The Organization of International Trade

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Abstract

This paper discusses how international trade is organized from export to trans-boundary transport to import. All evidence suggests that the transport sector is independent, exercises market power and may feature strong economies of scale. Using a large dataset of maritime transport costs, tariffs and export prices, we show that a decline in tariffs leads to a reduction in transport costs. Furthermore, we show that an increase tariffs does not leads to a decrease in export prices. Our results are consistent only with international trade being organized in vertical partnerships.
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1 Introduction

How is international trade organized from export to transboundary transport to import? In standard models of international trade, an exporter is selling to a large number of foreign buyers, and in order to do so, may face institutional barriers to trade like tariffs and may have to carry resource costs like transport costs. Usual assumptions in this context are that the pricing policy of the firm is confined to linear pricing, and that not only institutional barriers to trade but also transport costs are exogenous and fixed.[1] Our paper departs from these assumptions in order to explore how international trade is organized. First, we do consider the role of transport carriers explicitly, and we find that they are predominantly independent agents that are likely to operate under significant increasing returns to scale. While this gives this industry market power, it may also imply that a larger trade volume will lead to lower freight rates as idle capacities will be used. Second, we will consider a model of vertical partnership as an alternative to the standard model of trade.[2]

Since the predictions of export price responses vary across the two models, we employ a large dataset of maritime transport costs, tariffs and export prices to empirically investigate the role of transport costs and to test which generic trade model is consistent with our empirical results. We first find that a decrease in tariffs leads to a reduction in freight rates, meaning that the economies of scale effect is dominant and strong on average. Trade liberalization is thus supported by decreasing freight rates: economies of scale beat market power. This is an important finding, in particular as transport costs have become relatively more important as a barrier to trade compared to tariffs in some regions.[3] Second, we find that the effect of tariffs on export prices is not negative as standard models would predict. These results are consistent only with the vertical partnership

[1] This standard model has been used to discuss and estimate the gains from trade, and it has been used to explore how market power and firm heterogeneity affect market performance and welfare. For a summary of models of perfect competition, see Feenstra (2015), Chapters 1 and 2, and for the seminal papers on trade and firm heterogeneity, see Eaton and Kortum (2002) and Melitz (2003). Arkolakis *et al* (2012) show that the welfare gains from trade depend only on the expenditure share of domestic goods and the elasticity of imports with respect to trade costs in most standard models.

[2] In particular, the seminal work by Antràs (2003) and Antràs and Helpman (2004) has demonstrated the role of vertical partnerships in this context. See also Antràs (2016).

[3] See, for example, Moreira *et al* (2008) who investigate Latin American and Caribbean trade.

model that allows trading partners to use nonlinear pricing schemes.

The theoretical literature on transport markets in international trade is not too large. Falvey (1976) was the first to consider the impact of tariffs on transport markets. He integrates a transport industry into a Heckscher-Ohlin framework, and he shows that a tariff, imposed on the labor-intensive import good, makes the relative input price for a capital-intensive transport industry decline and thus partially offsets the effect on the domestic relative price. Francois and Wooton (2001) model shipping firms in a Cournot oligopoly that compete in quantities, and they evaluate the effects of more competition. More recently, Ishikawa and Tarui (2015) use an oligopoly Cournot model in which carriers face the backhaul problem due to unbalanced trade, and they show that trade policy may also affect capacities for own exports. Brancaccio *et al* (2017) employ a model of random matching to investigate the search frictions that may arise between exporters and available shipping capacities. The closest paper to our model is Hummels *et al* (2009) that considers shipping scale economies as a regional public good and employs a technology choice model. They show that a tariff reduction leads to a freight rate increase for a given transport technology, but a technology change may reverse this effect as it may become profitable to employ a technology that has a large fixed cost with an increase in transport volume.[4] We will use a model of a monopolistic carrier whose cost function may feature decreasing marginal costs, but let the data tell us whether market power or economies of scale dominate the response to trade liberalization. As in Hummels *et al* (2009), it is possible that trade liberalization will lead to lower marginal costs, and our empirical analysis will support the importance of this effect.[5]

In a second step, we will go beyond the transport market, and the analysis of export pricing behavior requires to distinguish between exporting at arm's length and exporting through cross-border vertical partnerships. Serving markets at arm's length is quick and easy, but does not allow specialized and tailor-made offers and is confined to linear pricing strategies. Vertical partnerships allow for these options, but at the same time these partnerships are subject to constraints due to moral hazard and holdup problems that

[4]Kleinert and Spies (2011), using a monopolistic competition model for producers and also a technology choice model, show that freight rates do not only depend on distance, but also on the level of exports. Thus, they also support the existence of economies of scale in this industry.

[5]There is also a controversy in transport economics whether cartelization is simply a result of market power or a response to destructive competition, see for example Sjostrom (2004).

will restrain the degree of cooperation in a partnership. Since all organizational forms have pros and cons, we may expect that the organizational design of international trade relations will be determined endogenously. It is thus important which design is most consistent with empirical evidence.

Note that dealing with maritime transport has several advantages. First, we stack the decks against vertical partnerships as distances are long on average.[6] Second, the interaction between economic activity and infrastructure in maritime transport is confined to vessel speed and capacity, and to port and channel capacity.[7] Land and rail transport is more complex and leads to backward and forward linkages with a lot of economic activities also across borders.[8] Third, price discrimination is much easier for carriers in maritime transport as strict documentation rules imply that a resale of transport services is nearly impossible and the carrier will know exactly the details of each shipment. Fourth, we find that carriers in maritime shipping are predominantly not vertically integrated, and this observation allows us to consider the carrier as an independent agent. And finally, the capacity of modern vessels (both bulk and container vessels) is so large that carriers might operate under substantial economies of scale, turning them into natural monopolists on some routes.[9]

Our paper also makes a contribution to the emerging literature that links goods and services trade, see for example Ariu *et al* (2016, 2017), Breinlich *et al* (2016) and Crozet and Milet (2017). First, transport is a genuine complementary service that is required by any goods trade. According to Eurostat, transport services account for 17% of total services exports to countries outside the EU and for 19% of total services imports from countries outside of the EU in 2015, and this makes transport services exports and imports

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[6]Rauch (1999) classifies products whether they are traded on an organized exchange and/or have a reference price or neither, and he finds finds that proximity is more important for differentiated products that are not traded on an organized exchange.

[7]See Clark *et al* (2004) for the role of port efficiency.

[8]Limão and Venables (2001) discuss the importance of domestic transportation infrastructure for trade, Blonigen and Wilson (2008) show how port infrastructure affects trade flows, and Storeygard (2016) investigates the role of inter-city transport costs for sub-Saharan African cities. For a summary of the literature on the interaction between transport and economic activities, see Redding and Turner (2015).

[9]See UNCTAD (2016). In 2016, Maersk was the largest liner shipping company with a market share of 15.1%. The four largest liner shipping companies have a market share of 45.5% and all have no cross-ownership with large exporting or importing firms.

the second largest service category, outnumbered only by other business services.[10] Second, it is well known that intra-firm trade within the boundaries of a multinational firm is complemented by the provision of headquarter and/or affiliate services; see for example Nordås (2010) for the role of intermediate services. Bundling goods and services trade allows partners in a vertical relationship to use nonlinear pricing schemes, and since our analysis supports that trade is organized in vertical partnerships, it also provides indirect evidence for the importance of complementary services trade.

The remainder of this paper is organized as follows. Section 2 reviews the literature on trade costs, the maritime transport industry and international pricing incentives to set the stage for our theoretical model and our empirical investigation. Section 3 sets up the transport model and discusses the behavior export prices in two alternative setups, the standard trade model, and the vertical partnership model. Section 4 explains the databases we use and presents our empirical results. Section 5 offers some concluding remarks.

2 Transport Costs and Pricing Incentives

This section will provide a thorough overview of the role of trade and transport costs, the transport sector and export pricing behavior. It is a main insight of models using the gravity equation to estimate trade flows that trade costs play an important role, see for example Anderson and van Wincoop (2004). Furthermore, there is a large literature on trade elasticities that can explain gains from trade liberalization in standard models of trade, but the estimates differ substantially, see for example Arkolakis *et al* (2012), Baier and Bergstrand (2001), Broda and Weinstein (2006), Caliendo and Parro (2015), Hillberry and Hummels (2013)and Romalis (2007). In this paper, we want to take a closer look on trade costs, and for this reason, it is important to distinguish between administrative costs like tariffs and transport costs that arise due to the necessity to move goods across borders. This distinction is also empirically important. For example, using a constant elasticity of transformation function in a gravity equation, Baier and Bergstrand (2001) find that the relative contribution to trade growth from tariff reductions is 25 %, but only

[10]Eurostat distinguishes twelve service categories, see http://ec.europa.eu/eurostat/statistics-explained/index.php/EU_international_trade_in_transport_services, accessed February 1, 2018.

8 % are originate from transport cost reductions (and income growth adds 67 %).[11]

While international trade can be organized by different transport modes (air, rail, truck, ship), maritime transport is the dominant form of long-distance shipping. Figure 1 exemplarily shows the modal shares for the imports by trade value of the EU27 from 2000 to 2016. In recent years sea transport accounted for about 50% of value imports followed by air transport (slightly more than 20%), road transport (around 15%) and "other"(around 10%). Modal shares for maritime transport are slightly lower, and shares for air and road transport are slightly higher for value exports of the EU27. When trade is measured in weight rather than values, maritime transport dominates even more with modal shares of around 80% for both importing and exporting. [12]

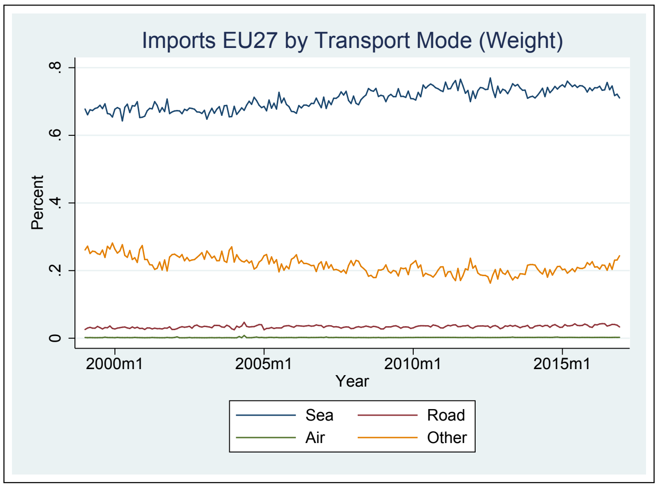

Figure 1

Source: EUROSTAT – http://epp.eurostat.ec.europa.eu/newxtweb/mainxtnet.do.

Maritime transport has several sub-modes, the most important ones are bulk carriers and liners.[13] Bulk carriers usually go with full load, but may face a backhaul problem as

[11]Trade facilitation, that is, reducing trade costs, is also an important issue for the WTO. On 22 February 2017, the Trade Facilitation Agreement (TFA) among WTO members came into force that deals with the movement, release and clearance of goods, and it offers measures to increase cooperation among customs authorities and provides technical assistance.

[12]Evidence in the literature suggests that Europe is the continent with the lowest modal share of maritime transportion. See Cristea *et al* (2013) for a detailed provision of data on trade shares by transport mode for different regions in 2004.

[13]Bulk cargo does not have to be packed, but is poured into the vessel while general cargo needs

they usually go back empty. Liners publish freight tariffs and routes and run at scheduled times, and all liner trade is by container among developed countries (Helmick, 2002). While bulk carriers run the risk of staying idle when not needed, liners may have to go with underutilized capacity, giving rise to potential economies of scale and decreasing marginal costs.[14] Interestingly, the degree of vertical integration is surprisingly low.[15] Casson (1986) concluded that vertical integration is rare due to scale economies, and recent contributions on the corporate governance and capital structure of maritime shipping companies show that both ownership concentration, measured by the proportion of equity held by the largest shareholder, and the share held by institutional investors is relatively low.[16]

Transport costs could be considered as a resource cost only if the market structure of this industry were competitive, and most of the literature does not consider the cost and market structures of the transport industry explicitly.[17] However, there is overwhelming evidence that carriers in the maritime transport industry have substantial market power (Hummels *et al* 2009). In the past, this industry was even allowed to fix freight rates in so-called conferences. Both the US and Europe have liberalized the maritime shipping market,[18] but this development did not mean that this market became very competitive.

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packaging.

[14]For example, Piorrong (1992) finds falling average costs over a substantial rate of output. Moneta (1959) was the first study to estimate freight costs, and found for ocean-shipped imports to Germany in 1951 that freight rates increase with unit values.

[15]This is even true for bulk carriers; for example, product oil and crude oil tankers are mostly not owned by oil companies. The Teekay Group is considered to be the largest tanker shipping company in the world. The top six companies carrying crude oil are all independent from oil companies (see Investopedia, 2015).

[16]See Tsionas *et al* (2012) who report an ownership concentration below 34% on average, and Andreou *et al* (2015) who report that about 20% are held only by institutional investors in their respective datasets. Giannakopoulou *et al* (2016) report that a large share of the maritime shipping firms in Greece are still run as a family business. Any vertical integration in the maritime industry is obviously confined to port management and land logistics (see Altuntaş and Göçer, 2014), but does not extend to freight generation.

[17]For papers considering the transport market explicity, see Ishikawa and Tarui (2015), Hummels (1999, 2007), Hummels and Lugovskyy (2007), Hummels and Skiba (2002), Kleinert and Spies (2011).

[18]The US Shipping Act of 1984 opened conferences to outsiders, eliminated loyalty contracts and allowed conference members to deviate from conference rates with 10 days notice. Fox (1995), however, concludes that this had no impact on market performance. McCutcheon (1997) argues that antitrust made cartelization easier, since punishment is more severe as there is no room for renegotiations. The US Ocean Shipping Act Reform Act (OSRA) in 1998 allowed long-term contracts to be confidential (see Fusillo 2003, 2013). The North Europe–US conference was the Transatlantic Conference Agreement (TACA) that was abandoned just before the EU Commission abolished the Block Exemption for ocean liner shipping in October 2008.

Conferences were replaced by alliances that aim at cross route rationalization and exploiting economies of density, and there is evidence that exporters have not too many carrier options to choose from. For example, from 2004 to 2016 UNCTAD (2016) reports a substantial decline of 35% in the number of carriers competing for an average country's cargo. In general, transport costs are found to be additive, and not of the iceberg-type (see Hummels and Skiba, 2004, and Irarrazabal *et al* 2015), supporting the hypothesis that we find linear pricing in the shipping industry. However, this does not mean that prices do not differ across shipped commodities and destinations.[19]

What about reported import prices? In a setup in which exporters have to use linear pricing, export prices will be set such that they will maximize the profit of the exporter, taking into account the additional cost of a tariff. It is then relatively easy for customs authorities to check whether the reported import price is consistent with the actual export price: they could, in principle, compare the sales price with the import price documentation. However, this exercise is much more difficult if a nonlinear pricing scheme is employed and exporters and importers are organized in some form of vertical partnership. For this case, it does not matter whether they are vertically integrated or independent partners, as long as they can find other ways of sharing potential profits than by linear pricing. There is a lot of empirical evidence that the value of imports is under-invoiced to save on tariff duties.[20] This possibility has also been acknowledged by the World Trade Organization, and the WTO Agreement on Implementation of Article VII of the GATT in 1994, that followed the Uruguay Round, sets out rules how imports should be valued. The basic principle is the transaction value that is accepted in case of related partners only if an importer can demonstrate that the vertical partnership did not influence the price.[21] Since

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[19]Ardeleany and Lugovskyyz (2017), using firm-level data from Chile, find that carriers do not only price-discriminate based on the product price, but also based on the size of the shipment.

[20]See Bernard et al (2006), Bhagwati, J. (1964, 1967), Buehn and Eichler (2011), De Wulf (1981), Das et al (2016), Ferrantino et al (2012), Fisman and Wei (2004), Javorcik and Narciso (2008), Liu et al (2016), McDonald (1985) and Swenson (2001). A part of this literature studies the incentives to under-report the value of exports from China as the Chinese value added tax is not completely refunded at the Chinese border.

[21]See Agreement on Implementation of Article VII of the General Agreement on Tariffs and Trade 1994 (Customs Valuation Agreement), https://www.wto.org/english/res_e/booksp_e/analytic_index_e/cusval_01_e.htm, accessed November 16, 2017. If the customs authorities are in doubt of the applicability of the transaction value, (i) they may ask the importer to provide further information, (ii) and in case of no or no sufficient response,

most of the importing countries in our dataset were WTO members in 1995 or became members later on, we may assume that these procedures are more or less followed, but it should be clear that there is much more discretion for exporters and importers in case of nonlinear pricing schemes.

There is also a literature on corruption and under- and over-reporting of imports. In maritime transport, over- or underreporting of volumes seems to be much more difficult as documentation requirements are substantial: each shipment must be documented by the bill of lading, and each ship must have a "manifest", that is, a collection of information from all the bills of lading. Consequently, carriers in maritime shipping should know precisely the type of their shipments.[22] The shipping line will verify that the cargo description and other information shown on the import or export declaration to customs authorities is the same as that is shown on the line's bill of lading. This is especially important when the shipment is in containers. When carriers know the value and the weight of the shipment, they can price-discriminate across products and destinations.[23] While misreporting of import volumes is not completely impossible as carriers have to rely on the information provided by the shipper to some extent,[24] the shipper runs the danger that customs authorities cross-check the manifest and customs declarations. Furthermore, underreporting would also imply underinsurance.

The corruption literature focuses on options to falsify product codes and the underreporting of volumes, and Sequeira (2016) finds that corruption implies mostly a misrepresentation of import levels. Thus, it seems that corruption may have a significant effect on reported import volumes, but less so on product code falsification. We will not consider volumes, but will focus on the pricing behavior and the reported prices, as we are interested how tariff changes affect export price behavior and freight rates, given potential misinvoicing. In what follows we will thus focus on the reported export prices that,

they will conclude that the value cannot be determined using the transaction value. In this case, other methods must be applied in a prescribed hierarchical order.

[22]The bill of lading has also the purpose to prove evidence to the importer that the goods have been received by the carrier and are carried.

[23]In case of Full Container Load (FCL) cargoes, that is, full container shipments that are used by a single costumer only, the shipping line or any agent is not privy to the packing of the containers or the nature of the cargo that is inside the containers. Misreporting is possible in terms of value, but would be fraudulent on the part of the exporter.

[24]However, any misreporting in terms of weight and measurement would immediately be detected.

together with the tariff and the freight rates, will determine the import price.

What do we take away from our analysis of transport markets and reported prices? First, transport markets are dominated by independent carriers that have market power and may operate with substantial economies of scale. Thus, we need a modeling approach that takes both aspects into account. Second, we will have to model potential discretion in terms of import value declarations and how this behavior will change with tariff changes if exporters and importers are not confined to linear pricing. The next section will develop a simple model that can accommodate both linear and nonlinear pricing, and section 4 will show that the response of export prices to tariff changes can be explained only in a nonlinear pricing setup.

3 Theoretical Framework

Consider an export activity that can create a certain net revenue in the importing country; this net revenue is the difference between sales and all local costs after the import price, the freight rate and the tariff duties have been paid for. This export activity can be in the form of an intermediate or a final good and will be subject to an ad valorem import tariff τ.[25] Whatever the details of this export activity are, we keep our model as general as possible and assume that it will generate a net revenue of size $R(x)$ in the importing country where $R_x(0) > 0$ and $R_{xx}(x) < 0$.[26] For example, if the import good can be turned into one unit of the final good for a constant marginal cost $\gamma, \gamma \geq 0$, $R(x) = (p(x) - \gamma)x$ where $p(x)$ denotes the residual inverse demand function that the importer faces. If the import good is an intermediate input, the net revenue is given by $R(x) = \max_z p(y(x,z)y(x,z)) - w \cdot z$ where $y(x,z)$ is the production function that depends on the intermediate input x and on a vector of other inputs, denoted by z; w denotes the vector of the respective factor prices.

The outcome will depend on how export prices and freight rates will be determined. As for the transport market, we allow for economies of scale. Since carriers have to build

[25] We chose the ad valorem tariff in our model as nearly all of the tariffs in our database are of this type.

[26] Throughout the paper, subscripts denote (partial) derivatives.

up capacity, either in terms of a schedule for liner shippers or in terms of vessel capacity for bulk carriers, carriers have to set their freight rates before other parties arrange all trans-boundary transactions. Consequently, we start our analysis with the carrier. As we could show above, the carrier is an independent agent. The carrier will anticipate that the freight rate has an effect on the import volume. The profit of the carrier is given by

$$\pi^c = \rho x - \Psi(x), \Psi_x(x) > 0, \tag{1}$$

where $\Psi(x)$ denotes the transport cost of shipping x units from the exporting to the importing country, and ρ denotes the freight rate per unit, respectively. Empirical evidence suggests that the transport sector may feature strong economies of scale, so an increase in transport volume may result in a decline in marginal costs as carrying more units allows for better use of transport capacities and/or a substantial reduction in handling costs in ports and on vessels. Thus, it is not clear whether $\Psi_{xx}(x)$ is positive or negative in the relevant range. If a carrier runs close to the capacity limit, $\Psi_{xx}(x)$ will be clearly positive, but if the carrier has spare capacity, $\Psi_{xx}(x)$ could as well be negative. In any case, the first-order condition

$$\pi^c_\rho = \rho x_\rho + x - \Psi_x(x) x_\rho = 0 \tag{2}$$

will determine the freight rate ρ. We assume that any decline in marginal transport costs is not too strong such that $\pi^c_{\rho\rho} = 2x_\rho + \rho x_{\rho\rho} - \Psi_x(x)x_{\rho\rho} - \Psi_{xx}(x)x^2_\rho < 0$ holds so that the first-order condition is also sufficient. More importantly, the cross-derivative w.r.t. the tariff is given by

$$\pi^c_{\rho\tau} = x_\tau + \rho x_{\rho\tau} - \Psi_x(x)x_{\rho\tau} - \Psi_{xx}(x)x_\rho x_\tau, \tag{3}$$

and its sign can be both positive or negative, depending on the behavior of exports and the behavior of transport costs with the tariff. Suppose that the tariff is reduced. In this case, we would expect an increase in x and $R(x)$ as the export activity has become more profitable. Two effects materialize: on the one hand, the export market has become more attractive, so the carrier has an incentive to increase the freight rate to benefit from trade liberalization.[27] If the carrier already runs at or close to the capacity limit, it will have even more of an incentive to do so as $\Psi_{xx}(x) > 0$. On the other hand, if $\Psi_{xx}(x) < 0$ in the relevant range, an increase in shipping volume may go along with a decline in marginal transport cost as it adds little or no additional cost. If this effect is strong enough, the carrier will decrease the freight rate, and tariffs and freight rates go the same way, supporting each other. Consequently, we find:

Proposition 1. *For all organizational modes, the effect of the tariff on the freight rate is ambiguous and depends on the sign of* $\pi^c_{\rho\tau}$.

Proof. $\rho_\tau = -\pi^c_{\rho\tau}/\pi^c_{\rho\rho}$. □

Note carefully that Proposition 1 holds for all organizational forms.[28] Of course, export levels x will differ across modes, but we can conclude that strong economies of scale may imply a co-movement of tariffs and freight rates. In this case, the gains from trade liberalization are supplemented by an efficiency gain in the transport industry that is able to utilize capacities more productively, and this effect overcompensates the rent-seeking effect of higher freight rates. In our model, the carrier is an independent monopolist, and we may wonder how our results extend to a setting of oligopolistic competition. In Appendix A.3, we generalize our approach using a Salop model of product differentiation between carriers. We show that our main result that the effect of marker power versus potential economies of scale decides on freight rate changes continues to hold. Additionally, freight rates may also decline with falling tariffs because they are strategic complements in a price competition model.

Let us now turn to the organization of export and import activities. A crucial distinction will be whether the importer and the exporter will be in a vertical partnership or not, that is, whether they can work out an arrangement that does not have to rely on linear pricing or whether the exporter is independent and arranges exports at arm's length and is thus confined to linear pricing. In the latter case, an independent exporter sells directly

[27] Due to double marginalization, this effect would at least partially compensate the tariff effect. There is also a related literature on private contractual arrangements replacing institutional barriers to trade, see for example Raff and Schmitt (2006).

[28] We show the details for the case of an independent exporter in Appendix A.1. Appendix A.2 and Appendix A.4 show that Proposition 1 also holds for the case of mill pricing and for a vertical partnership, respectively.

to consumers in the other country or to a number of local wholesalers and retailers in the foreign country. It is important to note that these transactions are done via a market with a sufficiently large number of buyers, and thus pricing must be linear due to potential arbitrage and market clearing conditions.

The independent exporter is responsible also for the trans-border transaction and will have to arrange transport by himself. This is the classical trade model of a firm selling directly to a large number of customers in an importing country. Consider an independent exporter that is facing the market in the importing country in which his market power is determined by the respective residual demand such that the net revenues are the residual market demand $R(\cdot) = px(p)$ where p denotes the market-clearing price. In this case, he sells to an anonymous market, anticipating its behavior. The export profit is equal to

$$\pi = \frac{R(x(p))}{1+\tau} - (c + \gamma + \rho)\, x(p), \tag{4}$$

where $\gamma \geq 0$ denotes the transaction cost of selling through the market in the importing country. This market is managed by traders that clear the market, and thus the pricing strategy is confined to linear pricing. These traders can also be local wholesalers and retailers, and a positive γ implies that the supplier has to carry some per unit cost to access the respective market. As it is well-known, the pricing behavior in terms of the consumer price is determined by

$$p^* = \frac{\epsilon(\cdot)}{\epsilon(\cdot) - 1}(1 - \tau)(c + \gamma + \rho). \tag{5}$$

where $\epsilon(\cdot) > 1$ denotes the elasticity of the residual demand $x(p)$ in the importing country in absolute terms. We assume in line with the literature that $\epsilon_x(\cdot) < 0$ holds, that is, that the elasticity of demand increases with a reduction in consumption.[29] Export prices will be denoted by q, and since the export (FOB) price is given by $q = p/(1 + \tau) - \rho$, the optimal export price is equal to

$$q^* = \frac{\epsilon(\cdot)}{\epsilon(\cdot) - 1}(c + \gamma + \rho) - \rho. \tag{6}$$

[29] For details, see Feenstra (2015), Chapter 7. Most demand functions fulfill $\epsilon_x(\cdot) < 0$ which implies that demand is not more convex than a constant-elasticity demand function.

We find:

Proposition 2. *In case of linear pricing, an increase in the tariff will lead to a decrease in the export price. The effect of freight rate changes on the export price is ambiguous.*

Proof. Differentiation q^* (see (6)) w.r.t. τ yields $q^*_\tau = -\epsilon_x(\cdot)x^*_\tau(c+\gamma+\rho)/(\epsilon(\cdot)-1)^2 < 0$, and differentiation of q^* w.r.t. ρ yields $q^*_\rho = -\epsilon_x(\cdot)x^*_\rho(c+\gamma+\rho)/(\epsilon(\cdot)-1)^2 + 1/(\epsilon(\cdot)-1)$ where - $\epsilon_x(\cdot)x^*_\rho(c+\gamma+\rho)/(\epsilon(\cdot)-1)^2 < 0$ and $1/(\epsilon(\cdot)-1) > 0$. □

We find that an independent exporter will decrease the export price in response to a tariff increase. The case of an independent exporter is mainly an extension of the standard model of trade to include the role of freight rates, and one of its main applications is final goods trade. However, we can show that the tariff effect can also be observed in a mill pricing model in which a firm produces intermediate or final goods, and an importer will source these goods from this supplier. The main difference is that this supplier is active on a market in the exporting country: she will offer final or intermediate goods on this market to importers from other countries, but possibly also domestically. We deal with this case in Appendix A.2 and show that the response to the tariff is qualitatively the same.

We now turn to the case in which the exporter and the importer are in a vertical partnership. In this setup, partners are not confined to linear pricing. For our purpose, it is not important whether the two partners belong the same legal entity, have some cross-ownership or are legally independent. A vertical partnership can encompass many equity arrangements. It is, however, important that the partners have a contractual arrangement that allows them to go beyond arm's-length-trade. These contracts may be subject to holdup and moral hazard problems and thus incomplete. We model this incompleteness by assuming that the cost function can be marginally increasing: $C(x)$ with $C_x(x) > 0, C_{xx}(x) \geq 0$. Whatever the source of incompleteness, it is well-known that these frictions lead to less than optimal arrangements, and $C_{xx}(x) > 0$ may reflect that a more ambitious partnership has to carry some extra costs. Furthermore, it may also be the result of payout arrangements that become more difficult to organize and to guarantee the more ambitious the partnership is.

For our analysis it does not matter how contracts are designed in detail. We assume that they maximize the joint profit of a vertical partnership subject to several constraints implying $C(x)$. A crucial aspect of this partnership is the role of the export price. Since the partners have other means to arrange their payouts than linear pricing, the export price takes over the role of a transfer price. More specifically, a partnership has to report to customs authorities that the export of size x has some unit value of size q, leading to a tariff duty of τqx, and thus the partnership has a strong incentive to under-report the export price. Only for a zero tariff (or a specific tariff), the export price does not matter as it cancels out from aggregate profits of the partnership. For $\tau > 0$, the cost for the partnership is equal to τqx.

If the partnership were free to choose the export price, it would set $q = 0$ as to avoid any tariff payment. This is, of course, not a realistic option as customs authorities will not accept a declared zero value import; they are likely to apply the procedures according to the WTO guidelines as they have been discussed in the last section. The partnership will have to declare the product code of the good, and the customs authorities will have an idea about the possible prices for which these goods are usually traded. We will assume that a reference price $\tilde{q}$ exists, and the partnership will not have to carry an additional cost if it declares an export price equal to or larger than $\tilde{q}$. If it claims that the export price is smaller, it will have additional costs that summarize all administrative and legal costs that could arise from concealing the true value and claiming a lower value. In particular, we assume that the partnership will maximize its profit given by

$$\Pi = R(x) - (\tau q + \rho)\, x - C(x) - \Delta(q) \tag{7}$$

where

$$\Delta(q) = \begin{cases} 0 & \text{if} \quad q \geq \tilde{q}, \\ > 0 & \text{if} \quad q < \tilde{q}. \end{cases} \tag{8}$$

$\Delta(q)$ is the concealment cost function for which $q < \tilde{q}$: $\Delta_q(q) < 0, \Delta_{qq}(q) > 0$ holds.[30] The concealment cost function implies that the marginal concealment cost increases with under-invoicing. Furthermore, we assume that

[30] Concealment cost functions have been used in the public economics literature on corporate taxation and transfer pricing, see for example Haufler and Schjelderup (2000), and Nielsen et al (2008, 2010, 2014). Kant (1988) uses an approach in which under-invoicing can be detected with a certain probability, leading to a penalty. This approach is strategically equivalent to a concealment cost approach. Our results do not change if we make this cost function more complex, for example, if costs also depend on the efforts of the customs authorities.

$$\zeta(q) = -\frac{d\Delta_q(q)/\Delta_q(q)}{dq/q} > 1$$

holds: a decrease in the transfer price by 1% increases the marginal concealment cost by more than 1% which will imply a normal response of exports to tariffs, that is, a decline with τ. The partnership now has two strategic variables, x and q, and the first-order conditions are given by

$$\begin{aligned} R_x(x^{**}) - q^{**}\tau - \rho - C_x(x^{**}) &= 0, \\ -\tau x^{**} - \Delta_q(q^{**}) &= 0. \end{aligned} \tag{9}$$

We find:

Proposition 3. *In case of a vertical relationship, an increase in the tariff rate τ has an ambiguous effect on the export price. An increase in the freight rate leads to an increase in the export price.*

Proof. See Appendix A.4. □

Proposition 3 shows that the effect of the freight rate on the export price is now unambiguous: when the freight rate increases, exports become more expensive and will be reduced, and thus the endeavor to reduce q becomes less profitable. The impact of the tariff, however, is ambiguous. The reason is that the export price is a transfer price now, and the partnership has to balance the costs of reducing this transfer price successfully with its benefits. On the one hand, an increase in the tariff makes reducing q more profitable as $q\tau$ has gone up per unit of exports. On the other hand, the tariff will reduce exports, making the reduction in q less effective as the export volume will be smaller. However, the level of exports will decrease with a tariff increase, irrespective of the response of the export price, as a tariff increase will increase the cost of exporting.

In summary, we have arrived at a clear prediction from our models of trade: the effect of the tariff rate on the export price of the vertical partnership is ambiguous, while the independent exporter will decrease the export price if the tariff rate goes up. For both cases, the effect of the tariff rate on the freight rate depends on the potential strength of the economics of scale in the transport industry. We now turn to our empirical analysis and show that only the vertical partnership model is consistent with our data.

4 Data and Empirical Results

For our empirical exercise, we create a rich dataset by combining data on transport costs, tariffs and export prices. Our baseline dataset is the OECD Maritime Transport Cost database, the most comprehensive dataset on maritime transport rates known to date.[31] As discussed in Section 2, our focus on maritime costs is well justified by the fact that the largest fraction of world trade is sea borne.[32] The maritime transport cost data is either directly taken from the original customs data or estimated at the product level from carriers' actual rates, if data is only available at more aggregated levels. It covers different modes of maritime shipment such as bulk carriers, tankers or containers and reports two different cost measures: unit costs (transport costs per kilogram) and ad valorem equivalents (transport costs divided by the import value) between country pairs at the 6-digit commodity level.

For the first part of our empirical analysis that focuses on the effect of tariff changes on transport costs, we combine the transport cost data with tariff data from the UNCTAD TRAINS database. For our analysis, we use tariffs measured as effectively applied tariffs. After matching and cleaning the final dataset covers the time period of 1991 to 2007 and contains about 3.57 million transport cost and tariff observations for 39 importing countries from 219 countries of origin for 4,826 different products at the detailed 6-digit commodity level (HS1988).[33] The observations include both primary products and also a

[31]For more information see https://stats.oecd.org/Index.aspx?DataSetCode=MTC or see Korinek (2011).

[32]In 2004, approximately 50% of trade by value traveled by sea; the share increases to about 95% when measured in service units (kg-km). See Cristea *et al* (2013) for a detailed provision of data on trade shares by transport mode for different regions in 2004.

[33]The importing countries include Algeria, Argentina, Australia, Bangladesh, Bolivia, Brazil, Chile, China, Colombia, Ecuador, Egypt, European Union, Hong Kong, India, Indonesia, Iran, Japan, Jordan, Korea, Malaysia, Mexico, Morocco, New Zealand, Pakistan, Paraguay, Peru, Philippines, Russia, Saudi Arabia, Singapore, South Africa, Sri Lanka, Thailand, Tunisia, United Arab Emirates, United States, Uruguay, Venezuela and Vietnam. The OECD data only contain information for the EU15 as a single custom union, but not for each of its member states separately. Countries covered include Austria, Bel-

wide range of manufacturing goods. The data constitute an unbalanced panel, since data for a particular country may not be available for every year.

In a second step, we then combine the dataset with export price data taken from the UN Comtrade Database to additionally analyze the role of export prices. Comtrade reports all bilateral trade between two countries at the 6-digit product level. We collect the goods prices at the exporter side to obtain FOB prices that exclude international transport and insurance costs. More precisely, we generate unit export prices (price per kilogram). After matching, we are left with around 2.13 million observations for 38 importing countries from 153 countries of origin for 4,807 different products at the detailed 6-digit commodity level (HS1988).[34]

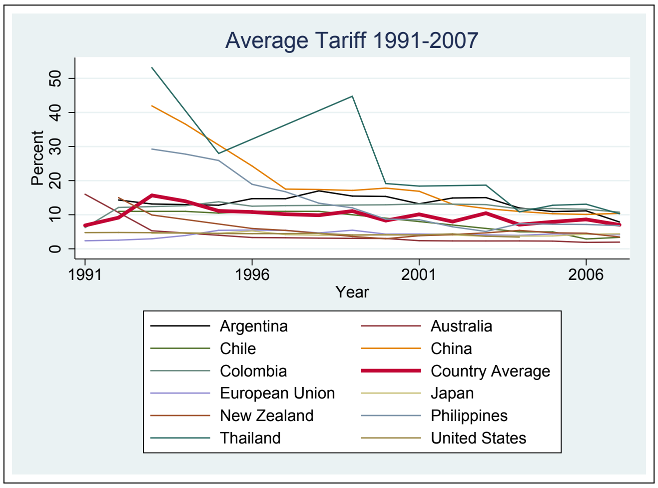

Figure 2

Our dataset covers a time period that is characterized by decreasing import tariffs for almost all importers - not least triggered by the Uruguay Round that came into effect in 1995 with deadlines ending in 2000. Figure 2 shows the average tariff over all imported

gium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom. In order to obtain tariff and export price data that match the transport cost data, weighted averages with import values as the weight are used to aggregate the tariffs (TRAINS) and export prices (Comtrade) from country level to the EU15 level.

[34]One reason for missing matches is that only those countries from the Comtrade Database are included that report trade data in the HS classification to avoid inaccuracies from the use of correspondence tables.

goods for a number of countries in our dataset. On average, import tariffs for all 39 importing countries decreased from 15.67% to 7.03% from 1993 to 2007 (thick red line).[35] The largest decreases can be identified for the middle-income countries in our sample, especially for Asian countries. For instance, from 1993 to 2007 the average tariff dropped by 22.46 percentage points to 6.79% in the Philippines, by 31.53 percentage points to 10.4% in China and by 42.89 percentage points to 10.29% in Thailand. Average tariffs for high-income countries fall at a much lower rate as the base rate is already comparably low or remain at a stable level. In the US, for instance, average tariffs decreased from 7.76% in 1991 to 3.44% in 1992. For Japan, average tariffs remained at a constant rate of about 4.5%. However, there is substantial variation across goods and countries.

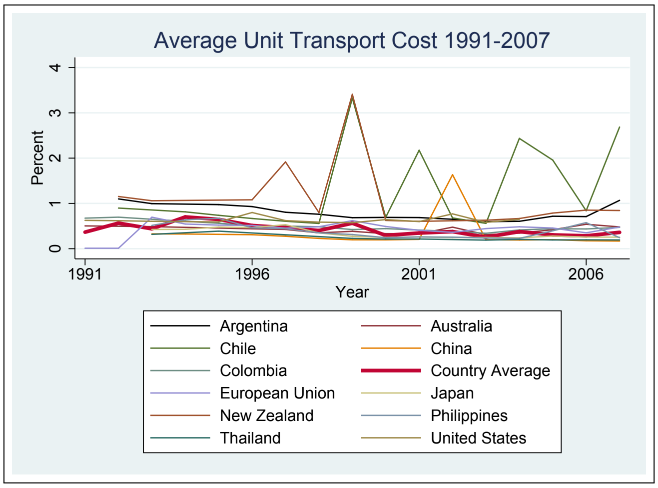

Figure 3

During the same time period there is no clear pattern for neither the average transport costs (see Figure 3) nor the average export price (see Figure 4). Transport costs and export prices overall remain at a rather stable level, but show variation both over time and across countries.

We now use these data to test for the interaction of tariffs, freight rates and export

[35]Note that this average tariff is not a weighted average as it does not control for transaction size for a given country. For the first two years almost only tariff data from highly industrialized countries (that generally have lower import tariffs than less industrialized countries) is available, and this explains the lower average tariff rates for these years.

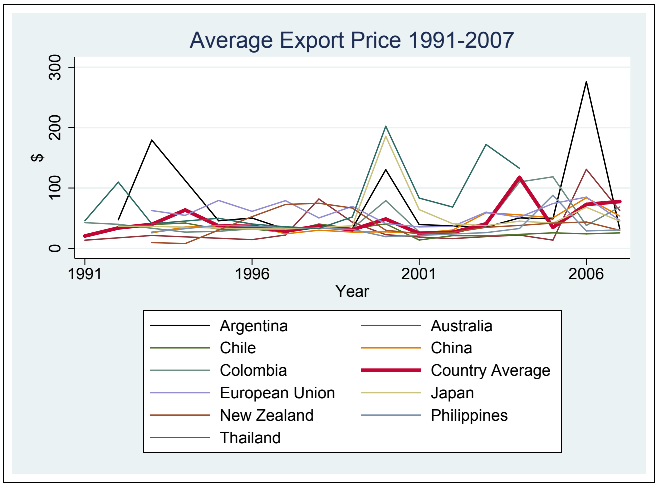

Figure 4

prices. First, we test for the effect of tariff changes on the transport costs by running the following two regressions:

$$\ln \text{Transportcost}_{ijnt} = \alpha + \beta_1 \ln \text{Tariff}_{ijnt} + c_{ijn} + d_{it} + e_{jt} + f_{nt} + u_{ijnt}, \quad (10a)$$

$$\ln \text{Transportcost}_{ijnt} = \alpha + \beta_1 \ln \text{Tariff}_{ijnt} + d_{int} + e_{jnt} + u_{ijnt}. \quad (10b)$$

where ln Transportcost are the logarithmized transport costs (either measured as unit value or ad valorem) between importer i and exporter j for product n at time t, ln Tariff are the logarithmized effectively applied tariffs,[36] In regression (10a), c_{ijn} are importer-exporter-good triple fixed effects, d_{it}, e_{jt} and f_{nt} are importer-time, exporter-time and product-time double fixed effects, respectively, and u_{ijnt} is the robust standard error. In regression (10b), d_{int} are importer-good-time triple fixed effects and e_{jnt} are exporter-good-time triple fixed effects. [37] We apply the product fixed effects at the 6-digit product level.

[36]To estimate elasticities, the effectively applied tariffs are defined as $ln(1 + tf)$, whereas tf is the decimal tariff rate.

[37]All equations are estimated using the STATA reghdfe command (Correia, 2016) that is well suited for large datasets with high-dimensional fixed effects.

We like to emphasize that our specification controls for unobserved time-invariant importer-exporter-product attributes and time-variant importer, exporter and product attributes. Thus the only remaining identifying variation originates from country-pair-specific deviations from product-specific good trends. Despite our choice to include high dimensional fixed effects, we find positive and significant effects of tariff changes on transport costs both when measured in unit values and ad valorem.[38] The results are shown in Table 1, indicating strong economies of scale in the transport industry.[39]

Table 1: Tariffs and Transport Cost

Transport Cost Measure	(1) Unit Value	(2) Ad Valorem	(3) Unit Value	(4) Ad Valorem
ln Tariff	0.0266**	0.1225***	1.5555***	1.4430***
	(0.0128)	(0.0134)	(0.0372)	(0.0312)
F	4.34	84.01	1752.84	2132.31
$Prob > F$	0.0371	0	0	0
Adj. R^2	0.7229	0.6312	0.5791	0.5522
Root MSE	0.6354	0.6530	0.6923	0.6918
N	3,373,938	3,356,902	2,691,673	2,671,789

Notes: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. (1)/(2): eq. (10a), (3)/(4): eq. (10b). The number of observations differs between the two transport cost measures due to randomly missing data. Includes importer-exporter-goods fixed effects, importer-time fixed effects, exporter-time fixed effects and goods-time fixed effects.

Using the second dataset with merged trade data from Comtrade, we then test for the

[38]There are 489,305 different importer-exporter-product pairs, which implies that on average each of the triple fixed effects contains around 6.9 observations.

[39]We have also conducted several robustness check in which we have dropped observations for which we cannot rule out some cross-ownership between carriers and large exporters, but our results have not changed. The details are available upon request.

effect of tariff changes on export prices. In particular, we estimate the following equations

$$\begin{aligned} \ln \text{ExpPrice}_{ijnt} &= \alpha + \beta_1 \ln \text{Transportcost}_{ijnt} + \beta_2 \ln \text{Tariff}_{ijnt} \quad (11a) \\ &+ c_{ijn} + d_{it} + e_{jt} + f_{nt} + u_{ijnt}, \\ \ln \text{ExpPrice}_{ijnt} &= \alpha + \beta_1 \ln \text{Transportcost}_{ijnt} + \beta_2 \ln \text{Tariff}_{ijnt} \quad (11b) \\ &+ d_{int} + e_{jnt} + u_{ijnt}, \end{aligned}$$

where the unit value FOB export price ln ExpPrice is calculated as the total trade value divided by the net weight in kilogram for a given product. We find that the coefficient is positive, contrary to the independent exporter model, and insignificant in specification (11a) (see Table 2).

Table 2: Export Prices and Tariffs

	(1)	(2)	(3)	(4)
ln Transport Cost	.	.	0.05***	0.1134***
	.	.	(0.0009)	(0)
ln Tariff	0.0078	1.0179***	0.0071	0.7819***
	(0.0158)	(0.0417)	(0.0168)	(0)
F	0.24	596.16	1525.41	4896.93
$Prob > F$	0.6239	0	0	0
Adj. R^2	0.8431	0.8202	0.8434	0.8225
Root MSE	0.6392	0.6561	0.6385	0.6519
N	1,814,136	1,307,465	1,814,088	1,307,422

Notes: Robust standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. (1)(3): eq. (11a), (2)/(4): eq. (11b). Includes importer-exporter-goods fixed effects, importer-time fixed effects, exporter-time fixed effects and goods-time fixed effects.

In conclusion, we find that the maritime transport industry has featured strong economies of scale that have supported trade liberalization by a reduction in freight rates.[40] Furthermore, our finding on the behavior of export prices are consistent only

[40]Other transport sectors, like air transport, might not experience any increasing returns to scale. Hummels and Schaur (2010) investigate air transport and maritime shipping as competing transport

with the vertical partnership model as export prices either increase with tariffs or remain uninfluenced by the tariff rate on average.

5 Concluding remarks

This paper has shown that maritime transport costs and tariffs co-move. As maritime transport is highly cartelized and monopolized, the only explanation for this co-movement are strong economies of scale. On average, carriers had spare capacity and could handle additional freight for decreasing marginal costs. Thus, it is obvious that the role of the transport industry has to be reconsidered as it seems inappropriate to assume that the resource costs of trade are constant. Furthermore, we could show that the impact of the tariff on export prices is not clear. Only our vertical partnership model could explain this empirical patterns.

Since maritime transport implies long distance and sea travel and vertical partnerships are more likely for exports relying on road and rail transport, our setup was stacking the deck against this organizational form. However, as we could show, even for maritime transport, it seems that the vertical partnership model is on average the dominating organizational form. Our results are consistent with the observation that a large part of international trade is of the intra-firm type, that is, within firm boundaries of a multinational enterprise (for a recent contribution, see Corcos *et al*, 2013). At the same time, however, Ramondo *et al* (2016) find for US multinationals that only a very small number of affiliates are involved in intra-firm trade. Our analysis thus also indicates that vertical partnerships seem to be more universal, may go beyond firm boundaries and may cover also inter-firm trade.

Our results also show that the standard model of trade, assuming an independent seller, is not the model our data can support. This raises serious questions on how gains from trade liberalization have been estimated in the past relying on this model, in particular because these models have found only very modest welfare effects. A vertical partnership does not have to rely on linear pricing, and while decreasing freight rates decrease export prices, we cannot report that decreasing tariffs do the same. The export price is a trans-

modes.

fer price in vertical partnerships, and a lower tariff will also reduce the under-invoicing incentive. Nevertheless, a tariff reduction will imply an increase in export activities, also in vertical partnerships, due to a reduction in overall export costs, irrespective of the behavior of the export price. But the welfare effects of trade liberalization seem to be more complex in these partnerships, and thus we have to explore in more detail how they are organized as to understand the gains from trade.

Appendix

A.1 Independent exporter

As for the interaction with the carrier, this model is closest to the standard models in which an exporting firms takes all costs as given when deciding on foreign sales. In this case, the carrier correctly anticipates how the seller will respond to the tariff and the freight rate. Solving the equivalent maximization problem $\max_x R(x)/(1+\tau) - (c+\gamma+\rho)x$ allows us to determine the anticipated changes in optimal exports x^*. The first-order condition reads $\pi_x = R_x(x^*)/(1+\tau) - (c+\gamma+\rho) = 0$ and the second-order condition $\pi_{xx} = R_{xx}(x^*)/(1+\tau) < 0$ makes this condition also sufficient. The relevant changes in exports in response to tariff and freight rate changes are thus given by

$$\begin{aligned} x_\tau &= -\frac{\pi_{x\tau}}{\pi_{xx}} = \frac{R_x(x^*)}{R_{xx}(x^*)(1+\tau)} < 0, \\ x_\rho &= -\frac{\pi_{x\rho}}{\pi_{xx}} = \frac{(1+\tau)}{R_{xx}(x^*)} < 0, \end{aligned} \tag{A.1}$$

and its cross-derivative is equal to

$$x_{\rho\tau} = \frac{R_{xx}(x^*) - \frac{R_x(x^*)R_{xxx}(x^*)}{R_{xx}(x^*)}}{R_{xx}(x^*)^2}. \tag{A.2}$$

Eqs. (A.1) and (A.2) determine the sign of $\pi^c_{\rho\tau}$ in (3) together with the features of the transport cost function in the relevant range.[41] Since we cannot rule out that the carrier has spare capacity in the relevant range of x such that $\Psi_{xx}(x) < 0$, we find that the effect on the freight rate is ambiguous and depends on the sign of $\pi^c_{\rho\tau}$.

[41] $x_\tau < 0$ also proves that $q^*_\tau < 0$, see footnote 29.

A.2 Mill pricing

In case of mill pricing, the supplier does not sell directly to customers in the foreign country, but to a number of importers that are active in his own country. In this case, the market is also anonymous and confined to linear pricing, but located in the exporter's country, so the transaction of the supplier is carried out in the exporting country only. The importer acquires inputs or final goods from the independent supplier and arranges transport to the importing country.

Given this background, the supplier will set an export price q that will maximize her profit $\pi^e = (q - c)x$. Since the supplier sells in the exporting country, it has neither to carry any additional cost that may arise in the exporting country nor any transport costs. The pricing behavior of the supplier is given by the first-order condition

$$\pi^e_q = (q^* - c)x_q + x = 0, \tag{A.3}$$

where q^* denotes the profit-maximizing export price. Given q and ρ, the importer profit is given by

$$\pi = R(x) - ((1+\tau)q + \gamma + \rho)\, x, \tag{A.4}$$

Maximization leads to the first-order condition

$$R'(x^*) - ((1+\tau)q + \gamma + \rho) = 0, \tag{A.5}$$

where x^* denotes the optimal import volume. Both the supplier and the carrier correctly anticipate x^*. The carrier and the exporter act simultaneously, and the marginal changes of imports with the tariff, the export price and the freight rate are respectively given by

$$x^*_\tau = q/\pi_{xx} < 0, x^*_q = (1+\tau)/\pi_{xx} < 0 \text{ and } x^*_\rho = 1/\pi_{xx} < 0,$$

implying

$$x^*_{\rho\rho} = -\frac{\pi_{xxx}}{\pi^3_{xx}}, x^*_{qq} = -\frac{(1+\tau)^2\pi_{xxx}}{\pi^3_{xx}}, x^*_{\rho q} = -\frac{(1+\tau)\pi_{xxx}}{\pi^3_{xx}},$$
$$x^{**}_{\rho\tau} = -\frac{q\pi_{xxx}}{\pi^3_{xx}}, x^*_{\tau\tau} = -\frac{q^2\pi_{xxx}}{\pi^3_{xx}}, x^*_{q\tau} = -\frac{q(1+\tau)\pi_{xxx}}{\pi^3_{xx}}.$$

As a result, we find that the cross derivatives of the carrier's profits and the supplier's profits are given by

$$\pi^c_{\rho\tau} = q(\pi^c_{\rho\rho} - x^*_\rho), \pi^c_{\rho q} = (1+\tau)(\pi^c_{\rho\rho} - x^*_\rho) \tag{A.6}$$

and

$$\pi^e_{q\tau} = \frac{q}{1+\tau}(\pi^e_{qq} - x^*_q), \pi^e_{q\rho} = \frac{1}{1+\tau}(\pi^e_{qq} - x^*_q), \tag{A.7}$$

respectively. Eq. (A.7) shows that $\pi^e_{q\rho} > (<)0$ if $\pi^e_{qq} > (<)x^*_q$, that is, freight rate and export prices are strategic complements (substitutes) for the independent supplier if $\pi^e_{qq} > (<)x^*_q$. Furthermore, we observe that $\pi^c_{\rho q}\pi^e_{\rho q} = (\pi^c_{\rho\rho} - x^*_\rho)(\pi^e_{qq} - x^*_q)$, so that the Jacobian is positive and equal to $\det(J) = x^*_q(\pi^c_{\rho\rho} + \pi^e_{q\rho})$. Defining the two matrices

$$A_1 = \begin{bmatrix} -\pi^c_{\rho\tau} & \pi^c_{\rho q} \\ -\pi^e_{q\tau} & \pi^e_{qq} \end{bmatrix}, A_2 = \begin{bmatrix} \pi^c_{\rho\rho} & -\pi^c_{\rho\tau} \\ \pi^e_{q\rho} & -\pi^e_{q\tau} \end{bmatrix}.$$

allows us to compute the change of the freight rate and the export price with the tariff that are respectively given by

$$\rho^*_\tau = \frac{\det(A_1)}{\det(J)} = -\frac{x^*_q \pi^c_{\rho\tau}}{\det(J)} \tag{A.8}$$

and

$$q^*_\tau = \frac{\det(A_2)}{\det(J)} = -\frac{q x^*_\rho (x^*_q + (q-c)x^*_{qq})}{(1+\tau)\det(J)} < 0. \tag{A.9}$$

respectively, as $x^*_q + (q-c)x^*_{qq} < 0$. Expression (A.8) shows that ρ_τ depends on the sign of $\pi^c_{\rho\tau}$.

These results shows that the effect of the tariff rate on the export price is the same as for the independent exporter. The reason is that the supplier anticipates that an increase in the tariff rate will lead to a decrease in her export demand, and she will partially compensate for this decline by lowering the export price. The market has become less profitable, and the supplier is thus able to avoid a too large reduction in her profit by decreasing the export price. The role of the freight rate has not changed: a sufficiently strong decline in marginal transport costs can lead to a reduction in freight rates as a response to a decline in tariffs. Thus, we expect that transport costs and tariffs show a co-movement for those goods that are easier to carry in large volumes, and we can show also for this setup that a carrier might reduce the freight rate in order to exploit decreasing marginal transport costs. The interaction between the export price and the freight rate depends on how the freight rate affects the marginal profit of the exporter w.r.t. to the export price. In case of strategic complementarity (substitutability) in the sense of Bulow *et al* (1985), the export price will co-move (not co-move) with the freight rate.

What will happen if there are more than just one supplier? An additional effect in case of an oligopoly will originate from the strategic interaction among suppliers. But also with strategic interactions of any kind, we do not expect our results to be turned upside down.

An increase in the tariff rate reduces the attractiveness of the market for the suppliers, and part of this tariff increase will be carried by suppliers as long as the export price is strictly larger than the marginal production cost. Only in case of perfect competition, the export price will be equal to the marginal production cost and will not change with a change in the tariff or the freight rate.

A.3 Oligopolistic competition in the transport market

Assume a Salop circle with its circumference normalized to unity. An exporter will learn its location after freight rates have been set, and the location probability is uniformly distributed along the circle. The carriers are located in equal distance on the circle,[42] as they offer transport that may be a good or bad match for the exporter. Without loss of generality, let us consider carrier i whose location we normalize to zero. Thus, when n carriers compete, moving rightwards, the neighboring rival is located at location $1/n$, and the other neighboring rival is also $1/n$ away on the left at location $(n-1)/n$. The cost of the mismatch is the distance from the next carrier times a cost t per unit. This mismatch is due to an inconvenient schedule, an inconvenient shipping route to the destination of exports, etc. The market for carrier i is between location $(n-1)/n$ and $1/n$, and we will focus on symmetric equilibria,. The exporter $\bar{y}$ that is indifferent between carrier i and the one located at location $1/n$ is given by

$$\rho_i x(\rho_i, \cdot) + t\bar{y} = \rho_j x(\rho_j, \cdot) + t\left(\frac{1}{n} - \bar{y}\right)$$

such that all exporters located between 0 and $\bar{y}$ will use carrier i, and those located between $\bar{y}$ and $1/n$ will use the other carrier. The exporter will want to minimize the sum of freight charges and mismatch costs, and the one located at $\bar{y}$ carries the same total cost with both carriers. The model is thus an extension of the standard Salop model with a export-dependent cost component.[43] Since the exporter draws her location from a uniform distribution, and since the same market exists to the left for carrier i, the probability of winning the exporter is given by

$$\text{Prob}(\rho_i, \rho_j) = \frac{1}{n} - \frac{1}{t}\left(\rho_i x(\rho_i, \cdot) - \rho_j x(\rho_j, \cdot)\right),$$

where ρ_j denotes the (symmetric) price of the rival right and left of carrier i. Note that

[42] If location of carriers were endogenous, it is straightforward to show that this would also be their equilibrium location as the Principle of Maximum Product Differentiation applies here.

[43] The Salop model has been extended to flexible demand, see for example Gu and Wenzel (2012) and the cited literature.

$$\frac{\partial \text{Prob}(\rho_i, \rho_j)}{\partial \rho_i} = -\frac{1}{t}\left(\rho_i x_{\rho_i}(\rho_i, \cdot) + x(\rho_i, \cdot)\right) < 0,$$

as long as the marginal revenue is positive; this derivative does not depend on ρ_j. The same is true for

$$\frac{\partial \text{Prob}(\rho_i, \rho_j)}{\partial \rho_j} = \frac{1}{t}\left(\rho_j x_{\rho_j}(\rho_j, \cdot) + x(\rho_j, \cdot)\right) < 0$$

for a positive marginal revenue. The effect of a tariff depends on the difference in costs:

$$\frac{\partial \text{Prob}(\rho_i, \rho_j)}{\partial \tau} = -\frac{1}{t}\left(\rho_i x_{\tau}(\rho_i, \cdot) - \rho_j x_{\tau}(\rho_j, \cdot)\right).$$

Furthermore,

$$\frac{\partial^2 \text{Prob}(\rho_i, \rho_j)}{\partial {\rho_i}^2} = -\frac{1}{t}\left(\rho_i x_{\rho_i \rho_i}(\rho_i, \cdot) + 2x_{\rho_i}(\rho_i, \cdot)\right)$$

and

$$\frac{\partial^2 \text{Prob}(\rho_i, \rho_j)}{\partial \rho_i \partial \tau} = -\frac{1}{t}\left(\rho_i x_{\rho_i \tau}(\rho_i, \cdot) + x_{\tau}(\rho_i, \cdot)\right).$$

The expected profit for carrier i is given by

$$\pi^i(\rho_i, \rho_j) = \text{Prob}(\rho_i, \rho_j)\left[\rho_i x(\rho_i, \cdot) - \Psi(x(\rho_i, \cdot))\right].$$

The first-order condition is given by

$$\begin{aligned}\frac{\partial \pi^i(\rho_i, \rho_j)}{\partial \rho_i} &= \frac{\partial \text{Prob}(\rho_i, \rho_j)}{\partial \rho_i}\left[\rho_i x(\rho_i, \cdot) - \Psi(x(\rho_i, \cdot))\right] \\ &+ \text{Prob}(\rho_i, \rho_j)\left[\rho_i x_{\rho_i}(\rho_i, \cdot) + x(\rho_i, \cdot) - \Psi_x(x(\rho_i, \cdot))x_{\rho_i}(\rho_i, \cdot)\right] = 0.\end{aligned}$$

Since $[\partial \text{Prob}(\rho_i, \rho_j)/\partial \rho_i]\left[\rho_i x(\rho_i, \cdot) - \Psi(x(\rho_i, \cdot))\right] < 0$, pricing behavior will be more aggressive with potential rivals as the carrier's market share decreases with an increase in the carrier's freight rate. The second-order condition requires

$$\begin{aligned}
\frac{\partial^2 \pi^i(\rho_i,\rho_j)}{\partial {\rho_i}^2} &= \frac{\partial^2 \text{Prob}(\rho_i,\rho_j)}{\partial {\rho_i}^2}\left[\rho_i x(\rho_i,\cdot) - \Psi(x(\rho_i,\cdot))\right] \\
&+ 2\frac{\partial \text{Prob}(\rho_i,\rho_j)}{\partial \rho_i}\left[\rho_i x_{\rho_i}(\rho_i,\cdot) + x(\rho_i,\cdot) - \Psi_x(x(\rho_i,\cdot))x_{\rho_i}(\rho_i,\cdot)\right] \\
&+ \text{Prob}(\rho_i,\rho_j)\left[\rho_i x_{\rho_i\rho_i}(\rho_i,\cdot) + 2x_{\rho_i}(\rho_i,\cdot) - \Psi_x(x(\rho_i,\cdot))x_{\rho_i\rho_i}(\rho_i,\cdot)\right. \\
&- \left.\Psi_{xx}(x(\rho_i,\cdot))x_{\rho_i}(\rho_i,\cdot)^2\right] < 0.
\end{aligned}$$

Freight rates are strategic substitutes because

$$\frac{\partial^2 \pi^i(\rho_i,\rho_j)}{\partial \rho_i \partial \rho_j} = \frac{\partial \text{Prob}(\rho_i,\rho_j)}{\partial \rho_j}\left[\rho_i x(\rho_i,\cdot) - \Psi(x(\rho_i,\cdot))\right] > 0.$$

As in the monopoly case, the cross derivative

$$\begin{aligned}
\frac{\partial^2 \pi^i(\rho_i,\rho_j)}{\partial \rho_i \partial \tau} &= \frac{\partial^2 \text{Prob}(\rho_i,\rho_j)}{\partial \rho_i \partial \tau}\left[\rho_i x(\rho_i,\cdot) - \Psi(x(\rho_i,\cdot))\right] \\
&+ \frac{\partial \text{Prob}(\rho_i,\rho_j)}{\partial \tau}\left[\rho_i x_{\rho_i}(\rho_i,\cdot) + x(\rho_i,\cdot) - \Psi_x(x(\rho_i,\cdot))x_{\rho_i}(\rho_i,\cdot)\right] \\
&+ \text{Prob}(\rho_i,\rho_j)\left[\rho_i x_{\rho_i\tau}(\rho_i,\cdot) + x_\tau(\rho_i,\cdot) - \Psi_x(x(\rho_i,\cdot))x_{\rho_i\tau}(\rho_i,\cdot)\right. \\
&- \left.\Psi_{xx}(x(\rho_i,\cdot))x_{\rho_i}(\rho_i,\cdot)x_\tau(\rho_i,\cdot)\right]
\end{aligned}$$

is ambiguous in sign. In an equilibrium with symmetric prices, $\partial\text{Prob}(\rho_i,\rho_j)/\partial\tau = 0$. Note in particular that $[\partial\text{Prob}(\rho_i,\rho_j)/\partial\rho_i x_\tau(\rho_i,\cdot)]\,[\rho_i - \Psi_x(x(\rho_i,\cdot))] > 0$, an effect that is not present in case of a monopoly: a tariff reduction increases exports, and thus the competition for market shares becomes more intense, and this partial effect leads to a decrease in freight rates.

A.4 Proof of Proposition 3

The second derivatives and the cross-derivatives are given by $\Pi_{xx} = R_{xx}(x^{**}) - C_{xx}(x^{**}) < 0$, $\Pi_{qq} = -\Delta_{qq}(q^{**}) < 0$, $\Pi_{xq} = -\tau$, $\Pi_{x\rho} = -1$, $\Pi_{q\rho} = 0$, $\Pi_{x\tau} = -q$, $\Pi_{x\tau} = -x$. Thus, the Hessian is equal to $\det(H) = -\left(R_{xx}(x^{**}) - C_{xx}(x^{**})\right)\Delta_{qq}(q^{**}) - \tau^2 > 0$, and we assume that the Hessian is positive, making the first-order conditions sufficient. Writing in matrix form

$$\begin{bmatrix} \Pi_{xx} & -\tau \\ -\tau & \Pi_{qq} \end{bmatrix} \begin{bmatrix} dx^{**} \\ dq^{**} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix} d\rho + \begin{bmatrix} q \\ x \end{bmatrix} d\tau$$

allows us to compute the change of the exports and change of the export price with the freight rate and the tariff that are respectively given by

$$x_\rho^{**} = \frac{\Pi_{qq}}{\det(H)} < 0, q_\rho^{**} = \frac{\tau}{\det(H)} > 0, \tag{A.10}$$

$$x_\tau^{**} = \frac{q\Pi_{qq} + \tau x}{\det(H)} < 0, q_\tau^{**} = \frac{x\Pi_{xx} + q\tau}{\det(H)}. \tag{A.11}$$

$x_\tau^{**} < 0$ because $\Pi_{qq} = -\Delta_{qq}(q)$, $\Delta_q = \tau x$ and $\xi(q) > 1$. Note that we cannot sign $x_{\rho\tau}^{**}$ in general that determines $\pi_{\rho\tau}^c$ in Proposition 1 together with x_ρ^{**}, x_τ^{**} and $\Psi_{xx}(x^{**})$.

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