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What Goes Around Comes Around: Export-Enhancing Effects of Import-Tariff Reductions

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What Goes Around Comes Around:
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Abstract

In international trade, transportation requires a round trip for which a transport firm has to commit to the shipping capacity to meet the maximum shipping volume. This may cause the "backhaul problem." Trade theory suggests that facing the problem, transport firms with market power adjust their freight rates strategically when import tariffs change. As a consequence, a country reducing its import tariffs may experience an increase in exports as well as imports. Using worldwide data during 2000-2007, we find evidence that supports these predictions. These findings indicate a new mechanism through which import-tariff reductions lead to export expansions.

JEL Codes: F12, F13, R40

Key words: Transport firm; freight rates; tariffs; backhaul problem

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1. Introduction

It is obvious that a country's import tariffs affect its domestic imports. However, import tariffs may also affect the country's exports. Existing studies identify a few channels through which domestic import tariffs affect domestic exports. Early studies indicate a negative effect of import liberalization on exports; for example, restricting imports could enhance exports when the protected industry exhibits increasing returns to scale (Krugman, 1984). However, more recent studies identify positive effects of reducing import restrictions on exports. For example, global supply chains and associated vertical trade could explain the following positive effects: a country that lowers its import tariffs on intermediate inputs may lead to lower production costs, thereby increasing its exports of final goods.[1]

Recently, Ishikawa and Tarui (2018) incorporate key features of transport costs to investigate theoretically whether domestic import tariffs affect domestic exports. Most trade models assume away transport costs or treat them in an ad hoc manner (e.g., the usual iceberg cost specification, Samuelson 1952); in particular, the transport costs are assumed to be exogenous and symmetric. Ishikawa and Tarui (2018) find that once an explicit transport sector with market power is considered and asymmetric transport pricing is allowed, an increase in domestic import tariffs may indeed reduce domestic exports because the tariff increase raises transport costs for domestic exports (the mechanism is detailed in Section 2).

Our focus on the role of the transport sector is based on findings of empirical studies that indicate that transport costs affect international trade in a significant manner. First, transport costs pose a barrier to international trade that is often higher than tariffs (Hummels, 2007).[2] An estimate suggests that transportation costs and trade barriers (i.e., tariffs and non-tariff barriers) account for 21% and 7.7%, respectively, of representative trade costs for industrialized countries (Anderson and van Wincoop, 2004). A survey by Behar and Venables (2011) identifies studies that show that freight costs have a statistically significant and quantitatively important impact on trade flows.

Second, the transport sector exhibits considerable market power (Hummels et al., 2009). For example, the top seven liner operators account for more than 70% of the global shipping capacity in TEU (twenty-foot equivalent unit) terms.[3] Furthermore, liner trade is organized into three alliances: 2M, The Alliance, and Ocean Alliance. In particular, the two largest linear operators, APM-Maersk and Mediterranean Shipping Company, form 2M, which accounts for more than one third of the containerized trade. Similarly, the global share of the top seven air cargo carriers in

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[1] For example, by using Indonesian firm-level data, Amiti and Konings (2007) find that a reduction in import tariffs on inputs leads to a productivity gain by the firms in the sectors that import these inputs. This might indicate that these firms may in turn increase their exports.

[2] Deardorff (2014) says "[t]he most obvious cost of trade is transportation, but even this has been surprisingly neglected in trade theory."

[3] https://www.alphaliner.com/

terms of scheduled freight tonne km is approximately 50%.[4] Air cargo carriers also form alliances such as SkyTeam Cargo and WOW Alliance.

Third, depending on the direction of shipments, freight rates are different on the same route. Hummels et al. (2009) and Waugh (2010) find that developing countries pay substantially higher transport costs than developed countries. The market average freight rates for shipping from Asia to the United States were approximately 1.5 times the rates for shipping from the United States to Asia in 2009 (United Nations Conference on Trade and Development, 2010).[5] This asymmetry is due to not only the elasticity of demand for shipping but also the backhaul problem. The backhaul problem arises because carriers have to commit to the shipping capacity to meet the maximum shipping volume, which may result in an imbalance in shipping volume in two directions. Such an imbalance implies an opportunity cost associated with the failure to return with a full load. Transport companies adjust shipping capacity and freight rates to avoid the backhaul problem as much as possible.[6] In fact, a reason for the transport firms to form an alliance is to avoid the backhaul problem.

Ishikawa and Tarui (2018) explicitly take the backhaul problem into account in their model and point out that the backhaul problem plays a crucial role when investigating trade and industrial policies. In particular, they show that an increase in domestic import tariffs decreases domestic exports when a carrier avoids the backhaul problem. This is because a transport firm, subject to its capacity constraints on shipping, responds to policy changes by adjusting the freight rates charged on shipping in both directions and its capacity level.

The purpose of this paper is to test Ishikawa and Tarui's (2018) theoretical predictions by exploiting variations in tariff rates across countries and over time. Specifically, we examine how freight rates between two countries are related to their respective tariff rates. For this purpose, we apply data on freight rates from the Maritime Transport Costs database published by OECD and tariffs from the World Integrated Trade Solution (WITS). Our sample for estimation includes bilateral freight rates and tariffs for 137 export countries and 10 import countries during 2000-2007. We find that a reduction in a country's (weighted average) tariff rates against a partner's goods lowers the freight rates on the export from the former to the latter, supporting the theoretical prediction described above. This finding is robust under several alternative specifications of the econometric model.

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[4] http://www.aircargonews.net/news/single-view/news/top-25-cargo-airlines-fedex-maintains-top-spot-but-abc-and-qatar-on-the-up.html

[5] Brown (2015) documents that the relative increases in the costs of tracking on the import leg from Canada to the United States and the export leg to Canada after 9/11 were consistent with the relative trade flow between the two countries.

[6] Dejax and Crainic (1987) provide an early survey of the research on backhaul problems in transportation studies.

In addition, we examine empirically the relationship between exports and tariff rates. A decrease in freight rates on the export to a trading partner, driven by lower import tariffs, will obviously increase export volume to the partner. To investigate this consequence on trade volume, we estimate gravity equations for the worldwide trade quantities by introducing not only own country's tariffs but also a partner's tariffs. We find that a country's export quantity is larger when its import tariff rates are lower. Furthermore, as mentioned above, vertical trade and the presence of global supply chains also explain the export-enhancing effects (on outputs) of import tariff reduction (on inputs). We examine a regression specification without trade in final products in order to eliminate this channel and find a similar result, providing support for the export-enhancing effect due to changes in the freight rates.

Several recent studies take into account market power by transport firms and endogeneity of transport costs in their empirical investigations on the economic consequence of endogenous transport costs (Asturias, 2016; Brancaccio et al., 2017; Boddin and Stähler, 2018). For example, Asturias (2016) studies endogenous costs of containerized shipping through oligopolistic competition among transport firms. However, the study does not consider the backhaul problem or capacity constraints faced by transport firms. As a result, neither the theory nor the policy experiments capture the export-enhancing effects of import tariff reductions. Similarly, other recent empirical studies on endogenous transport costs focus on the direct impact of import tariffs on shipping costs of imports but not on those of exports. In short, this study is the first to examine empirically the effects of import tariffs on freight rates of the export to a partner.

A significant point of departure of our study is to test whether import tariffs affect the shipping costs on exports. The theory underlying our investigation provides careful consideration to the backhaul problem, hence the link between a country's import tariff and the transport cost from the country. Indeed, our point estimates indicate that the effect of changes in import tariffs on the freight costs on exports is sizeable: a percentage reduction in a country's import tariff is associated with about a 0.15% decline in the freight rates on its export. Therefore, our results suggest that the welfare impacts of tariff reductions are likely to be larger than what the recent empirical studies on endogenous transport cost indicate.

In what follows, we first present a theoretical framework that explains the effects of trade liberalization on freight costs and trade quantities (Section 2). Section 3 summarizes the empirical framework that we employ to test the theory by using data on trade and transport costs. Section 4 presents our main empirical results, as well as a few extensions that address their robustness. Section 5 concludes the paper.

2. Conceptual Framework

Our theoretical framework relies on the trade model with an explicit transport sector developed by Ishikawa and Tarui (2018). Their two-country model incorporates the transport sector into a standard framework of international trade. They specifically take into account the following characteristics of international shipping when constructing their model: (i) market power, (ii) asymmetric freight rates among directions, (iii) backhaul problem, and (iv) linear pricing or additive transport costs.[7] In the following, we briefly explain their basic model tailored to derive our testable hypotheses.

Consider trade between two countries A and B. Country $A(B)$ exports good $A(B)$ and imports good $B(A)$. The markets of goods A and B are perfectly competitive. Country i (i=A,B) sets an ad valorem import tariff. A monopolistic firm provides transport services, which are required for trade between the two countries. Thus, when exporting the good, each firm faces an ad valorem import tariff imposed by the other country as well as freight rates charged by the monopolistic transport firm. The assumption of the monopolistic transport firm is not extreme; Hummels et al. (2009) observe from 2006 data that one in six importer-exporter pairs worldwide was served by a single direct liner "service," meaning that only one ship was operating on that route. They also state that "[o]ver half of importer-exporter pairs were served by three or fewer ships, and in many cases all of the ships on a route were owned by a single carrier." In fact, Ishikawa and Tarui (2018) find that the main result presented here holds when there are more than one transport firms with market power.

Suppose the (inverse) export supply of a good from country i to j, X_{ij}, satisfies

$$p_i = S_i(X_{ij}),$$

where p_i is the price that the producers receive and $S_i' > 0$. The (inverse) import demand for the good in country j is given by

$$p_i(1+\tau_j) + T_{ij} = D_j(X_{ij}),$$

where T_{ij} is the freight rate for shipping from country i to j, τ_j the tariff rate set by country j, and $D_j' < 0$. This specification follows the empirical findings that the transport costs, unlike import tariffs, are additive. From these two equations we have a condition for the market equilibrium:

$$S_i(X_{ij})(1+\tau_j) + T_{ij} = D_j(X_{ij}).$$

Solve this equation for the demand for transportation of the good from country i to j:

$$X_{ij} = \phi^{ij}(T_{ij}, \tau_j).$$

[7] Using multi-country bilateral trade data at the six-digit HS classification, Hummels and Skiba (2004) find that shipping technology for a single homogeneous shipment more closely resembles per unit, rather than ad valorem, transport costs. Using Norwegian data on quantities and prices for exports at the firm/product/destination level, Irarrazabal et al. (2015) find the presence of additive (as opposed to iceberg) trade costs for a large majority of product-destination pairs.

A monopolistic transport firm's costs of shipping, C, are given by

$$C = f + rk,$$

where $r, f,$ and k are, respectively, the marginal cost of operating a means of transport such as vessels, the fixed cost, and the shipping capacity such that

$$k = \max\{X_{ij}, X_{ji}\}.$$

The transport firm chooses the shipping capacity k and the freight rates T_{ij} and T_{ji} (for each route (i, j)) in order to maximize its profit:

$$\Pi_T = T_{ij}\phi^{ij}(T_{ij}, \tau_j) + T_{ji}\phi^{ji}(T_{ji}, \tau_i) - rk,$$

where the shipping quantity is constrained by the capacity.

The backhaul problem arises if either $X_{ij} < X_{ji} = k$ or $X_{ji} < X_{ij} = k$ holds. We focus on the case in which the transport firm avoids the backhaul problem (i.e., $X_{ji} = X_{ij} = k$). If $X_{ij} = X_{ji} = k$ holds, then the transport firm solves the profit maximization problem subject to $\phi^{ij}(T_{ij}, \tau_j) = \phi^{ji}(T_{ji}, \tau_i)$. In this case, the equilibrium shipping quantity, X_{ij}^*, is decreasing in both τ_j and τ_i:

$$\frac{\partial X_{ij}^*}{\partial \tau_i} < 0, \qquad \frac{\partial X_{ij}^*}{\partial \tau_j} < 0. \tag{1}$$

It also follows that the equilibrium freight rates depend on the tariff rates in the following manner (see appendix A):

$$\frac{\partial T_{ij}^*}{\partial \tau_i} > 0, \qquad \frac{\partial T_{ij}^*}{\partial \tau_j} < 0. \tag{2}$$

Therefore, country j's tariff necessarily increases the freight rate from country j to country i and decreases country j's exports.

The mechanism of the export-enhancing effect of import tariff reduction is as follows: A country's lower import tariff induces the transport firm to raise the freight rate on the import (thus partially offsetting the effect of tariff reduction). Because the increase in the freight rates only partially offset the transport cost reduction due to a lower tariff, the import quantity increases. When the trade volume is balanced, the transport firm lowers the freight rate on the export in order to avoid the backhaul problem. This results in an increase in the export by the country (Ishikawa and Tarui, 2018, Proposition 2). Their paper subsequently illustrates that this finding is robust when there are multiple output sectors (Proposition 4) and when there are multiple, oligopolistic transport firms (Proposition 8). In these extensions, balanced trade is not necessarily required for the export-enhancing effects of tariff reductions to be present.

In what follows, we investigate the following testable hypotheses based on Ishikawa and Tarui's (2018) results as summarized in inequalities (1) and (2):

Hypothesis 1. *A tariff reduction by a country tends to reduce the freight rate for shipping from the country.*

Hypothesis 2. *A tariff reduction by a country tends to increase the country's export (in addition to the country's import).*

3. Empirical Framework

This section discusses our empirical framework to investigate the two hypotheses listed above. As shown in equation (2), freight rates depend not only on the importer's tariff rates but also on the exporter's tariff rates. To examine this theoretical prediction, we estimate the following reduced-form equation by the ordinary least square (OLS) method.

$$\ln Freight_{ijpt} = \gamma_1 \ln\left(1 + Tariff_{ijt}\right) + \gamma_2 \ln\left(1 + Tariff_{jit}\right) + u_{ijp} + u_{it} + u_{jt} + \epsilon_{ijpt},$$

where $Freight_{ijpt}$ represents additive freight rates when exporting product p from country i to country j in year t. The variable $Tariff_{ijt}$ is ad-valorem tariff rates applied when country i exports to country j in year t. As demonstrated in the previous section, the coefficients for importer's tariffs (i.e., $Tariff_{ijt}$) and exporter's tariffs (i.e., $Tariff_{jit}$) are expected to be negative and positive, respectively.

To identify the effect of tariffs on the freight rates, we introduce various fixed effects that control for other factors that affect freight rates. Exporter-importer-product fixed effects (u_{ijp}) control for time-invariant country pair-product specific elements, including costs specific to the freight routes between two countries, in addition to product-specific components of freight rates. For example, freight rates for transporting goods to landlocked countries would contain components that are different from those for transporting goods between two island countries. As in the gravity studies, these fixed effects also control for country-pair specific factors, such as geographical distance, linguistic commonality, and national border sharing. Time-variant export country characteristics such as production capacity or factor prices are controlled for by exporter-year fixed effects (u_{it}). Importer-year fixed effects (u_{jt}) control for time-variant import country characteristics such as demand sizes. These time-variant fixed effects also capture the effects of changes in the price of oil, which is a significant cost component of ocean shipping. The last variable ϵ_{ijpt} is the disturbance term.

The data on our main variable, i.e., freight rates, are obtained from the Maritime Transport Costs database published by OECD (Korinek, 2011).[9] It provides the data on freight rates for 43 importing countries (including EU15 countries as a custom union) and 218 countries of origin at the detailed commodity (six-digit) level of the Harmonized System (HS) 1988. Although the database includes not only original customs data but also estimates, we only use the former, which are available for imports by Australia, New Zealand, the United States, Argentina, Brazil, Chile, Colombia, Ecuador, Peru, and Uruguay.[10] A total of 137 countries are included as exporters. Our sample covers trade during 2000-2007. We can observe the data on freight rates only for the countries between which trade relationship exists because we use freight rates computed based on the actual trade. To reduce the share of missing observations (i.e., combinations with no trade relationship) in all possible combinations, i.e., to mitigate the risk of the sample selection bias, we define the product at the HS two-digit level, although the analysis at a finer level enables us to minimize the change of freight rates based on the product mix. We focus on freight rates in transporting products subject to containerized trade (as opposed to tankers or bulk shipping) because containerized ocean transportation is provided by imperfectly competitive firms as is consistent with our theoretical setting.[11] As suggested in the empirical literature on transport costs (Hummels and Skiba, 2004; Irarrazabal et al., 2015), we specify freight rates as additive (i.e., freight rates per kilogram) instead of ad valorem.

Another important variable in our analysis is tariff rates. We exploit variations of the average of tariff rates over all commodities subject to containerized trade over time and across country pairs. Just as a container may carry a mixture of products from various sectors, freight rates on a particular manufacturing good may depend not only on the trade volume of the good itself but on the total trade volume between countries. Therefore, we define tariff variables at a country pair-year level rather than at a country pair-product-year level.[12] To compute country-pair level average tariff rates, we use the weighted average in terms of imports at a commodity (HS six-digit)-level because the effect of tariff rates on freight rates will be larger for products with larger trade volume or values. As a weight, we use the trade data evaluated at a free-on-board (fob) basis because freight rates play a key role in our theoretical prediction. Thus we should use trade values that do not include freight rates.

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[9] https://stats.oecd.org/Index.aspx?DataSetCode=MTC#

[10] Hummels and Lugovskyy (2006) also use the same data for New Zealand and the United States.

[11] As listed in Korinek (2011), such products include all products except for HS codes 10, 1201-1207, 1507-1514, 25, 26, 2701-2716, 28, 29, 31, 72, 8701-8705, 8716, 8802, and 89. For more details on the Maritime Transport Costs database, see Korinek (2011).

[12] We also estimated the model with tariff variables at a country pair-product-year level but found insignificant results, which may be consistent with our conjecture that freight rates on a particular product depend on not only its trade volume but also the trade volume of the other products. The results are available upon request.

Our data sources for this analysis are as follows. We obtain trade data, which are used for computing a weight in tariff variables, from the BACI database in CEPII. This database provides the data on bilateral trade values at the fob basis. We constructed our tariff variables in the following manner. First, tariff line-level data on tariff rates are obtained from the WITS database[13]. Second, at a tariff-line level, we identify the lowest tariff rates among all schemes, including regional trade agreements (RTAs), available for each country pair. Namely, our tariff rates are applied rates. Third, tariff rates at the tariff-line level are converted to those at the six-digit level of HS1988 using the conversion table available on the website of United Nations Statistics Division[14]. We apply the simple average for this aggregation. Finally, we compute the weighted average of tariff rates by using HS six-digit level imports (of which data are drawn from the BACI) as a weight.

4. Empirical Results

We first report the results of our baseline estimation and then show the findings from additional analyses. We also examine the effects of tariff rates on trade.[15]

4.1. Baseline Estimation

Table 1 presents our baseline estimation results. Column (I) reports the results, with the right-hand side containing importer's tariffs (i.e., $Tariff_{ijt}$), but not exporter's tariffs. Column (II) is based on the specification where only the exporter's tariffs (i.e., $Tariff_{jit}$) are included on the right-hand side (but the importer's tariffs are not). The specification under column (III) includes both importer's and exporter's tariffs on the right-hand side. The coefficient for importer's tariffs is significantly negative, indicating that the rise of transportation demand through tariff reduction raises freight rates. This result is consistent with the natural relationship between transport demand and transport prices. On the other hand, the coefficient for exporter's tariffs is positively significant. This is consistent with our theoretical prediction that the transport sector would reduce the freight charges in order to balance the two-way transport volumes. In short, a country's tariff rates against its partner's goods are positively correlated with freight rates to the partner country.

=== Table 1 ===

13 http://wits.worldbank.org/WITS/
14 https://unstats.un.org/unsd/trade/classifications/correspondence-tables.asp
15 Basic statistics of our variables are reported in Table B1 in Appendix B.

Next, we introduce exporter-product-year and importer-product-year fixed effects instead of exporter-year and importer-year fixed effects. These fixed effects control for demand and supply side elements at a more detailed level. More importantly, importer-product-year fixed effects control for the change of the most favored nation (MFN) status. Namely, our tariff variables in this specification mainly capture the change of tariff rates due to the entry of RTAs into force. Several RTAs entered into force during our sample period. For example, Australia had RTAs with Singapore in 2003 and with the U.S. and Thailand in 2005. Chile had RTAs with the European Free Trade Association and South Korea in 2004 and with Japan and India in 2007. As a result, we still have enough variation in the change of our tariff variables, even after controlling for exporter-product-year and importer-product-year fixed effects. The estimation results are shown in columns (IV)-(VI) in Table 1. While the magnitude of the coefficients is slightly different, those are again significant with the signs consistent with our theoretical expectation.

We further conduct two kinds of robustness checks. First, we exclude country pairs in which either the importer or the exporter is landlocked. When landlocked countries conduct trade involving ocean shipping, goods need to pass the national boundary of a third country. Due to the land transport involved, freight rates may be heavily affected by trade volume between the third country and the importing or the exporting country. Although we control for the difference in the level of freight rates across country pairs by applying exporter-importer-product fixed effects, the coefficients for tariff variables may also be different. To examine this possible difference, we use a subsample that excludes observations associated with landlocked countries and focus on countries that face coasts. The results are reported in columns (I) and (II) in Table 2 and again show the negative coefficients for importer's tariffs and the positive coefficients for exporter's tariffs. Compared with columns (III) and (VI) in Table 1, columns (I) and (II) in Table 4 show the larger (absolute) estimates for the importer's tariffs and the smaller estimates for exporter's tariffs. Second, we exclude observations with top 5% of freight rates change over the sample period, i.e., outliers. The results are reported in columns (III) and (IV) in Table 2 and are qualitatively unchanged.

=== Table 2 ===

Finally, we try other specifications of the tariff variables. In columns (I) and (II) in Table 3, we introduce non-logged tariffs. Although we specify our empirical model as a log-log model, the theory does not necessarily indicate that freight rates and tariffs should be logged.[16] The results

[16] As shown in Table B1 in Appendix B, the freight rates have large standard deviation, thus we maintain its log specification in order to address heteroscedasticity.

with non-logged tariff variables indicate the negative coefficients for importer's tariffs and the positive coefficients for exporter's tariffs. Specifically, column (I) shows that one percentage-point rises of importer's and exporter's tariffs increase freight rates by 0.36% and decrease those by 0.13%, respectively. In columns (III) and (IV), we introduce square terms of logged importer's and exporter's tariffs to see non-linear effects of tariffs. Although the coefficients for the first-order terms turn out to be insignificant, the square terms for importer's and exporter's tariffs have significantly negative and positive coefficients, respectively. Namely, the effects of tariffs on freight rates become larger when tariff rates are higher.

=== Table 3 ===

4.2. Extended Analysis

In this subsection, we conduct three kinds of extended analyses. First, we examine lagged effects of tariff change on freight rates. Although our theoretical analysis is based on a static model, the effects of importer's and exporter's tariff change may not be realized at the same time. On one hand, we expect the effect of importer's tariffs on freight rates to show up immediately due to the change of freight demand. On the other hand, the effect of exporter's tariffs may be realized with a time lag because transport firms adjust freight rates to balance two-way trade volume after the change of the freight demand and rates in the opposite direction. To examine this lagged effect, we introduce one-year lagged variables of importer's and exporter's tariffs. The results are reported in columns (I) and (II) in Table 4. As is consistent with the above expectation, coefficients for the current year of importer's tariffs are significantly estimated, but those of exporter's tariffs are not. Instead, the one-year lagged variable of exporter's tariffs is significantly positive.

=== Table 4 ===

Second, we examine the role of an imbalance in the shipment volume of bilateral trade between trading partners. As discussed in Section 2, the positive effect of exporter's tariffs is based on the adjustment of freight rates to balance two-way trade. This adjustment is likely to occur when the two-way trade volumes are in balance. Therefore, the effect of exporter's tariffs is expected to be insignificant when there is a large gap in shipment volume between a country's import and export with a trading partner. To examine this implication, we introduce interaction terms of exporter's tariffs with quantile dummy variables on the absolute gap in total trade volume between two countries. Specifically, we focus on containerized trade and use the average gap between two countries over the sample period. The results are shown in columns (III) and (IV) in Table 4. Only the interaction terms with the first and second quantiles have significantly positive coefficients. In other words, no positive effect of exporter's tariffs exists when the gap in the shipment volume in the opposite directions is large—a result consistent with the theoretical prediction in Ishikawa and Tarui (2018).

Third, we examine the role of port call in freight rates. Container ships may call at various ports on the way to import countries. In this case, the freight rates between two countries depend not only on the freight volume between the two countries but also on the freight volumes among countries on the shipping routes. Specifically, the number of such ports and countries will be larger when the distance between the two trading countries is larger. Then, the effect of exporter's tariffs may decrease. To examine this possibility, we introduce the interaction term of exporter's tariffs with the log of geographical distance between trading countries. The results are reported in columns (V) and (VI). Both columns show the significant positive coefficients for exporter's tariffs. Particularly in column (VI), the coefficient for the interaction term is estimated to be significantly negative, as is consistent with the above expectation.

4.3. Effects on Trade Quantity

So far, we have examined the effects of tariff rates on freight rates. As mentioned before, through such changes in freight rates, reduced tariff rates in a country will increase not only its import but also its export. Here, we empirically examine such effects on trade. Specifically, we estimate the following gravity equation.

$$\ln Export_{ijpt} = \gamma_1 \ln\left(1 + Tariff_{ijt}\right) + \gamma_2 \ln\left(1 + Tariff_{jit}\right) + u_{ijp} + u_{ipt} + u_{jpt} + \epsilon_{ijt},$$

where $Export_{ijpt}$ represents the export quantity (measured in ton) of product p from country i to country j in year t. The trade data are again obtained from the BACI database in CEPII. As in the analysis for freight rates, we focus on trade in products subject to containerized trade. Independent variables are the same as in the previous specifications for freight rates. The first variable on tariff rates is often included in the gravity analysis (e.g., Disdier et al., 2015). On the other hand, the second variable, i.e., exporter's tariffs, has never been examined in the gravity literature. As mentioned above, we also expect the coefficient γ_2 to be negative. Our dataset for this gravity estimation includes trade among 157 countries during 2000-2013.[17]

The OLS estimation results are shown in column "All" in Table 5. We regress on logged and non-logged tariff variables. The coefficients for importer's tariffs are significantly negative—a result consistent with the gravity studies. Our novel variable, exporter's tariffs, also has a

[17] It is common in the gravity literature to address an issue of zero-valued trade, i.e., sample-selection issue, by employing the Poisson pseudo-maximum likelihood estimation technique (Silva and Tenreyro, 2006) or the extended version of the Heckman two-step estimation (Helpman et al., 2008). However, our use of the weighted average of tariff rates, which is another important variable in our analysis, means that tariff variables are available only for country pairs with positive trade. Therefore, in this paper, we do not take this issue into account.

significantly negative coefficient as our theory predicts. This is the first evidence on the effect of exporter's tariffs on trade. In short, the results indicate that a country's import tariff rates against a trading partner's goods are negatively correlated with not only the imports from but also the exports to the partner country.

=== Table 5 ===

Our conjecture is that a change in a country's import tariffs affects its export by inducing a change in the freight rates. However, there are other mechanisms that may explain a similar relationship between the exporter's tariffs and exports. For example, when a country reduces tariff rates on materials (intermediate inputs), the country's export of the sectors that use these inputs may increase.[18] To exclude such export-enhancing effects of tariff reduction in inputs in the presence of vertical trade, we consider a specification that excludes trade in final goods and focuses instead on trade in materials. Specifically, we restrict the dependent variable to include only the products categorized as materials, i.e., numbers 111, 112, 21, 31, 42, and 53 in the Broad Economic Categories. Note that, due to the reason explained in the previous section, we apply (weighted) average tariff rates across all containerized commodities (instead of the tariff rates for the corresponding sectors) as independent variables. The results are shown in column "Material." Although the coefficient for non-logged exporter's tariffs is insignificant, the other coefficients are significantly estimated with expected signs. This finding indicates that vertical trade alone does not explain the export-enhancing effects of import tariff reductions.

5. Conclusion

Our empirical investigation based on freight rates and bilateral trade data across approximately 150 countries in 2000-2007 provides support for Ishikawa and Tarui's (2018) prediction that domestic tariff reductions induce the transport firms to lower their freight rates on domestic exports, thereby expanding not only domestic imports but also domestic exports. Given the global trend of trade liberalization, this finding implies that reducing import barriers may indeed enhance countries' exports instead of affecting them negatively.

Our study thus identifies an overlooked channel—endogenous transport costs—through which import liberalization has a positive effect on the country's exports. There are other channels through which an import tariff reduction may enhance export. As indicated in the introduction, tariff reductions on intermediate goods may expand the sectors that use those goods as inputs,

[18] Cruz and Bussolo (2015) confirm this effect.

enabling them to increase their exports (Cruz and Bussolo, 2015). This effect via global supply chains may be through direct effects on production costs (that drop due to lower input costs) or indirect effects through more intense import competition and resulting in productivity increases for the affected firms (Trefler, 2004; Amiti and Konings, 2007). A robustness check in the previous section implies that these effects alone do not explain our empirical finding.

However, there are other possibilities that we have not addressed in our empirical investigation. For example, trade liberalization may induce foreign direct investment, leading to increases in exports by multinational enterprises in the host countries. Further investigations of the export-enhancing effects of tariff reductions, and associated welfare impacts, are left for future research.

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Table 1. Estimation Results

	(I)	(II)	(III)	(IV)	(V)	(VI)
ln (1+Importer's tariffs)	-0.360		-0.381	-0.249		-0.273
	[0.126]		[0.127]	[0.121]		[0.122]
ln (1+Exporter's tariffs)		0.136	0.154		0.141	0.155
		[0.072]	[0.073]		[0.071]	[0.072]
Exporter-importer-product FE	YES	YES	YES	YES	YES	YES
Exporter-year FE	YES	YES	YES	NO	NO	NO
Importer-year FE	YES	YES	YES	NO	NO	NO
Exporter-product-year FE	NO	NO	NO	YES	YES	YES
Importer-product-year FE	NO	NO	NO	YES	YES	YES
Number of observations	117,459	117,459	117,459	105,995	105,995	105,995
Adjusted R-squared	0.6086	0.6086	0.6087	0.6632	0.6632	0.6632

Notes: The dependent variable is the log of freight rates per weight at an HS two-digit level. In the parenthesis is the heteroscedasticity-consistent standard error. “FE” refers to fixed effects.

Table 2. Robustness Check: Excluding Landlocked Countries and Outliers

	(I)	(II)	(III)	(IV)
ln (1+Importer's tariffs)	-0.408	-0.324	-0.359	-0.28
	[0.130]	[0.124]	[0.130]	[0.124]
ln (1+Exporter's tariffs)	0.13	0.125	0.143	0.161
	[0.075]	[0.073]	[0.073]	[0.073]
Exporter-year FE	YES	NO	YES	NO
Importer-year FE	YES	NO	YES	NO
Exporter-product-year FE	NO	YES	NO	YES
Importer-product-year FE	NO	YES	NO	YES
Exporter-importer-product FE	YES	YES	YES	YES
Exclude Landlocked Countries	YES	YES	NO	NO
Exclude Outliers	NO	NO	YES	YES
Number of observations	108,076	98,231	111,505	101,392
Adjusted R-squared	0.6136	0.6676	0.6188	0.6671

Notes: The dependent variable is the log of freight rates per weight at an HS two-digit level. In the parenthesis is the heteroscedasticity-consistent standard error. In columns (I) and (II), we exclude country pairs in which either the importer or exporter is landlocked. In columns (III) and (IV), we exclude observations with the top 5% of freight rates change over the sample period. “FE” refers to fixed effects.

Table 3. Robustness Check: Tariff Variables

	(I)	(II)	(III)	(IV)
Importer's tariffs	-0.359	-0.256		
	[0.112]	[0.107]		
ln (1+Importer's tariffs)			0.265	0.155
			[0.257]	[0.244]
Square of ln (1+Importer's tariffs)			-2.626	-1.734
			[0.910]	[0.818]
Exporter's tariffs	0.131	0.137		
	[0.055]	[0.055]		
ln (1+Exporter's tariffs)			-0.017	-0.055
			[0.128]	[0.127]
Square of ln (1+Exporter's tariffs)			0.322	0.418
			[0.219]	[0.218]
Exporter-year FE	YES	NO	YES	NO
Importer-year FE	YES	NO	YES	NO
Exporter-product-year FE	NO	YES	NO	YES
Importer-product-year FE	NO	YES	NO	YES
Exporter-importer-product FE	YES	YES	YES	YES
Number of observations	117,459	105,995	117,459	105,995
Adjusted R-squared	0.6087	0.6632	0.6087	0.6632

Notes: The dependent variable is the log of freight rates per weight at an HS two-digit level. In the parenthesis is the heteroscedasticity-consistent standard error. “FE” refers to fixed effects.

Table 4. Extended Estimation: Lag Effects, Gap of Shipment Volume, and Distance

	(I)	(II)	(III)	(IV)	(V)	(VI)
ln (1+Importer's tariffs)	-0.297	-0.343	-0.362	-0.246	-0.409	-0.306
	[0.151]	[0.152]	[0.128]	[0.123]	[0.129]	[0.124]
L1. ln (1+Importer's tariffs)	0.062	0.093				
	[0.146]	[0.144]				
ln (1+Exporter's tariffs)	0.096	0.096			1.663	1.876
	[0.084]	[0.084]			[0.993]	[0.961]
* Q1. Gap			0.172	0.212		
			[0.121]	[0.126]		
* Q2. Gap			0.298	0.27		
			[0.140]	[0.137]		
* Q3. Gap			0.109	0.116		
			[0.097]	[0.096]		
* Q4. Gap			-0.228	-0.328		
			[0.215]	[0.209]		
* ln Distance					-0.163	-0.186
					[0.106]	[0.103]
L1. ln (1+Exporter's tariffs)	0.143	0.17				
	[0.085]	[0.085]				
Exporter-year FE	YES	NO	YES	NO	YES	NO
Importer-year FE	YES	NO	YES	NO	YES	NO
Exporter-product-year FE	NO	YES	NO	YES	NO	YES
Importer-product-year FE	NO	YES	NO	YES	NO	YES
Exporter-importer-product FE	YES	YES	YES	YES	YES	YES
Number of observations	85,413	76,325	117,459	105,995	117,459	105,995
Adjusted R-squared	0.6705	0.7117	0.6087	0.6632	0.6087	0.6632

Notes: The dependent variable is the log of freight rates per weight at an HS two-digit level. In the parenthesis is the heteroscedasticity-consistent standard error. “L1.X” indicates the one-year lagged variable of X. “Q*i*” is the *i*-th quantile dummy variable on Gap, which is an absolute difference in total trade volume between two countries. “FE” refers to fixed effects.

Table 5. Effects of Ad-valorem Tariffs on Trade Quantity

	All		Materials	
	(I)	(II)	(III)	(IV)
ln (1+Importer's tariffs)	-0.099		-0.386	
	[0.027]		[0.052]	
Importer's tariffs		-0.067		-0.221
		[0.020]		[0.038]
ln (1+Exporter's tariffs)	-0.067		-0.078	
	[0.018]		[0.039]	
Exporter's tariffs		-0.029		-0.021
		[0.012]		[0.025]
Number of observations	5,969,157	5,969,157	5,969,157	5,969,157
Adjusted R-squared	0.8445	0.8445	0.8400	0.8399

Notes: The dependent variable is the log of export quantity. In the parenthesis is the heteroscedasticity-consistent standard error. In column "Material", we focus only on trade in material products. All specification includes exporter-product-year, importer-product-year, and exporter-importer-product fixed effects.

Appendix for

What Goes Around Comes Around:

Export-Enhancing Effects of Import-Tariff Reductions

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Appendix A. Derivation of Equation (1)

In this appendix, we derive equation (1). The first order conditions for shipping between country i and j are given by

$$\phi^{ij} + (T_{ij} - r + \lambda)\phi_T^{ij} = 0, \qquad \phi^{ji} + (T_{ij} - \lambda)\phi_T^{ji} = 0, \qquad \phi^{ij} - \phi^{ji} = 0,$$

where λ represents the Lagrangian multiplier associated with the constraint and $\phi_T^{ij} \equiv \partial\phi^{ij}/\partial T_{ij}$. Total differentiation of the first order condition yields

$$\phi_T^{ij} dT_{ij} + \phi_\tau^{ij} d\tau_j + (T_{ij} - r + \lambda)(\phi_{TT}^{ij} dT_{ij} + \phi_{T\tau}^{ij} d\tau_j) + \phi_T^{ij}(dT_{ij} + d\lambda) = 0,$$

$$\phi_T^{ji} dT_{ji} + (T_{ji} - \lambda)\phi_{TT}^{ji} dT_{ji} + \phi_T^{ji}(dT_{ji} - d\lambda) = 0,$$

$$\phi_T^{ij} dT_{ij} + \phi_{\tau_j}^{ij} d\tau_j - \phi_T^{ji} dT_{ji} = 0.$$

It follows that

$$\begin{pmatrix} 2\phi_T^{ij} + (T_{ij} - r + \lambda)\phi_{TT}^{ij} & 0 & \phi_T^{ij} \\ 0 & 2\phi_T^{ji} + (T_{ji} - \lambda)\phi_{TT}^{ji} & -\phi_T^{ji} \\ \phi_T^{ij} & -\phi_T^{ji} & 0 \end{pmatrix} \begin{pmatrix} dT_{ij} \\ dT_{ji} \\ d\lambda \end{pmatrix}$$

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$$= \begin{pmatrix} -\{\phi_\tau^{ij} + (T_{ij} - r + \lambda)\phi_{T\tau}^{ij}\} \\ 0 \\ -\phi_\tau^{ij} \end{pmatrix} d\tau_j.$$

Let F represent the 3x3 matrix on the left-hand side. Evaluated at the solution, the determinant satisfies

$$|F| = -\phi_T^{ij}(2 - \varepsilon^{ij})(\phi_T^{ji})^2 - \phi_T^{ji}(2 - \varepsilon^{ji})(\phi_T^{ij})^2,$$

where $\varepsilon^{ij} \equiv \phi^{ij}\phi_{TT}^{ij}/(\phi_T^{ij})^2$ represents the elasticity of the slope of the inverse demand curve for shipping from i to j.

By following the literature (Brander and Spencer 1984; Ishikawa and Spencer 1999), we assume the demand functions are not too convex: $2 - \varepsilon^{ij} > 0$ and $2 - \varepsilon^{ji} > 0$, so that $|F| > 0$, i.e., the second order condition for the transport firm's profit maximization holds. Apply Cramer's rule to obtain

$$\frac{\partial T_{ij}}{\partial \tau_j} = \frac{1}{|F|} \begin{vmatrix} -\{\phi_\tau^{ij} + (T_{ij} - r + \lambda)\phi_{T\tau}^{ij}\} & 0 & \phi_T^{ij} \\ 0 & 2\phi_T^{ji} + (T_{ji} - \lambda)\phi_{TT}^{ji} & -\phi_T^{ji} \\ -\phi_\tau^{ij} & -\phi_T^{ji} & 0 \end{vmatrix}$$

$$= \left(\frac{1}{|F|}\right)\left[\{\phi_\tau^{ij} + (T_{ij} - r + \lambda)\phi_{T\tau}^{ij}\}(\phi_T^{ji})^2 + \{2\phi_T^{ji} + (T_{ji} - \lambda)\phi_{TT}^{ji}\}\phi_T^{ij}\phi_\tau^{ij}\right].$$

To evaluate the expression inside the square brackets, we can compute the derivatives of function ϕ^{ij} by totally differentiating the equilibrium condition on shipping, $(1 + \tau_j)S_i(X_{ij}) + T_{AB} = D_j(X_{ij})$:

$$(1 + \tau_j)S_i' dX_{ij} + dT_{ij} + S_i d\tau_j = D_j' dX_{ij}.$$

It follows that

$$\frac{\partial \phi^{ij}}{\partial T_{ij}} \equiv \phi_T^{ij} = \frac{-1}{(1 + \tau_j)S_i' - D_j'} = -1/Z < 0,$$

$$\frac{\partial \phi^{ij}}{\partial \tau_j} \equiv \phi_\tau^{ij} = \frac{-S_i}{(1 + \tau_j)S_i' - D_j'} = S_i\phi_T^{ij} < 0,$$

$$\frac{\partial^2 \phi^{ij}}{\partial T_{ij}^2} \equiv \phi_{TT}^{ij} = Z^{-2}\{(1 + \tau_j)S_i'' - D_j''\}\phi_T^{ij},$$

$$\frac{\partial^2 \phi^{ij}}{\partial \tau_j \partial T_{ij}} \equiv \phi_{T\tau}^{ij} = Z^{-2}\{(1 + \tau_j)S_i'' - D_j''\}\phi_\tau^{ij} + Z^{-2}S_i',$$

where $Z \equiv (1 + \tau_j)S_i' - D_j' > 0$. Substituting these terms into the expression of $\partial T_{ij}/\partial \tau_j$, we have

$$\frac{\partial T_{ij}}{\partial \tau_j} = \left(\frac{1}{|F|}\right)\left[\left\{S_i\phi_T^{ij} - \frac{\phi^{ij}}{\phi_T^{ij}}\left(S_i\phi_{TT}^{ij} + Z^{-2}S_i'\right)\right\}\left(\phi_T^{ji}\right)^2 + \left\{2\phi_T^{ji} - \frac{\phi^{ji}}{\phi_T^{ji}}\phi_{TT}^{ji}\right\}S_i\left(\phi_T^{ij}\right)^2\right]$$

$$= \frac{1}{|F|}\left[S_i\phi_T^{ij}\left\{1 - \varepsilon^{ij} - \frac{1}{\varepsilon_S^i}\right\}\left(\phi_T^{ji}\right)^2 + \phi_T^{ji}\{2 - \varepsilon^{ji}\}S_i\left(\phi_T^{ij}\right)^2\right],$$

where $\varepsilon_S^i \equiv S_i/\left(\phi^{ij}S_i'\right)$ is the price elasticity of excess supply from country i.

Assumption 1: $1 - \varepsilon^{ij} - \frac{1}{\varepsilon_S^i} > 0$.

Under Assumption 1, we have $\frac{\partial T_{ij}}{\partial \tau_j} < 0$: the equilibrium freight rate from country i to country j is decreasing in the tariff by country j. Assumption 1 holds if the inverse demand for shipping is not too convex and if the excess supply from each county is not too low.

Turning to $\frac{\partial T_{ji}}{\partial \tau_j}$, we have

$$\frac{\partial T_{ji}}{\partial \tau_j} = \frac{1}{|F|}\begin{vmatrix} 2\phi_T^{ij} + \left(T_{ij} - r + \lambda\right)\phi_{TT}^{ij} & -\{\phi_\tau^{ij} + \left(T_{ij} - r + \lambda\right)\phi_{T\tau}^{ij}\} & \phi_T^{ij} \\ 0 & 0 & -\phi_T^{ji} \\ \phi_T^{ij} & -\phi_\tau^{ij} & 0 \end{vmatrix}$$

$$= \left(\frac{1}{|F|}\right)\left[\{\phi_\tau^{ij} + \left(T_{ij} - r + \lambda\right)\phi_{T\tau}^{ij}\}\phi_T^{ij}\phi_T^{ji} - \{2\phi_T^{ij} + \left(T_{ij} - r + \lambda\right)\phi_{TT}^{ij}\}\phi_T^{ji}\phi_\tau^{ij}\right],$$

where the expression inside the square brackets reduces to

$$-\phi_\tau^{ij}\phi_T^{ij}\phi_T^{ji} + \phi_T^{ji}\left(T_{ij} - r + \lambda\right)\left(\phi_T^{ij}\phi_{T\tau}^{ij} - \phi_\tau^{ij}\phi_{TT}^{ij}\right).$$

The first term is positive. Rearrange the second term to obtain

$$\phi_T^{ji}\left(T_{ij} - r + \lambda\right)\left(\phi_T^{ij}\phi_{T\tau}^{ij} - \phi_\tau^{ij}\phi_{TT}^{ij}\right) = \phi_T^{ji}\left(T_{ij} - r + \lambda\right)Z^{-2}S_i'\phi_T^{ij} > 0.$$

We conclude that $\frac{\partial T_{ij}^*}{\partial \tau_i} > 0$ and $\frac{\partial T_{ij}^*}{\partial \tau_j} < 0$. ■

Appendix B. Table

Table B1. Descriptive Statistics

	Obs	Mean	Std. Dev.	Min	Max
ln Freight	117,459	-1.2372	1.0249	-9.2103	7.2462
ln (1+Importer's tariffs)	117,459	0.0739	0.0548	0	0.4795
ln (1+Exporter's tariffs)	117,459	0.0698	0.0787	0	0.9723
Importer's tariffs	117,459	0.0783	0.0604	0	0.6153
Exporter's tariffs	117,459	0.0760	0.1020	0	1.6441
Square of ln (1+Importer's tariffs)	117,459	0.0085	0.0117	0	0.2299
Square of ln (1+Exporter's tariffs)	117,459	0.0111	0.0427	0	0.9454
ln (1+Exporter's tariffs) * ln Distance	117,459	0.6335	0.7346	0	9.5274
ln Quantity (Total, All)	208,428	7.2348	3.9011	-10.5286	20.4155
ln Quantity (Total, Materials)	183,097	5.8056	3.8752	-8.7920	17.1059
ln Quantity (HS2, All)	5,969,157	3.3322	3.5561	-15.2183	20.3761
ln Quantity (HS2, Materials)	1,748,134	3.0291	3.5973	-16.4632	16.9044

Source: The authors' computation.