital goods. Final goods and capital formation can also be purchased directly from abroad (highlighted in purple). These transactions can be either domestic or international which is indicated respectively by the diagonal and off-diagonal cells in the table. Rows in the bottom of the table (highlighted in red and blue) display respectively taxes and value added creation by industry.

[18] US GAO (2018) states that "MARAD estimates this operating cost differential [is] currently between USD 6.2 million and USD 6.5 million per vessel per year, up from an estimated USD 4.9 million in 2009 and 2010 – an increase of more than 25 percent."

Figure 3.2 *Inter-Country Input-Output (ICIO) Table*



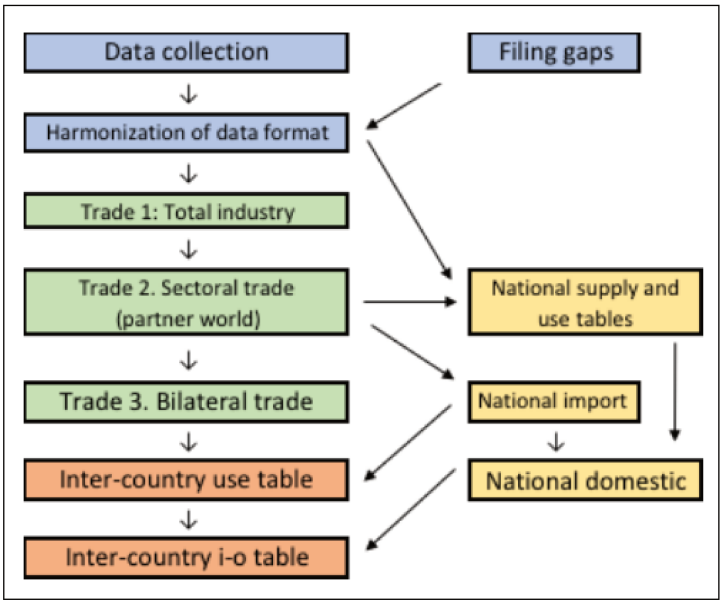
Source: Gourdon and Steidl (2019) taken from OECD (2021).

Our analysis uses an OECD internal version of the 2021 ICIO data that includes a separate industry on 'shipbuilding and repair activity' (ISIC D301) which has been carved out from the sector 'manufacturing of other transport equipment' (ISIC D30). The interlinkage of the US shipbuilding industry with ICIO economies was estimated and incorporated into the full ICIO system based on a compilation methodology by Yamano (2017). As for the whole ICIO system, the disaggregation and rebalancing of the system follow four major steps, see figure 3.3 (Yamano, 2017). First, national account tables with information on the production structure of the shipbuilding industry are available for key countries, like the US, South Korea, Japan, Canada, United Kingdom, or were provided by OECD's Shipbuilding Division. The data were harmonized and used to fill missing observations from secondary sources.[19] Second, trade flows are balanced separately for the total industry, by sectors and bilateral trade by taking care of re-exports and re-imports in addition to the valuation differences in basic prices and purchasers' prices. Third, national input-output and supply-use tables are estimated under the sectoral and total (world) constraints for gross output (production), value added and trade flows that were defined in the previous steps. Fourth, inter-country transaction flows are estimated

[19]Information on key shipbuilding industry variables, like output, value added, intermediate consumption, taxes paid, labor costs, employment, etc., for main countries is publicly available on OECD.STAT under the Structural Analysis (STAN) database.

based on harmonized international data sources of national input-output tables and balanced by trade partner shares derived in the previous steps.

Figure 3.3 *The ICIO compilation procedure*



Source: Yamano (2017).

The original ICIO data covers 45 industries while the ICIO used in this paper considers 46 industries due to the breakdown of the industry 'manufacturing of other transport equipment' into 'building of ships and boats' and 'manufacturing of other transport equipment'. In this way, we are able to simulate shocks to output or value added creation in the US shipbuilding industry and analyse the impact on the rest of the US economy and foreign countries. The US domestic water transport sector is also available in the published ICIO data. The results of our simulations are based on the the full (balanced) ICIO system, this means they consider all interconnections of the US economy with the other 66 economies in the system.

3.4.2 Input-Output models

Input-Output (IO) theory and models were originally developed by the Nobel prize winner Wassily Leontief in the early 1930s. Leontief's work can be traced back to the concept of treating the economy as a circular flow to understand how income are generated and distributed. It was originally designed as a model based on *Quesnay's Tableau Economique* (Leontief, 1936). As such, IO tables are a representation of the structure of an economy, allowing to understand how interconnections between different sectors take place and how those generate income and employment.

According to Miller and Blair (2022), since the original work of Leontief the use of input-output analysis has been growing in importance and in use, such as for analyses related to economic structure, energy, environment, disaster, regional development, trade, income generation and distribution, employment, productivity, investment or development. IO tables have also been incorporated and served as a basis for different modelling strategies, such as Computable General Equilibrium (CGE) or Econometric Input-Output models.

Despite their apparent simplicity, IO models are complex but, at the same time, flexible models and can be elaborated in different ways or applied jointly with other models. The estimation of IO tables is demanding on data and represents a major part for constructing CGE models (Rose, 1995). IO tables show an equilibrium situation of the economy in a given year, where relative prices are set and supply and demand are in equilibrium in all markets. This makes IO tables an essential source of data for CGE models, given that CGE models simulate a disruption in the equilibrium of an economy and derive how the economy reacts in reaching another equilibrium point. A theoretical comparison between IO and CGE models can be found, for instance, in Rose (1995), while a comparison of the results obtained from these models can be seen in Koks et al. (2016), Hu et al. (2014) or West (1995).

The work of Rose (1995) and Miller and Blair (2022) presents an overview of standard assumptions of IO models and how researchers can incorporate extensions or apply IO models with different modelling strategies to make them more flexible. For instance, the literature discusses the following main assumptions of IO models and proposes extensions:

- IO models require the use of fixed technical coefficients for the year the IO was estimated. However, time-series data offer more flexibility allowing these technical coefficients to change in each new estimation of the IO tables and thereby accounting for changes in the economic structure. Variable technical coefficients can also be obtained by estimating a new equilibrium system based on econometric IO or CGE models (Miller and Blair, 2022; Rose, 1995).
- Prices play no role in standard IO models, meaning that price changes do not materialise when working with the quantity model. However, IO models can be extended to capture the effects of prices over technical coefficients and final demand based on the Leontief price model (see section 15.7 in Miller and Blair (2022).
- IO is a static model at its origin but if dynamic adjustment effects of the economy are to be studied, Leontief's dynamic IO model can be applied. The dynamic IO model is a temporal model where changes in capital are endogenized and will impact the level of production in time t+1 (see section 14 in Miller and Blair (2022). This model follows the same idea as of dynamic models in macroeconomics.

- IO is mainly a model of production but it can be extended to other areas of work, such as for environmental analysis, energy, emissions, material flows, income distribution, employment by gender and age, impacts of migration, disaster analysis, ageing of the population etc. (Miller and Blair, 2022).

The IO model developed in this paper is a general equilibrium model considering all interconnections among the producing industries to reach final demand. The income generated in the production process is equal to the income used to buy final goods and services. In this way, supply equals demand in all markets and the whole system is in equilibrium.

The goal of this paper is to understand the role of the shipbuilding industry in the US and how different shocks, here the abolition of the Jones Act, can affect the US economy as well as the interconnection of the shipbuilding industry with other industries and economies. We model these shocks on the economy one at a time, using an Inter-Country Input-Output (ICIO) table and IO analysis specifically tailored to the shipbuilding industry. In this way, we use a structural analysis which allows a better understanding of how the US economy is structured and reacts to policy changes.

3.4.3 National model

From the basic Leontief model (Leontief, 1951; Miller and Blair, 2022), total output of an economy can be expressed as the sum of intermediate and final consumption, revenue and demand side, or the sum of intermediate consumption and value added, cost and supply side. Figure 3.4 displays a national input-output table for the case of an economy with two industries.

Figure 3.4 *National Input-Output Table*

	Intermediate use		Final	Total
	Ind 1	Ind *2*	Consumption	Output
Product flows from				
Industry *1*	z_{11}	z_{12}	y_1	x_1
Industry *2*	z_{21}	z_{22}	y_2	x_2
Value added	$(v_1)'$	$(v_2)'$		
Total inputs	$(x_1)'$	$(x_2)'$		

Source: Authors.

From the revenue and demand side, an economy's total output can be expressed as shown in equation 3.1:

$$\sum_{j=1}^{n} z_{ij} + y_i \equiv x_i \qquad \text{for } i = 1, 2, \ldots, n \tag{3.1}$$

where:
z_{ij} is the output of industry i which is used as intermediate input by industry j
y_i is the output of industry i which goes to final consumption
x_i is the total output of industry i
n is the number of industries in the economy

Assuming intermediate flows per unit of final output as fixed, we can express 3.1 as:

$$\sum_{j=1}^{n} a_{ij} x_j + y_i \equiv x_i \qquad \text{for } i = 1, 2, \ldots, n \tag{3.2}$$

where $a_{ij} = \dfrac{z_{ij}}{x_j}$ is the technical coefficient showing the quantity of input from industry i which is needed to produce one unit of final output in industry j.

Equation 3.2 can be expressed in matrix format as:

$$Ax + y = x \tag{3.3}$$

where A is the $n \times n$ direct input-coefficient matrix which describes inter-industry relationships between all industries of the economy, x represents the $n \times 1$ total output vector, and y is the $n \times 1$ final demand vector.

By solving equation 3.3 we obtain output of industries in the economy which is needed to meet final demand (consumption). This means:

$$x = (I - A)^{-1} y \tag{3.4}$$

$$x = By \tag{3.5}$$

where $B = (I - A)^{-1}$, also known as the Leontief inverse, is a $n \times n$ matrix of coefficients capturing total (direct plus indirect) requirements of industries. The element b_{ij} shows total inputs from industry i which is necessary to produce one unit of output to meet final demand of industry j.

3.4.4 Inter-country model

The methodology for the national model can be expanded to a system of more than one economy. Figure 3.5 illustrates the case of two economies, country *L* and *M* with *n* industries in each country.

Figure 3.5 *Inter-Country Input-Output Table*

	Intermediate use		Final Consumption		Total
	in *L*	in *M*	in *L*	in *M*	Output
Product flows from					
Country *L*	$\boldsymbol{Z}^{LL}$	$\boldsymbol{Z}^{LM}$	$\boldsymbol{Y}^{LL}$	$\boldsymbol{Y}^{LM}$	$\boldsymbol{X}^{L}$
Country *M*	$\boldsymbol{Z}^{ML}$	$\boldsymbol{Z}^{MM}$	$\boldsymbol{Y}^{ML}$	$\boldsymbol{Y}^{MM}$	$\boldsymbol{X}^{M}$
Value added	$(\boldsymbol{V}^{L})'$	$(\boldsymbol{V}^{M})'$			
Total inputs	$(\boldsymbol{X}^{L})'$	$(\boldsymbol{X}^{M})'$			

Source: Authors.

With regards to the national model presented in figure 3.4, in the inter-country model, in figure 3.5, the matrices of intermediate consumption (Z), final demand (Y) and output (X) are broken down by country of origin and destination as follows:

$$Z = \begin{bmatrix} Z^{LL} & Z^{LM} \\ Z^{ML} & Z^{MM} \end{bmatrix}$$

$$Y = \begin{bmatrix} Y^{LL} & Y^{LM} \\ Y^{ML} & Y^{MM} \end{bmatrix}$$

$$X = \begin{bmatrix} X^{L} \\ X^{M} \end{bmatrix}$$

where:

Z^{LL}, Z^{LM}, Z^{ML}, Z^{MM} show flows of output from industries in country of origin (*L* or *M*) which are used as intermediate inputs by industry in country of destination (*L* or *M*). For instance, Z^{LM} shows the output of industries of origin country *L* that are used as intermediate inputs by industry in destination country *M*.

Y^{LL}, Y^{LM}, Y^{ML}, Y^{MM} show flows of output from industries in country of origin (*L* or *M*) which go to final consumption in country of destination (*L* or *M*). For instance, Y^{LM} shows outputs of industries of origin country *L* which go to final consumption in destination country *M*.

X^{L}, X^{M} show flows of total output respectively of industries in countries *L* or *M*.

The economic identity presented in equation 3.1 for countries *L* and *M* in the inter-country case becomes:

$$\sum_{j=1}^{n} z_{ij}^{LL} + \sum_{j=1}^{n} z_{ij}^{LM} + y_i^{LL} + y_i^{LM} \equiv z_i^{L} \tag{3.6a}$$

$$\sum_{j=1}^{n} z_{ij}^{ML} + \sum_{j=1}^{n} z_{ij}^{MM} + y_i^{ML} + y_i^{MM} \equiv z_i^{M} \tag{3.6b}$$

$$\text{for } i = 1, 2, \ldots, n$$

In the same way, the development of the Leontief system becomes:

$$\sum_{j=1}^{n} a_{ij}^{LL} x_j^{L} + \sum_{j=1}^{n} a_{ij}^{LM} x_j^{M} + y_i^{LL} + y_i^{LM} \equiv z_i^{L} \tag{3.7a}$$

$$\sum_{j=1}^{n} a_{ij}^{ML} x_j^{L} + \sum_{j=1}^{n} a_{ij}^{MM} x_j^{M} + y_i^{ML} + y_i^{MM} \equiv z_i^{M} \tag{3.7b}$$

$$\text{for } i = 1, 2, \ldots, n$$

where $a_{ij}^{LL} = \frac{z_{ij}^{LL}}{x_j^L}$, $a_{ij}^{LM} = \frac{z_{ij}^{LM}}{x_j^M}$, $a_{ij}^{ML} = \frac{z_{ij}^{ML}}{x_j^L}$, $a_{ij}^{MM} = \frac{z_{ij}^{MM}}{x_j^M}$ are technical coefficients showing the quantity of input from industry *i* in country of origin (*L* or *M*) which is needed to produce one unit of final output in industry *j* in the country of destination (*L* or *M*). All other variables are defined as above.

In matrix format, equations 3.7a and 3.7b are as follows:

$$\begin{bmatrix} A^{LL} & A^{LM} \\ A^{ML} & A^{MM} \end{bmatrix} \quad \begin{bmatrix} X^L \\ X^M \end{bmatrix} + \begin{bmatrix} Y^L \\ Y^M \end{bmatrix} = \begin{bmatrix} X^L \\ X^M \end{bmatrix} \tag{3.8}$$

$$\left\{ \begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix} - \begin{bmatrix} A^{LL} & A^{LM} \\ A^{ML} & A^{MM} \end{bmatrix} \right\} \quad \begin{bmatrix} X^L \\ X^M \end{bmatrix} = \begin{bmatrix} Y^L \\ Y^M \end{bmatrix} \tag{3.9}$$

$$\begin{bmatrix} X^L \\ X^M \end{bmatrix} = \left\{ \begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix} - \begin{bmatrix} A^{LL} & A^{LM} \\ A^{ML} & A^{MM} \end{bmatrix} \right\}^{-1} \quad \begin{bmatrix} Y^L \\ Y^M \end{bmatrix} \tag{3.10}$$

$$\begin{bmatrix} X^L \\ X^M \end{bmatrix} = \begin{bmatrix} B^{LL} & B^{LM} \\ B^{ML} & B^{MM} \end{bmatrix} \quad \begin{bmatrix} Y^L \\ Y^M \end{bmatrix} \tag{3.11}$$

$$\begin{bmatrix} B^{LL} & B^{LM} \\ B^{ML} & B^{MM} \end{bmatrix} = \left\{ \begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix} - \begin{bmatrix} A^{LL} & A^{LM} \\ A^{ML} & A^{MM} \end{bmatrix} \right\}^{-1} \tag{3.12}$$

where $\begin{bmatrix} B^{LL} & B^{LM} \\ B^{ML} & B^{MM} \end{bmatrix}$ is a matrix of coefficients showing the total, direct plus indirect, requirements of the industries in country of destination. For instance, the element b_{ij}^{LM} shows total inputs from industry *i* in origin country *L* which is necessary to produce one unit of output to attend final demand of industry *j* in destination country *M*. Following the same idea of the national model, equation 3.11 becomes as follows for the inter-country model:

$$X = BY \tag{3.13}$$

3.4.5 Impact analysis

From the Leontief model previously defined in equations 3.5 and 3.13, it is possible to measure the impact of changes in final demand (Y), or each of its components such as

household consumption, government spending, investment, and exports, on total output, value added, employment, imports, taxes, wages, among others. Thus, one would have that:

$$\Delta X = B\Delta Y \tag{3.14}$$

$$\Delta V = \hat{v}\Delta X \tag{3.15}$$

$$\Delta V = \hat{v}B\Delta Y \tag{3.16}$$

where ΔX and ΔY are vectors, or matrices, which respectively show the sectoral strategy and impact on volume of production. Vector or matrix, ΔV represents the impact on any of the aforementioned variables, such as value added, employment, imports, taxes, wages among others. At its turn, $\hat{v}$ is a diagonal matrix whose diagonal elements are the coefficients of value added, employment, imports, taxes, wages, among others, which are obtained by dividing, for each sector, the value of these variables in industry i by the total output of the corresponding industry i so that:

$$v_i = \frac{V_i}{X_i} \tag{3.17}$$

To obtain the total impact in an economy, and for each of the variables being analysed, such as output, all the elements of ΔX and ΔY for the specific economy are summed.

Based on the ICIO system and using the theory behind input-output analysis, we simulate the economic impact of production or price changes in the US shipbuilding or water transport sector. The estimation of the economic effect of reduced freight rates for water transport services associated with the Jones Act fleet draws on information of US water transport margins. The simulations of the impact on the overall US economy consider the full ICIO system, including the US spill-over effects on all ICIO economies and the feedback loop from these economies on the US.

3.5 Simulation results

This section presents our simulation results of a hypothetical abolition of the US Jones Act. We investigate the effect of three shocks separately on output (GDP) of the target's sectors' up- and downstream industries. First, we simulate a reduction in shipbuilding output and highlight its impact on the major supplier and buyer industries of the shipbuilding sector. Second, we investigate which US sectors are most affected by reductions in output of domestic water transport services. Third, we analyse which US sectors will most benefit from reductions in domestic water transport costs (i.e. maritime freight rates).

3.5.1 Reduction in shipbuilding output

With the abolition of the Act, shipping companies are free to purchase cheaper and more competitive ships at the international market, thereby reducing demand for domestically produced US ships. In other words, the domestic shipbuilding industry will lose production of Jones Act ships in 2018.

We estimate the direct effect of a reduction in shipbuilding output on up- and downstream industries. Our results show that for each reduction in shipbuilding output by 1,000 USD the US economy will experience an additional reduction by 800 USD (total multiplier by 1.8). For instance, should the US shipbuilding industry lose the entire output of Jones Act compliant ships worth 620 million USD, as derived in section 3.3.1, the US economy faces additional reductions in GDP of around 500 million USD across up- and downstream industries. Table 3.1 lists the US industries that are most affected by reductions in domestic shipbuilding production.

The strongest indirect effect of of a reduction in ship production is observed in ship repair with around 17 percent of the additional effect on GDP, as fewer ships will be repaired in the US building yards. Overall, the US services sector is most affected. Wholesale and retail trade account for 17 percent of the additional loss in output. Yet, this sector being more generic than specialised can more easily switch to other activities in the economy. Other affected services include with 12 percent professional, scientific and technical activities, such as legal services, accounting and architectural or engineering.[20] Furthermore, administrative services account for around 6 percent of the additional effect on GDP, followed with 5 percent

[20]D69T75 Professional, scientific and technical activities includes: Legal Services: NAICS 5411; Accounting, Tax Preparation, Bookkeeping, and Payroll Services: NAICS 5412; Architectural, Engineering, and Related Services: NAICS 5413; Specialized Design Services: NAICS 5414; Computer Systems Design and Related Services: NAICS 5415; Management, Scientific, and Technical Consulting Services: NAICS 5416; Scientific Research and Development Services: NAICS 5417; Advertising and Related Services: NAICS 5418; Other Professional, Scientific, and Technical Services: NAICS 5419.

by each financial and insurance activities as well as real estate services. Supplier industries of intermediate inputs, such as basic metals, fabricated metal products and computer equipment, each make up between 7 and 8 percent of the additional output reduction.

Table 3.1 *US industries most affected by reductions in shipbuilding output*

ISIC	Industry description	% of effect on GDP
D301	Shipbuilding and repair	17%
D45T47	Wholesale and retail trade; repair of motor vehicles	17%
D69T75	Professional, scientific and technical activities	12%
D24	Basic metals	8%
D25	Fabricated metal products	7%
D26	Computer, electronic and optical equipment	7%
D77T82	Administrative and support services	6%
D64T66	Financial and insurance activities	5%
D68	Real estate activities	5%
D302T309	Other transport equipment	4%
D28	Machinery and equipment, nec	3%
D49	Land transport	3%
D20	Chemical and chemical products	2%
D62T63	IT and other information services	2%
D29	Motor vehicles, trailers and semi-trailers	2%

Note: The table indicates the share of reductions in output (GDP) by industry as a result of reductions in shipbuilding output. For instance, for each reduction in shipbuilding output by 1,000 USD, an additional reduction in output of around 800 USD will take place in other industries of the economy dependent on shipbuilding activity. These up- and downstream industries that are most affected by output reduction in the shipbuilding industry are listed in the table. In this example, the basic metals industry will face a reduction in output of around 8 percent of the indirect effect of 800 USD, hence 64 USD for each reduction of 1,000 USD in ship production.
Source: Authors.

Evidently, the complete shutdown of the production of Jones-Act ships will not lead to a loss of input factors, such as capital and labour, that have been set free with the abolition of the policy. Instead, input factors will move into other sectors so that structural adjustment in the US economy can take place in the long-term, for instance supported by adequate policies.

3.5.2 Reduction in output of domestic water transport services

The abolition of the Act implies liberalising domestic water transport services in the US. In this situation, firms are free to contract foreign maritime service providers which are

significantly cheaper and more competitive than US domestic firms (Section 3.3.2). We therefore simulate the effect on GDP of a reduction in annual output of US shippers.

Our estimates imply that a reduction in output of domestic water transport services by 1,000 USD leads to an additional reduction in US GDP by around 1,200 USD (total multiplier by 2.2). The overall result depends on the extent to which US domestic shipping firms manage to realise the cost reductions and compete with foreign firms in the domestic US shipping market. For instance, the US shipping sector generated around 7.9 billion USD revenues in water transport services on Great Lakes and coastal waterways that are related to the Jones Act law in 2018 (Section 3.3.2). In the worst case scenario, if domestic service providers are entirely crowded out by foreign shipping firms the US domestic shipping market will entirely lose its annual revenues and the US imports shipping services from abroad.[21] A complete loss of 7.9 billion USD would be reflected in the short-term in additional reductions in GDP across up- and downstream industries by around 9.4 billion USD.

Table 3.2 shows the US industries most affected by production declines in the US domestic water transport sector. The US financial and insurance sector for maritime transport is most impacted if shipping revenues decline, amounting to 24% of additional reduction in GDP, followed by administrative and support services (15%) and professional, scientific and technical activities, such as legal, accounting or engineering services (9%). In addition, postal (6%) or warehousing activities (6%) and wholesale trade (6%) are concerned. The manufacturing of coke and refined petroleum products is one among the most impacted US industries, accounting for a share of around 4% in additional reductions in GDP.

[21] We also investigate the effect on US GDP of an increase in imports of ships from the major three Asian shipbuilding economies. The impact is very small as the price of Jones Act ships purchased on the international market amounts to only 160 million USD (Section 3.3.1). The US economy will experience an increase in economic output of around 8 million USD from these imports, primarily in the wholesale sector making up 14 percent of additional output.

Table 3.2 *US industries most affected by a decline in shipping services*

ISIC	Industry description	% of effect on GDP
D64T66	Financial and insurance activities	24%
D77T82	Administrative and support services	15%
D69T75	Professional, scientific and technical activities	9%
D53	Postal and courier activities	6%
D52	Warehousing and support activities for transportation	6%
D45T47	Wholesale and retail trade; repair of motor vehicles	6%
D19	Coke and refined petroleum products	4%
D68	Real estate activities	4%
D25	Fabricated metal products	3%
D302T309	Other transport equipment	2%
D62T63	IT and other information services	2%
D49	Land transport and transport via pipelines	2%
D301	Shipbuilding and repair	2%
D05T06	Mining and quarrying, energy producing products	2%
D61	Telecommunications	1%

Note: The table indicates the share of reductions in output (GDP) by industry as a result of reductions in output in US domestic shipping services. Up- and downstream industries most affected by output reduction in the shipbuilding industry are listed in the table. In this example, the financial and insurance industry will face a reduction in output of around 24 percent of the indirect effect of 1,200 USD, hence 288 USD for each reduction of 1,000 USD in output in shipping services.
Source: Authors.

3.5.3 Reduction in shipping costs: Increase in output of domestic downstream industries

With the abolition of the Act, the US domestic water transport sector is open to foreign shipping firms that are considered significantly cheaper and more competitive than their domestic US counterparts. As detailed in section 3.3.2, freight costs of US Jones Act ships are almost three-times higher than of comparable foreign service providers who can choose the crew, flag state, builder country and ship ownership country internationally. We investigate the impact of reductions in water transport costs, arising from lower capital and operating costs, on output of US upstream and downstream industries.

Reduced water transport costs and competition with foreign service providers lead to lower freight rates which affect the US economy in two major ways. First, water transportation becomes relatively cheaper compared to other transport modes, leading to modal substitution towards coastal shipping. Second, lower shipping rates reduce unit production

costs, leading to an increase in demand for goods using domestic water transport services. We focus on the second impact which generates additional output in the economy from up- and downstream industries instead of a shift in existing output through inter-modal substitution.

We assume an elasticity of -0.55, so that a decrease in water transport rates by 1 percent, will lead to an average increase of 0.55 percent in the final demand for goods using domestic water transport services.[22]. Unfortunately, we were not able to obtain a more recent estimate of elasticity from the literature. However, as we use a static model, the relative effect across industries will not change when using different levels of trade elasticities.

Table 3.3 reports the results in percentages on the up- and downstream industries that benefit most from reduced domestic shipping rates. Food products will benefit the most with around 18 percent of additional output generated from lower shipping rates, followed by wholesale trade and agricultural products, each 8 percent, and pharmaceuticals, computer, electronics and optical equipment as well as petroleum products with 6 percent each.

Table 3.3 *Overview of effects on output on down- and upstream industries*

ISIC	Industry description	% of effect on GDP
D10T12	Food products, beverages and tobacco	18%
D45T47	Wholesale and retail trade; repair of motor vehicles	8%
D01T02	Agriculture, hunting, forestry	8%
D21	Pharmaceuticals, medicinal chemical and botanical products	6%
D26	Computer, electronic and optical equipment	6%
D19	Coke and refined petroleum products	6%
D20	Chemical and chemical products	5%
D28	Machinery and equipment, nec	5%
D69T75	Professional, scientific and technical activities	5%
D31T33	Manufacturing nec; repair and installation of machinery and equipment	4%
D05T06	Mining and quarrying, energy producing products	3%
D25	Fabricated metal products	3%
D17T18	Paper products and printing	2%
D64T66	Financial and insurance activities	2%
D49	Land transport and transport via pipelines	2%

Note: The table indicates the share of increases in output (GDP) by industry as a result of reductions shipping costs (i.e. maritime freight rates).
Source: Authors.

[22] US ITC (2002) assumes a trade elasticity of around 0.55 percent in 1999.

3.6 Conclusion

Restrictions on domestic water transport services, known as cabotage, are no new policy instruments and have been repeatedly analysed in the past. Yet, the US is ranked as having one of the most restrictive domestic maritime transport industries and a cabotage law that imposes economic costs ranking in magnitude second among US import restraints.

This paper analyses the economic effects of a hypothetical repeal of the long-standing US Jones Act that mandates domestic US seaborne trade be conducted on US built, US flagged, US crewed and US owned vessels. The simulations exploit OECD's Inter-Country Input-Output (ICIO) that has been disaggregated to the level of the US domestic shipbuilding industry. We analyse the impact of a policy change on the domestic shipbuilding and shipping sectors as well as up- and downstream industries. We detail the sectors most affected by the policy change through three separate shocks: i) reductions in domestic shipbuilding output, ii) reductions in domestic water transport services and iii) reductions in domestic water transport costs.

Overall the simulation results reveal that the domestic US shipping market withholds unrealised economic growth in the sectors of food, agriculture, wholesale, pharmaceuticals, electrical equipment, electronics and optical equipment. As non-coastal US States are most dependent on domestic shipping services, product prices from the mainland would decrease in these sectors with the abolition of the Act – a finding which echoes outcomes of other studies (Advantage, 2019; Dunham Associates, 2019).

However, the US shipbuilding industry associated with the construction of Jones-Act compliant ships makes up only a small share of US shipbuilding in total (11%). While US shipyards are considered uncompetitive in the construction of ocean-going vessels in light of the rising economic power of Asian shipbuilding countries, US firms remain competitive in the construction of inland vessels. In other words, resources in the shipbuilding industry that have been set free with the policy change could be reoriented towards other areas within the same industry, notably for the construction of vessels designed for inland waterways.

A liberalisation of the policy would also entail environmental benefits. As water transport is considered as one of the least polluting modes (Doll et al., 2020; Working Group III to IPCC, 2014), a restructuring of the domestic US water transport sector will not only increase demand for shipping services but might also shift trade away from more polluting modes, such as road or air transport. For future research it would be interesting to understand the environmental implications associated with an abolition of the Jones Act policy.

C Appendix

C.1 Details about US Jones Act requirements

The following details about the requirements of the US Jones Act in this section are based on and taken from Gourdon and Guilhoto (2019).

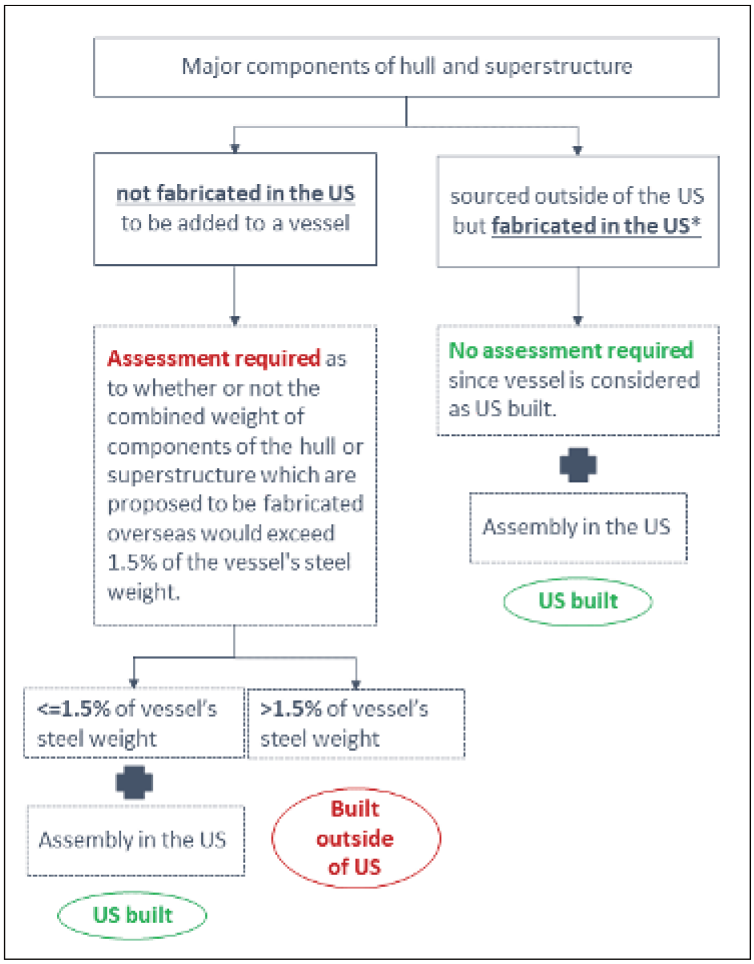
For a US-flagged vessel to be qualified to engage in US coastwise trade (46 USC 55102(b)), originally section 27 of the Merchant Marine Act of 1920, as amended Jones Act trade)) and qualify for a coastwise endorsement on its certificate of documentation it must be, inter alia:

- built in the US,
- owned by entities whose chief executive officer, president and chairman of the board of directors (and anyone that can act in their absence or disability) must be US citizens, and whose equity is at least 75 percent held (of record and beneficially) by US citizens,
- with 75 percent of US crew and
- registered under US flag.

Built in the US criteria: A vessel is deemed to be built in the US only if all major components of the hull and superstructure are fabricated in the US and the vessel is entirely assembled in the US (46 CFR §67.97). Figure C.1 provides an overview of the requirements for a ship to qualify for being built in the US, following a letter from US Department of Homeland Security (2017) to Philly Shipyard, a US shipyard. As long as major components of the vessel's hull and superstructure are fabricated in the US these components can be imported from outside of the US. However, once a major component of the hull and superstructure imported weights more than 1.5 percent of the vessel's steel weight it fails to fulfil the US built criteria. In this case, ship owners will not be allowed to operate the vessel in

intra-US maritime transport. Taken together, the information suggests that US shipbuilders are required to source a significant share of intermediate inputs domestically to fulfil the LCR and fabricate the major components of the hull and superstructure, as well as assemble the vessel in the US.

Figure C.1 *Jones Act's built in the US criteria*



Notes: **This criteria includes, for instance, major components of hull and superstructure that are purchased from foreign steel manufacturers in standard lengths, widths and shapes and are not custom designed or fabricated for use in the vessels.
Source: Gourdon and Guilhoto (2019) based on Frittelli (2019); US Department of Homeland Security (2017).

Bibliography

AAR (2021). Railroad 101. *Railroad 101*, (February).

Abreu, M. D. (2016). Preferential rules of origin in regional trade agreements. In *Regional Trade Agreements and the Multilateral System*, number March, pages 5–5.

ACI (2020). 2020 North American Airport Traffic Summary (Cargo).

Adão, R., Carrillo, P., Costinot, A., Donaldson, D., and Pomeranz, D. (2022). Imports, Exports, and Earnings Inequality: Measures of Exposure and Estimates of Incidence. *The Quarterly Journal of Economics*, 137(3):1553–1614.

Advantage (2019). Analysis of issues related to maritime transportation to Puerto Rico. Technical report, Advantage Business Consulting.

Agnosteva, D. E., Anderson, J. E., and Yotov, Y. V. (2019). Intra-national trade costs: Assaying regional frictions. *European Economic Review*, 112.

Albert, C. and Nilsson, L. (2016). To use, or not to use (trade preferences), that is the question.

Albrecht, L. and Tombe, T. (2016). Internal trade, productivity and interconnected industries: A quantitative analysis. *Canadian Journal of Economics*, 49(1):237–263.

Allen, T. (2014). Information Frictions in Trade. *Econometrica*, 82(6):2041–2083.

Allen, T. and Arkolakis, C. (2014). TRADE AND THE TOPOGRAPHY OF THE SPATIAL ECONOMY. *Quarterly Journal of Economics*, (2002):1085–1139.

Anderson, J. E. and van Wincoop, E. (2003). Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review*, 93(1):170–192.

Anderson, J. E. and van Wincoop, E. (2004). Trade Costs. *Journal of Economic Literature*, 42(3):691–751.

Anderson, J. E. and Yotov, Y. V. (2016). Terms of trade and global efficiency effects of free trade agreements, 1990-2002. *Journal of International Economics*, 99:279–298.

Angeli, M., Gourdon, J., Gutierrezø, I., and Kowalski, P. (2020). *Handbook of Deep Trade Agreements*. World Bank Publications.

Anouti, Y., Manzano, O. E., Tordo, S., and Warner, M. (2013). *Local Content Policies in the Oil and Gas Sector*. The World Bank Group.

Anson, J., Cadot, O., Estevadeordal, A., De Melo, J., Suwa-Eisenmann, A., and Tumurchudur, B. (2005). Rules of origin in North-South preferential trading arrangements with an application to NAFTA. *Review of International Economics*, 13(3):501–517.

Arkolakis, C., Costinot, A., and Rodríguez-Clare, A. (2012). New trade models, same old gains? *American Economic Review*, 102(1):94–130.

Asturias, J. (2020). Endogenous transportation costs. *European Economic Review*, 123:103366.

Augier, P., Gasiorek, M., and Lai Tong, C. (2005). The impact of rules of origin on trade flows. *Economic Policy*, 20(43):567–624.

Ayele, Y., Gasiorek, M., and Koecklin, M. T. (2022). Trade Preference Utilisation Post-Brexit : The Role of Rules of Origin.

Bahar, H., Egeland, J., and Steenblik, R. (2013). Domestic incentive measures for renewable energy with possible trade implications. *OECD Trade and Environment Working Papers*.

Baier, S. L. and Bergstrand, J. H. (2007). Do free trade agreements actually increase members' international trade? *Journal of International Economics*, 71(1):72–95.

Baldwin, R. and Taglioni, D. (2006). Gravity for dummies and dummies for gravity equations. Technical report.

BEA (2021). Marine Economy Satellite Account, 2014-2019.

Beaulieu, E. and Zaman, M. R. (2019). Do subnational trade agreements reduce trade barriers? Empirical evidence from Canadian provinces. *Canadian Public Policy*, 45(1):1–15.

Behar, A. and Venables, A. J. (2011). Transport costs and international trade. *Handbook of transport economics*, pages 97–115.

Belderbos, R. A. and Sleuwaegen, L. (1997). Local content requirements and vertical market structure. *European Journal of Political Economy*, 13(1):101–119.

Bergstrand, J. H., Larch, M., and Yotov, Y. V. (2015). Economic integration agreements, border effects, and distance elasticities in the gravity equation. *European Economic Review*, 78:307–327.

Bergstresser, D. and Melitz, M. (2017). The Jones Act and the Cost of Shipping Between US Ports. *EconoFact*.

Besedes, T. and Chu, J. (2021). Fly the Unfriendly Skies : the Role of Transport Costs in Gravity Models of Trade.

Besedeš, T. and Panini, A. (2017). Experimenting with Ash: The Trade-Effects of Airspace Closures in the Aftermath of Eyjafjallajökull.

Blonigen, B. A. and Wilson, W. W. (2008). Port efficiency and trade flows. *Review of International Economics*, 16(1):21–36.

Blum, B. S. and Goldfarb, A. (2006). Does the internet defy the law of gravity? *Journal of International Economics*, 70(2):384–405.

Bora, B., Kuwahara, A., and Laird, S. (2002). *Quantification of Non-tariff Measures*. Number 18.

Borchert, I., Larch, M., Shikher, S., and Yotov, Y. V. (2021). The international trade and production database for estimation (ITPD-E). *International Economics*, 166:140–166.

Borchert, I. and Yotov, Y. V. (2017). Distance, globalization, and international trade. *Economics Letters*, 153(C):32–38.

Brenton, P. (2003). Notes on Rules of Origin with Implications for Regional Integration on Southeast Asia. In *PECC Trade Forum*, pages 1–32.

Brunelin, S., De Melo, J., and Portugal-Perez, A. (2019). How Much Market Access? A Case Study of Jordan's Exports to the EU. *World Trade Review*, 18(3):431–449.

BTS (2012a). Freight Flows by Highway, Railroad, and Waterway: 2012.

BTS (2012b). Standard Classification of Transported Goods (SCTG) Codes.

BTS (2020). Transportation Statistics Annual Report 2020. Technical report.

BTS (2022). Water Transport Profile.

Bureau, J.-C., Chakir, R., and Gallezot, J. (2006). The Utilisation of EU and US Trade Preferences for Developing Countries in the Agri-Food Sector.

Burfisher, M. E. (2021). *Introduction to computable general equilibrium models*. Cambridge University Press.

Cadestin, C., Gourdon, J., and Kowalski, P. (2016). Participation in Global Value Chains in Latin America. *OECD Trade policy papers No. 192*.

Cadot, O., Carrere, C., De Melo, J., and Tumurchudur, B. (2006). Product-specific rules of origin in EU and US preferential trading arrangements: An assessment. *World Trade Review*, 5(2):199–224.

Cadot, O. and de Melo, J. (2008). Why OECD countries should reform rules of origin. *World Bank Research Observer*, 23(1):77–105.

Cadot, O. and Estevadeordal, A. (2006). Rules of Origin as export subsidies. *The Origin of Goods*, (February):149–172.

Cadot, O., Fernandes, A., Gourdon, J., Mattoo, A., and de Melo, J. (2014a). Evaluation in AFT: From Case-study Counting to Measuring. *The World Economy*, 37(4):516–529.

Cadot, O. and Gourdon, J. (2016). Non-tariff measures, preferential trade agreements, and prices: new evidence. *Review of World Economics*, 152(2):227–249.

Cadot, O., Graziano, A., Harris, J., and Volpe, C. (2014b). Do Rules of Origin Constrain Export Growth ? *Inter-American Development Bank*, (April):Discussion Paper No. IDB–DP–350.

Cadot, O. and Ing, L. Y. (2014). How Restrictive Are ASEAN's RoO? *ERIA Discussion Paper Series*, pages DP–2014–18.

Cadot, O. and Ing, L. Y. (2016). How restrictive are ASEAN's rules of origin? *Asian Economic Papers*, 15(3):115–134.

Candau, F., Fontagne, L., and Jean, S. (2004). The utilisation rate of preferences in the EU. *7th Global Economic Analysis Conference, Washington D.C., 17-19 June 2004*.

Carrère, C. and De Melo, J. (2011). Non-Tariff Measures: What Do We Know, What Might Be Done? *Journal of Economic Integration*, 26(1):169–196.

Carrère, C. and de Melo, J. (2015). *Are Different Rules of Origin Equally Costly? Estimates from NAFTA*.

Carrere, C., De Melo, J., and Wilson, J. (2009). The Distance Effect and the Regionalization of the Trade of Low-Income Countries. *CEPR Discussion Paper*.

Cato Institute (2018). The Jones Act: A Burden America Can No Longer Bear. *Cato Institute*, (845):1 – 21.

Cato Institute (2019). The Jones Act Fleet : High Costs and Limited Capabilities.

Cato Institute (2021a). How Would Jones Act Reform Impact U.S. Shipbuilding?

Cato Institute (2021b). New Reports Confirm the Jones Act's Paltry Contributions to U.S. Shipbuilding.

Center for Transportation Analysis Oak Ridge National Laboratory (2015). Freight Analysis Framework Version 4 User's Guide for Release 4.0. page 18.

Chaney, T. (2008). Distorted gravity: The intensive and extensive margins of international trade. *American Economic Review*, 98(4):1707–1721.

Chaney, T. (2018). The gravity equation in international trade: An explanation. *Journal of Political Economy*, 126(1).

Chen, N. (2004). Intra-national versus international trade in the European Union: Why do national borders matter? *Journal of International Economics*, 63(1):93–118.

Clark, X., Dollar, D., and Micco, A. (2004). Port efficiency, maritime transport costs, and bilateral trade. *Journal of Development Economics*, 75(2):417–450.

Clarksons Research (2022). World Fleet Register Database.

Combes, P. P. and Lafourcade, M. (2005). Transport costs: Measures, determinants, and regional policy implications for France. *Journal of Economic Geography*, 5(3):319–349.

Combes, P. P., Lafourcade, M., and Mayer, T. (2005). The trade-creating effects of business and social networks: Evidence from France. *Journal of International Economics*, 66(1):1–29.

Conconi, P., García-santana, M., Puccio, L., Venturini, R., The, S., Economic, A., August, N., Conconi, B. P., García-santana, M., Puccio, L., and Venturini, R. (2018). From Final Goods to Inputs. *The American Economic Review*, 108(8):2335–2365.

Coughlin, C. C. and Novy, D. (2012). Is the International Border Effect Larger than the Domestic Border Effect? Evidence from US Trade. *CESifo Economic Studies*, 59(2):249–276.

Coughlin, C. C. and Novy, D. (2016). Estimating Border Effects: The Impact of Spatial Aggregation. *Ssrn*.

Coughlin, C. C. and Novy, D. (2021). Estimating Border Effects: the Impact of Spatial Aggregation. *International Economic Review*, 0(0).

Coşar, A. K. and Demir, B. (2016). Domestic road infrastructure and international trade: Evidence from Turkey. *Journal of Development Economics*, 118:232–244.

de Melo, J. and Portugal-Perez, A. (2014). Preferential market access design: Evidence and lessons from african apparel exports to the United States and the European union. *World Bank Economic Review*, 28(1):74–98.

Department of Transportation (2020). Freight rail overview. *Federal Railroads Administration*, pages 15–17.

Deringer, B. H., Erixon, F., Lamprecht, P., and Marel, E. V. D. (2018). The economic impact of local content requirements : A case study of heavy vehicles. *ECIPE Occasional Paper*, (1):1–46.

Disdier, A.-C., Gaigné, C., and Herghelegiu, C. (2020). Do Standards Improve the Quality of Traded Products? pages 1–55.

Disdier, A.-C. and Head, K. (2008). The Puzzling Persistence of the Distance Effect on Bilateral Trade. *Review of Economics and Statistics*, 90(1):37–48.

Dixon, P. B., Rimmer, M. T., and Waschik, R. G. (2018). Evaluating the effects of local content measures in a CGE model: Eliminating the US Buy America (n) programs. *Economic Modelling*, 68:155–166.

Doll, C., Brauer, C., Köhler, J., and Scholten, P. (2020). Methodology for GHG Efficiency of Transport Modes. pages 1–88.

Donaldson, D. and Hornbeck, R. (2016). RAILROADS AND AMERICAN ECONOMIC GROWTH: A "MARKET ACCESS" APPROACH. *The Quarterly Journal of Economics*, 131(2):799–858.

Dunham Associates (2019). The Jones Act - a legacy of economic ruin for Puerto Rico. Technical report, John Dunham and Associates.

Duranton, G. (2015). Roads and trade in Colombia. *Economics of Transportation*, 4(1-2):16–36.

Duranton, G., Morrow, P. M., and Turner, M. A. (2014). Roads and trade: Evidence from the US. *Review of Economic Studies*, 81(2):681–724.

Eaton, J. and Kortum, S. (2002). Technology, Geography, and Trade. *Econometrica*, 70(5):1741–1779.

ECSA (2014). ECSA looks forward to fruitful EU-US trade negotiations.

Egger, P. H. and Nigai, S. (2015). Structural gravity with dummies only: Constrained ANOVA-type estimation of gravity models. *Journal of International Economics*, 97(1):86–99.

Espitia, A., Mattoo, A., Mimouni, M., Pichot, X., and Rocha, N. (2020). Preferential tariffs. *Handbook of Deep Trade Agreements*, page 45.

Estevadeordal, A. (2000). *Negotiating Preferential Market Access: The Case of NAFTA*, volume 34.

Estevadeordal, A., Harris, J., and Suominen, K. (2007). Multilateralizing Preferential Rules of Origin around the World.

European Commission (1995). THE EUROPEAN COMMUNITY RATIFIES OECD SHIP-BUILDING AGREEMENT.

European Commission (2017). Trade Sustainability Impact Assessment on the Transatlantic Trade and Investment Partnership (TTIP) between the European Union and the United States of America - Final Inception Report. Technical report, European Commission.

Fally, T. (2015). Structural gravity and fixed effects. *Journal of International Economics*, 97(1):76–85.

Feenstra, R. C. (2004). *Advanced international trade: theory and evidence*. Princeton university press.

Feyrer, J. (2019). Trade and income-exploiting time series in geography. *American Economic Journal: Applied Economics*, 11(4):1–35.

Feyrer, J. (2021). Distance, trade, and income — The 1967 to 1975 closing of the Suez canal as a natural experiment. *Journal of Development Economics*, 153(May):102708.

FHWA (2022). National Highway Freight Network.

Fitzgerald, T. and Mulligan, C. B. (2020). How the Jones Act literally has cows flying first class, and does environmental damage.

Fontagné, L., Orefice, G., Piermartini, R., and Rocha, N. (2015). Product standards and margins of trade: Firm-level evidence. *Journal of International Economics*, 97(1):29–44.

Francois, J., Hoekman, B., and Manchin, M. (2006). Preference erosion and multilateral trade liberalization. *World Bank Economic Review*, 20(2):197–216.

Francois, J. F., Arce, H. M., Reinert, K. A., and Flynn, J. E. (1996). Commercial policy and the domestic carrying trade. *Canadian Journal of Economics*, pages 181–198.

Frankel, J. and Romer, D. (1999). Does Trade Cause Growth? *The American Economic Review*, 89(3):379–399.

Frittelli, J. (2017). Revitalizing Coastal Shipping for Domestic Commerce.

Frittelli, J. (2019). Shipping Under the Jones Act: Legislative and Regulatory Background. Technical report, Congressional Research Service.

Fugazza, M. (2013). The Economics Behind Non-Tariff Measures: Theoretical Insights and Empirical Evidence. *Policy Issues in International Trade and Commodities Study Series*, (57):1–33.

Garamendi (2020). Congress Passes Garamendi Amendment Requiring Jones Act Enforcement in Offshore Wind.

Gillson, I. (2012). Deepening Regional Integration to Eliminate the Fragmented Goods Market in Southern Africa. In Brenton, P. and Isik, G., editors, *De-Fragmenting Africa: Deepening Regional Trade in Goods and Services*, chapter Chapter 8, pages 1–191. The World Bank Group.

Gourdon, J., Bastien, V., Folliot-Lalliot, L., Gourdon, J., Bastien, V., and Folliot-Lalliot, L. (2017). OECD taxonomy of measures affecting trade in government procurement processes. (198).

Gourdon, J., de Melo, J., and Gourdon, K. (2023). A (more) systematic exploration of the trade effect of product-specific rules of origin. *Robert Schuman Centre for Advanced Studies Research Paper*, (2023_26).

Gourdon, J., Kniahin, D., de Melo, J., and Mimouni, M. (2021). Mapping and comparing Rules of Origin across Regional Trade Agreements with ITC ' s Rules of Origin Facilitator.

Gourdon, J., Monjon, S., and Poncet, S. (2016). Trade policy and industrial policy in China: What motivates public authorities to apply restrictions on exports? *China Economic Review*, 40:105–120.

Gourdon, K. and Guilhoto, J. (2019). Local Content Requirements and Their Economic Effect on Shipbuilding. *OECD Science, Technology and Industry Policy Papers*, (69).

Gourdon, K. and Steidl, C. (2019). Global value chains and the shipbuilding industry. Technical report, OECD, Paris.

Grennes, T. (2018). An Economic Analysis of the Jones Act. *SSRN Electronic Journal*.

Hakobyan, S. (2015). Accounting for underutilization of trade preference programs : The US generalized system of preferences. *The Canadian Journal of Economics*, 48(2):408–436.

Harris, J. (2007). Measurement and Determinants of Rules of Origin in Preferential Trade Agreements. *Disertción de Doctorado, Universidad de Maryland, College Park*.

Hayakawa, K. (2011). Measuring fixed costs for firms' use of a free trade agreement: Threshold regression approach. *Economics Letters*, 113(3):301–303.

Hayakawa, K., Jinji, N., Matsuura, T., and Yoshimi, T. (2019). Costs of Utilizing Regional Trade Agreements. *RIETI Discussion Paper Series*, 19-E-054.

Hayakawa, K., Laksanapanyakul, N., and Urata, S. (2016). Measuring the costs of FTA utilization: evidence from transaction-level import data of Thailand. *Review of World Economics*, 152(3):559–575.

Head, K. and Mayer, T. (2010). Illusory border effects. In *The Gravity Model in International Trade*, page 165.

Head, K. and Mayer, T. (2014). Gravity Equations: Workhorse,Toolkit, and Cookbook. *Handbook of International Economics*, 4:131–195.

Heid, B., Larch, M., and Yotov, Y. (2017). Estimating the Effects of Non-discriminatory Trade Policies within Structural Gravity Models. *CESifo Working Paper*, 6735(November).

Herin, J. (1986). *Rules of Origin and Differences between Tariff Levels in EFTA and in the EC*. EFTA Dpt des affaires économiques.

Hillberry, R. and Hummels, D. (2003). Intranational home bias: Some explanations. *Review of Economics and Statistics*, 85(4):1089–1092.

Hillberry, R. and Hummels, D. (2008). Trade responses to geographic frictions: A decomposition using micro-data. *European Economic Review*, 52(3):527–550.

Hoekman, B. and Inama, S. (2018). Harmonization of Rules of Origin: An Agenda for Plurilateral Cooperation? *East Asian Economic Revi*, 22(1):3–28.

Holguín-Veras, J., Kalahasthi, L., Campbell, S., González-Calderón, C. A., and (Cara) Wang, X. (2021). Freight mode choice: Results from a nationwide qualitative and quantitative research effort. *Transportation Research Part A: Policy and Practice*, 143(November 2020):78–120.

Hu, A., Xie, W., Li, N., Xu, X., Ji, Z., and Wu, J. (2014). Analyzing regional economic impact and resilience: A case study on electricity outages caused by the 2008 snowstorms in southern China. *Natural Hazards*, 70(2):1019–1030.

Huang, R. R. (2007). Distance and trade: Disentangling unfamiliarity effects and transport cost effects. *European Economic Review*, 51(1):161–181.

Hufbauer, G. C. and Elliott, K. A. (1994). *Measuring the costs of protection in the United States*. Peterson Institute.

Hufbauer, G. C., Schott, J. J., and Cimino-Isaacs, C. (2013). *Local content requirements: A global problem*, volume 102. Columbia University Press.

Hummels, D. (1999). Have international transportation costs declined? *Purdue University*, 21(July):131–154.

Hummels, D. L. (2001). Toward a Geography of Trade Costs.

Hummels, D. L. and Schaur, G. (2013). Time as a trade barrier. *American Economic Review*, 103(7):2935–2959.

Huntington-Klein, N. (2021). *The effect: An introduction to research design and causality*. Chapman and Hall/CRC.

Hwang, H.-L., Hargrove, S., Chin, S.-M., Wilson, D., Lim, H., Chen, J., Taylor, R., Peterson, B., and Davidson, D. (2016). *The Freight Analysis Framework Version 4 (FAF4) - Building the FAF4 Regional Database: Data Sources and Estimation Methodologies*, volume 4.

Inama, S. (2022). *Rules of origin in international trade*.

ITF (2022). Mode choice in freight transport. Technical report.

Keck, A. and Lendle, A. (2012). New Evidence on Preference Utilization. *SSRN Electronic Journal*, (September).

Kelleher, S. (2012). Playing by the rules? The development of an amended index to measure the impact of rules of origin on intra-PTA trade flows UCD.

Kniahin, D. and de Melo, J. (2022). A Primer on Rules of Origin as Non-Tariff Barriers. *Journal of Risk and Financial Management*, 15(7).

Koks, E. E., Carrera, L., Jonkeren, O., Aerts, J. C., Husby, T. G., Thissen, M., Standardi, G., and Mysiak, J. (2016). Regional disaster impact analysis: Comparing input-output and computable general equilibrium models. *Natural Hazards and Earth System Sciences*, 16(8):1911–1924.

Komaromi, A., Cerdeiro, D. A., and Liu, Y. (2022). Supply chains and port congestion around the world.

Krishna, K., Salamanca, C., Suzuki, Y., and Martincus, C. V. (2021). LEARNING TO USE TRADE AGREEMENTS.

Krugman, P. (1991). *Geography and Trade*. MIT Press.

Larch, M. and Wanner, J. (2017). Carbon tariffs: An analysis of the trade, welfare, and emission effects. *Journal of International Economics*, 109.

Lendle, A., Olarreaga, M., Schropp, S., and Vézina, P. L. (2016). There Goes Gravity: eBay and the Death of Distance. *The Economic Journal*, 126(591):406–441.

Leontief, W. W. (1936). Quantitative Input and Output Relations in the Economic Systems of the United States. *Review of Economics and StatisticsStudies*, 18.

Leontief, W. W. (1951). The structure of American economy, 1919-1939: an empirical application of equilibrium analysis. Technical report.

Limao, N. and Venables, A. J. (2001). Infrastructure, geographical disadvantage, transport costs, and trade. *The World Bank economic review*, 15(3 (September 2001)):451–479.

Lloyd, P. J. (1993). A Tariff Substitute for Rules of Origin in Free Trade Areas. *World Economy*, 16(6):699–712.

Lux, M. (2011). Defying gravity: The substitutability of transportation in international trade.

Manchin, M. (2006). Preference utilisation and tariff reduction in EU imports from ACP countries. *World Economy*, 29(9):1243–1266.

Manchin, M. and Pelkmans-Balaoing, A. O. (2007). *Rules of origin and the web of East Asian free trade agreements*, volume 4273. World Bank Publications.

Marad (2018). U.S.-Flag Privately-Owned Fleet (As of October 1, 2018). Technical report, US Department of Transportation - Maritime Administration.

Marad (2021). America's Marine Highways.

MARAD (2021a). The Economic Importance of the U.S. Private Shipbuilding and Repairing Industry. Technical report.

MARAD (2021b). United States-Flag Privately-Owned Merchant Fleet Report. Technical report, U.S. Department of Transportation Maritime Administration.

Martínez-Zarzoso, I., García-Menéndez, L., and Suárez-Burguet, C. (2003). Impact of transport costs on international trade: The case of Spanish ceramic exports. *Maritime Economics and Logistics*, 5(2):179–198.

Martínez-Zarzoso, I. and Suárez-Burguet, C. (2005). Transport costs and trade: Empirical evidence for Latin American imports from the European Union. *Journal of International Trade and Economic Development*, 14(3):353–371.

Mavroidis, P. C. (2018). The case for dropping preferential rules of origin. *Journal of World Trade*, 52(1).

Mayer, T. and Zignago, S. (2011). The GeoDist Database on Bilateral Geographical Information. *Cepii*, page 18.

McCain, J. (2017a). S.1561 — 115th Congress (2017-2018).

McCain, J. (2017b). S.1894 — 115th Congress (2017-2018).

McCallum, J. (1995). American Economic Association National Borders Matter : Canada-U . S . Regional Trade Patterns Author (s): John McCallum Source : The American Economic Review , Vol . 85 , No . 3 (Jun ., 1995), pp . 615-623 Published by : American Economic Association. *The American Economic Review*, 85(3):615–623.

Medalla, E. M. and Balboa, J. (2009). ASEAN Rules of Origin: Lessons and Recommendations for Best Practice. *ERIA Discussion Paper (Economic Research Institute for ASEAN and East Asia)*, 2009-17.

Melitz, M. J. and Ottaviano, G. I. (2008). Market Size, Trade, and Productivity. *Review of Economic Studies*, 75:295–316.

Miller, R. E. and Blair, P. D. (2022). *Input–Output Analysis: foundations and extensions*. Cambridge University Press, Cambridge.

Millimet, D. L. and Osang, T. (2007). Do state borders matter for US intranational trade? The role of history and internal migration. *Canadian Journal of Economics/Revue canadienne d'économique*, 40(1):93–126.

Nilsson, L. (2011). SMALL TRADE FLOWS AND PREFERENCE UTILISATION: THE CASE OF THE EUROPEAN UNION. *South African Journal of Economics*, 79(4):392–410.

Nilsson, L. (2016). EU exports and uptake of preferences: a first analysis. *Journal of World Trade*, 50(2).

Nitsch, V. (2000). National Borders and International Trade: Evidence from the European Union. *Canadian Journal of Economics*, 33(4):1091–1105.

Novy, D. (2013). Gravity redux: measuring international trade costs with panel data. *Economic inquiry*, 51(1):101–121.

Obstfeld, M. and Rogoff, K. (2000). The six major puzzles in international macroeconomics: Is there a common cause? *NBER Macroeconomics Annual*, 15(1):326–390.

OECD (2021). OECD Inter-Country Input-Output Database.

Olivero, M. P. and Yotov, Y. V. (2012). Dynamic gravity : endogenous country size and asset accumulation. *The Canadian Journal of Economics*, 45(1):64–92.

Olney, W. W. (2020). Cabotage sabotage? The curious case of the Jones Act. *Journal of International Economics*, 127:1–37.

Orefice, G. (2017). Non-tariff measures, specific trade concerns and tariff reduction. *The World Economy*, 40(9):1807–1835.

O'Rourke, R. (2010). DOD Leases of Foreign-Built Ships : Background for Congress. Technical report, Congressional Research Service.

Ramondo, N., Rodríguez-Clare, A., and Saborío-Rodríguez, M. (2016). Trade, domestic frictions, and scale effects. *American Economic Review*, 106(10):3159–3184.

Rauch, J. E. (1999). Networks versus markets in international trade. *Journal of International Economics*, 48(1):7–35.

Rodrigue, J.-P. and Notteboom, D. T. (2020). The economic importance of transportation. In *The Geography of Transport Systems*, page 480. Routledge, London, 5th editio edition.

Rose, A. (1995). Input-output economics and computable general equilibrium models. *Structural Change and Economic Dynamics*, 6(3):295–304.

Rose, A. and Guha, G.-S. (2004). Computable General Equilibrium Modeling of Electric Utility Lifeline Losses from Earthquakes. (August 1999):119–141.

Samimi, A., Kawamura, K., and Mohammadian, A. (2011). A behavioral analysis of freight mode choice decisions. *Transportation planning and technology*, 34(8):857–869.

Silva, J. M. C. S. and Tenreyro, S. (2006). The log of gravity. *The Review of Economics and statistics*, 88(4):641–658.

Stone, S., Messent, J., and Flaig, D. (2015). Emerging policy issues: Localisation barriers to trade.

Suominen, K. (2004). *Rules of Origin in Global Commerce*. Phd thesis, University of California, San Diego.

Swisher, S. N. I. and Wong, W. F. (2015). Transport Networks and Internal Trade Costs - Quantifying the Gains from Repealing the Jones Act.

Sytsma, T. (2022). Improving Preferential Market Access through Rules of Origin: Firm-Level Evidence from Bangladesh. *American Economic Journal: Economic Policy*, 14(1):440–472.

Tanaka, K. and Fukunishi, T. (2022). Rules of origin and exports in developing economies: The case of garment products. *Journal of Asian Economics*, 82(October 2021):101514.

The White House (2021). President Biden's Bipartisan Infrastructure Law.

Tombe, T. and Winter, J. (2013). What's Inside Counts: Migration, Taxes, and the Internal Gains from Trade. *Department of Economics, University of Calgary, Working Papers: 2013-28, 2013*, pages –.

Trefler, D. (2004). The Long and Short of the Canada-U.S. Free Trade Agreement. *The American Economic Review*, 94(4):870–895.

UN (2019). THE RISE OF NON-TARIFF MEASURES INTRODUCTION Asia-Pacific Trade and Investment Repor: The rise of non-tariff measures. Technical report.

UNCTAD (2019). *International Classification of Non-Tariff Measures 2019*. UN.

US Census Bureau (2017). State & Local Government Finance Historical Datasets and Tables.

US Census Bureau (2021). 2007 Commodity Flow Survey Overview and Methodology.

US Department of Homeland Security (2017). Letter to determine fulfillment of domestic built criteria for Jones Act ship produced by Philly Shipyard.

US GAO (2018). MARITIME SECURITY DOT Needs to Expeditiously Finalize the Required National Maritime Strategy for Sustaining US-Flag Fleet. Technical Report August, United States Government Accountability Office.

US ITC (1993). The Economic Effects of Significant U.S. Import Restraints. Technical report, US ITC.

US ITC (1995). *The economic effects of significant US import restraints: First biannual update*, volume 2935. The US Trade Commission.

US ITC (2002). The Economic Effects of Significant US Import Restraints - Third Update.

US Marad (2011). COMPARISON OF U.S. AND FOREIGN-FLAG OPERATING COSTS. Technical Report September, U.S. Department of Transportation Maritime Administration.

Veloso, F. M. (2006). Understanding local content decisions: Economic analysis and an application to the automotive industry. *Journal of Regional Science*, 46(4):747–772.

Volpe Martincus, C. and Blyde, J. (2013). Shaky roads and trembling exports: Assessing the trade effects of domestic infrastructure using a natural experiment. *Journal of International Economics*, 90(1):148–161.

Volpe Martincus, C., Carballo, J., Garcia, P. M., and Graziano, A. (2014). How do transport costs affect firms' exports? Evidence from a vanishing bridge. *Economics Letters*, 123(2):149–153.

Weiss, M. (2016). The Role of Local Content Policies in Low-and Middle Income industries.

Wessel, J. (2019). Evaluating the transport-mode-specific trade effects of different transport infrastructure types. *Transport Policy*, 78(February):42–57.

West, G. R. (1995). Comparison of Input-Output, Input-Output + Econometric and Computable General Equilibrium Impact Models at the Regional Level. *Economic Systems Research*, 7(2):209–227.

Wolf, H. C. (2000). Intranational Home Bias in Trade. *The Review of Economics and Statistics*, 82(4):555–563.

Working Group III to IPCC (2014). Climate Change 2014 Mitigation of Climate Change: Transport Chapter. Technical report.

World Economic Forum (2013). *Enabling Trade Valuing Growth Opportunities*.

WTO (2020). Getting Down to Business: Making the Most of the WTO Trade Facilitation Agreement - Perishable goods : Article 7 . 9. Technical report.

WTO (2023). Regional Trade Agreements and the WTO Legal System.

Yamano, N. (2017). *DEVELOPMENT OF GLOBAL INTER-COUNTRY INTER-INDUSTRY SYSTEM FOR VARIOUS POLICY PERSPECTIVES*. PhD thesis, University of Illinois.

Yilmazkuday, H. (2012). Understanding interstate trade patterns. *Journal of International Economics*, 86(1):158–166.

Yilmazkuday, H. (2020). Gains from domestic versus international trade: Evidence from the US. *Journal of International Trade and Economic Development*, 29(2):199–210.

Yotov, Y. V. (2022). Gravity at 60 : A celebration of the workhorse model of trade.

Yotov, Y. V., Piermartini, R., Monteiro, J.-A., and Larch, M. (2016). *An advanced guide to trade policy analysis: The structural gravity model*. World Trade Organization Geneva.