The Round Trip Effect: Endogenous Transport Costs and International Trade

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Abstract

This paper studies transport costs as market outcomes and highlights the round trip effect, a key feature of the transportation industry that links transport supply between locations. Incorporating transportation into an Armington trade model, I show that this effect mitigates shocks on a country's trade with its partner and generates spillovers onto its opposite direction trade with the same partner. A country's import tariffs can therefore translate into a potential tax on its exports to the same partner. Using novel container freight rates data, I develop an instrumental variable based on this effect to estimate the containerized trade elasticity with respect to freight rates. Using my elasticity estimates as well as my trade and transportation model, I simulate a counterfactual increase in US import tariffs on all its partners. This tariff increase not only decreases overall US imports but also US exports on the same bilateral routes. A model with exogenous transport costs would over-predict the fall in US imports by 37 percent and fail to capture the associated bilateral reduction in US exports.

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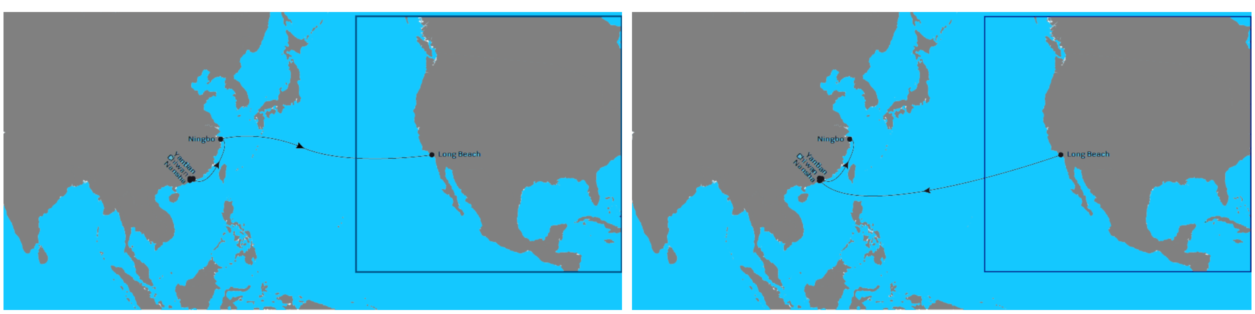
1 Introduction

“If transport costs varied with volume of trade, the [iceberg transport costs] would not be constants. Realistically, since there are joint costs of a round trip, [the going and return iceberg costs] will tend to move in opposite directions, depending upon the strengths of demands for east and west transport.”

Samuelson (1954), p. 270, fn. 2

The cost of transporting goods from origin to destination is determined in equilibrium by the interaction between the supply and demand for transportation between these locations. Additionally, carriers, such as containerships and airplanes, are re-used and therefore have to return to the origin in order to fulfill demand (Pigou and Taussig (1913), Jara-Diaz (1982), Dejax and Crainic (1987), Demirel, Van Ommeren and Rietveld (2010), De Oliveira (2014)). This in practice constrains carriers to a round trip (*the round trip effect*) and introduces joint transportation costs which links transport supply bilaterally between locations on major routes. Figure 1 highlights one example of the round trip effect with a US-China containership route currently serviced by Maersk, the largest containership company globally.[1]

Figure 1: Example of the round trip effect: Containership route between US and China
Source: Maersk East-West Network, TP3 Service



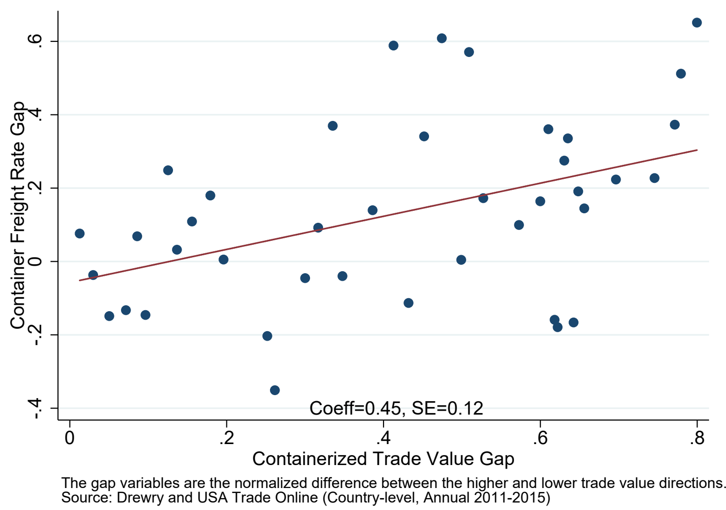
As a result, asymmetric demand between locations translates into asymmetric transport costs. Take US and China as an example: China runs a large trade surplus with the United States, and the cost to ship a container from China to the US ($1900 per container) is more than three times the return cost ($600 per container).[2] The US and UK, who have relatively

[1]On the Mearsk eastbound TP3 Service (left panel of figure 1), the containership departs from Yantian on a Tuesday, Ningbo on Thursday two days later, and Long Beach on the following Wednesday after 12 days. Two days later, on a Friday, the containership departs from Long Beach and return to Ningbo and Yantian on the westbound TP3 Service (right panel of figure 1). The specification of arrival/departure days is common to other services. Colors were changed in these figures compared to the figures on Maersk’s website.

[2]2013 container freight rates from Drewry Maritime Research.

more balanced trade with each other, have more similar container costs ($1300 per container from UK to US compared to the return cost of $1000 per container in 2013).[3] Figure 2 shows that the gap in containerized trade value to and from a pair of countries, which approximates the trade demand asymmetry between countries, is positively correlated with the gap in the cost of containers going to and from these countries.[4]

Figure 2: Positive correlation between container trade value gap and freight rate gap between countries



The principal contribution of this paper is to provide a microfoundation for transport costs which incorporates one of its key institutional features, the round trip effect. This paper is the first, to my knowledge, to study both the theoretical and empirical implications of the round trip effect for trade outcomes. I investigate the theoretical implications of the round trip effect by incorporating a transportation market into a partial equilibrium Armington trade model. Using a novel high frequency data set on container freight rates, I then develop an identification strategy utilizing the round trip effect to estimate the containerized trade elasticity with respect to freight rates. In order to quantify the trade prediction differences between my model and a model with exogenous transport cost, I simulate a counterfactual increase in US import tariffs on all its partners using my theoretical model and trade elasticity

[3] The round trip effect also applies to air cargo and US domestic trucking. The cost to ship air cargo from China to US is ten times more than the return cost ($3-$3.50 per kg from China to US compared to 30-40 cents per kg on the return; Behrens and Picard (2011)). Within the US domestically, it costs two times more to rent a truck from Chicago to Philadelphia than the return ($1963 at $2.69 per mile from Chicago to Philadelphia compared to $993 at $1.31 per mile for the return; DAT Solutions).

[4] Using container volume data, figure A.2 in the Appendix shows a similar positive correlation between the container volume gap and container freight rate gap between countries.

estimates.

Transport costs in the trade literature are typically modeled as exogenous. They are usually approximated by distance empirically and by the iceberg functional form theoretically.[5] From the previous example, container freight rates between US and China would be the same or close to being symmetric if they were predominantly determined by distance. However, this is not the case. Container freight rates also do not monotonically increase with distance: the distance between US and China is two times further than US and UK but the cost of a container from US to China is only two thirds of the cost from US to UK.[6] Furthermore, even as he introduced the notion of iceberg transport costs to the literature, Samuelson (1954) acknowledged that in the realistic presence of joint costs of a round trip, the iceberg transport costs between locations will move in opposite directions depending on both demand strengths. I provide evidence of this inverse relationship using my novel port-level data set on container freight rates.

I first introduce a transportation market, which is constrained by the round trip effect, into a partial equilibrium Armington trade model. I do this to study how the trade predictions from my model differs from a model with exogenous transport costs. I show two main differences. First, any shocks on a country's trade with its partner will be mitigated by transport costs. Second, through its impact on transport costs, the round trip effect generates spillovers from a shock to a country's trade with its partner onto the country's trade in the opposite direction with the same partner. For example, a unilateral increase in US tariffs on imports from China would not just result in a decrease in US imports from China (the magnitude of which is mitigated by a fall in US import transport cost from China) but also a decrease in US exports to China. This export decrease is due to an increase in the US export transport cost to China since less ships will come to the US due to the fall in the opposite direction (China to US) trade demand.

Through the round trip effect, an import tariff on a country's partner can therefore also translate into an export tax on the same partner. This is a novel prediction. Lerner symmetry predicts that a country's unilateral tariff increase on one partner will act as an export tax and reduce its exports to all its partners due to the balanced trade condition in a general equilibrium setting. I present a specific *bilateral* channel that impacts the country's exports to the same partner within a partial equilibrium framework, without requiring the balanced

[5] Exceptions include Donaldson (Forthcoming), Asturias and Petty (2013), Friedt and Wilson (2015), Hummels, Lugovskyy and Skiba (2009), Bergstrand, Egger and Larch (2013).

[6] Port distance between Los Angeles/Long Beach and Shanghai is 6,446 nautical miles while distance between Felixstowe and New York is 3,314 nautical miles (sea-distances.org).

trade condition.

Matching my data set to port-level distances as well as US containerized trade data, I provide suggestive evidence for two main predictions from my trade and transport model. First, freight rates within port pairs are negatively correlated across time and within routes. This inverse relationship is predicted in my model due to transport firms optimizing over a round trip. As such, the transport costs in each direction of the port pair route will move in opposing directions in response to demand changes across time. If freight rates were independently determined in each direction of a port pair, one would expect there to be no correlation. In addition, if freight rates were mostly determined by distance, one would also expect no correlation since route fixed effects are included in my regressions. Second, outgoing containerized trade value is positively correlated with incoming freight rates across time and within dyads. This applies to incoming trade value and outgoing freight rates as well. This relationship would not be present if there was no systematic linkage between aggregate outgoing containerized trade value and the incoming freight rates. The round trip effect provides one such explanation.[7]

Next, I estimate the containerized trade elasticity with respect to freight rates using the round trip insight. Since containers are required to transport containerized trade, this elasticity can also be interpreted as the demand elasticity for containers. In typical demand estimations, I require a transport supply shifter that is independent of demand determinants. In the example of estimating containerized trade demand from UK to US, I need a shifter of transport supply from UK to US that is independent of the demand determinants on the same route. I develop a novel supply shifter utilizing the round trip effect: shocks which affect the opposite direction containerized trade (from US to UK). These shocks will shift both its own container transport supply as well as the transport supply in the original direction (from UK to US). This latter transport supply shift will identify the containerized trade demand from UK to the US if the demand shocks between routes are uncorrelated.

Since demand shifts between countries are generally not independent, I construct a Bartik-type instrument that predicts trade between countries. I find that a one percent increase in container freight rates leads to a 2.8 percent decrease in containerized trade value, 3.6 percent decrease in trade weight, and a 0.8 percent increase in trade value per weight. Since trade value per weight can be interpreted as a rough measure of trade quality, my third result is in line with the positive link between quality and per unit trade costs first established by Alchian and Allen (1964).

[7]It is acknowledged here that supply chains could provide another such explanation if most of containerized trade is governed by supply chains. I return to discuss supply chains later at later points in the paper.

Using my trade elasticity estimated from the instrumental variable approach, I estimate parameters in my transportation and trade model by matching the observed freight rate and trade data. I then simulate a counterfactual in which US raises its tariffs on all its partners from an overall trade weighted average of two percent to five percent. I show that the rise in the US tariff will both decrease US imports from these partners and decrease US exports to these partners. I show that the same model with exogenous transport costs would over-predict the average import decrease by 37 percent and not predict the export decrease at all. Overall, the exogenous-transport-cost model would under-predict the average trade changes by 35 percent.

This paper contributes to several strands of literature. First, I highlight the round trip effect using a novel high frequency data set on bilateral container freight rates.[8] The few empirical papers that investigate transport costs and the round trip effect often have aggregate data at the regional level (Jonkeren et al. (2011), Friedt and Wilson (2015)) or within a country (Tanaka and Tsubota (2016)).[9] Most of these studies also use annual data. My data is at the monthly frequency, the port-level, and includes the largest ports globally. This high level of disaggregation allows me to better study the round trip effect and its trade implications. I am also able to exploit the panel nature of this data set in my empirical estimations.[10]

Second, I develop a new IV strategy using an institutional detail of the transportation industry in order to estimate a transport mode-specific trade elasticity with respect to transport cost. This is the first paper to do so. Previous studies focus on trade elasticities across transport modes (Head and Mayer (2014); Shapiro (2015)) and my elasticity contributes to understanding how trade elasticities respond to transport costs within a mode. Second, the round trip effect applies to the transportation industries servicing both international and domestic trade. As such, endogenous transport costs may have an important contribution to the spatial allocation of production in and across countries (Behrens and Picard (2011)).

[8] While not the focus of this paper, there has been work on containerization and trade. Bernhofen, El-Sahli and Kneller (2016) estimates the effects of containerization on world trade while Rua (2014) investigates the diffusion of containerization.

[9] There are studies on the round trip effect and firm decisions (Baesemann, Daughety and Inaba (1977), Wilson (1987), Beilock and Wilson (1994), Wilson (1994)).

[10] There has been substantial focus on transport costs and its impact on trade which do not take into account the round trip effect (Hummels (1999), Hummels (2007), as well as Limao and Venables (2001)). There are also studies that focus on market power within the transport sector (Hummels, Lugovskyy and Skiba (2009), Asturias and Petty (2013), Behrens et al. (2006) and Francois and Wooton (2001)), as well as economies of scale (Kleinert, Spies et al. (2011), Asturias and Petty (2013)). I abstract from issues of market power and scale economies in the transport industry in order to highlight the novel features of the round trip effect for trade.

My IV strategy can be utilized to identify this.

Third, this paper introduces a new bilateral channel for tariff impact within a partial equilibrium Armington trade model. Lerner symmetry (Lerner (1936)) predicts that an across-the-board increase in a country's tariffs on all trading partners will act as an across-the-board increase in the tax on the country's exports and lead to a drop in the country's multilateral exports that is commensurate with the drop in its multilateral imports. The round trip effect instead predicts a new and specific bilateral channel through which the country's import reduction will trigger an export reduction on a route-by-route basis (something that Lerner symmetry would not predict) over and above what would be predicted by Lerner symmetry alone.[11] Assuming linear demand, Ishikawa and Tarui (2016) find a similar spillover result as I do.

In the next section, I introduce a graphical illustration of the round trip effect and its mechanism using a simple linear transport demand and supply model. Incorporating a transportation market into an Armington model in section 3, I present the comparative statics from trade shocks in my model and compare them to outcomes from an exogenous transport cost model. In section 4, I introduce my novel data set on port-level container freight rates matched to containerized trade data in section 4 and establish suggestive evidence for two predictions in my theory model. I develop an instrument based on the round trip effect insight in section 5 to address endogeneity between transport cost and trade. I highlight my results in section 6. In section 7, I utilize my trade elasticity from section 6 to estimate parameters in my theory model in section 3 in order to match the observed trade and freight rates data. I then simulate a counterfactual increase in US import tariffs on all its partners. I compare the trade predictions from my model to a model with exogenous transport cost. Section 8 concludes.

2 The Round Trip Effect: Simple Model of Transport

In order to illustrate the round trip effect, I present a simple model of transport with two countries (i and j). There are two transport markets, one going from j to i and the other going back to j from i. I present both these markets without the round trip effect and then

[11]Looking at the behavior of foreign export sources into the US market, Mostashari (2010) finds evidence broadly consistent with the bilateral export impact of a country's import tariff as I do with the round trip effect. However, his mechanism is within a framework of intermediate goods imports. Unilateral import tariff cuts by developing countries can contribute to their bilateral exports to the US since these tariff cuts reduce the cost of their imported intermediate goods which makes their exports, using these intermediate goods, relatively more competitive.

introduce the round trip effect and its implications. This simple model is for illustration purposes. The next section embeds a transportation market with the round trip effect into an Armington trade model.

Defining the direction of transport from origin j to destination i as *route* ji, I assume linear transport demand functions for both route ji and ij:

$$Q_{ji}^{D} = D^{i} - d^{i}T_{ji} \text{ and } Q_{ij}^{D} = D^{j} - d^{j}T_{ij} \tag{1}$$

where Q_{ji}^{D} is the transport quantity demanded on route ji and T_{ji} is the transport cost, or transport price, on the same route. D^{i} is country i's demand intercept parameter for transport services from j ($D^{i} > 0$) while d^{i} is its demand slope parameter ($d^{i} > 0$). Similar notation applies for the opposite direction variables on route ij.

Following the demand assumption, I also assume linear transport supply. I first present the transport supply for both markets absent the round trip effect and then incorporate it.

2.1 Model absent the round trip effect

Absent the round trip effect, transport supply for both routes are separately determined:

$$\bar{Q}_{ji}^{S} = C_{ji} + c_{ji}T_{ji} \text{ and } \bar{Q}_{ij}^{S} = C_{ij} + c_{ij}T_{ij} \tag{2}$$

where $\bar{Q}_{ji}^{S}$ is the transport quantity supplied on route ji and T_{ji} is the transport cost or price on the same route. Route ji's fixed cost of transport supply is $C_{ji} \geq 0$ (for example the cost of hiring a captain) and its marginal cost is $c_{ji} > 0$ (for example fuel cost). This positive marginal cost generates an upward sloping supply curve.[12] Similar notation applies for the opposite direction variables on route ij.

The equilibrium transport price and quantity for route ji as well as ij, in the absence of the round trip effect, are:

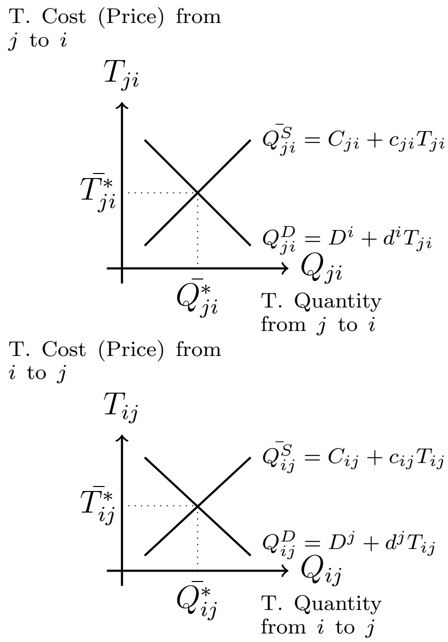
$$\begin{aligned} \bar{T}_{ji}^{*} &= \frac{1}{d^{i} + c_{ji}} \left(D^{i} - C_{ji}\right) \text{ and } \bar{Q}_{ji}^{*} = \frac{1}{d^{i} + c_{ji}} \left(c_{ji}D^{i} + d^{i}C_{ji}\right) \\ \bar{T}_{ij}^{*} &= \frac{1}{d^{j} + c_{ij}} \left(D^{j} - C_{ij}\right) \text{ and } \bar{Q}_{ij}^{*} = \frac{1}{d^{j} + c_{ij}} \left(c_{ij}D^{j} + d^{j}C_{ij}\right) \end{aligned} \tag{3}$$

[12] One interpretation is that there are a continuum of transport firms that provide transportation services between the two countries. These firms face heterogenous marginal costs of providing their services but are small.

where any changes in the demand and supply parameters of a route only affects the transport price and quantity of that route.

Both these markets are illustrated in figure 3. The top graph is the transport market for route ji while the bottom graph is the transport market for return direction route ij. Both demand and supply curves in these markets follow equations (1) and (2) and, as mentioned earlier, are independently determined within route. As can be seen in equation (3), a positive demand shock on route ji (increase in D^i) will only affect the transport price and quantity in the ji market. The same applies for a positive demand shock on route ij (increase in D^j). However, this is not the case for transport markets in the presence of the round trip effect.

Figure 3: Transport markets between countries i and j
in the absence of the round trip effect



2.2 Model with the round trip effect

Transport units, like containerships and cargo airplanes, are re-used by transport firms and therefore have to return to the origin location in order to provide transport services (Pigou and Taussig (1913); Jara-Diaz (1982); Dejax and Crainic (1987); Demirel, Van Ommeren and Rietveld (2010)). Between locations on major routes, these transport firms go back and forth in a round trip. As a result of the round trip effect, transport supply for both routes are jointly determined. For simplicity, I assume that the demand for transport between these two markets are symmetric enough that transport firms will always be at full capacity going between them.[13] As such, the supply of transport on both routes ($\overleftrightarrow{ij}$) will be the same:

$$Q^S_{ij} = Q^S_{ji} \equiv Q^S_{\overleftrightarrow{ij}}$$

The combined transport supply for both routes includes the fixed cost of transport, for example the cost of hiring a captain and crew ($C_{\overleftrightarrow{ij}}$), as well as the marginal cost of transport, like the fuel cost of an additional unit of transport service ($c_{\overleftrightarrow{ij}}$):[14]

$$Q^S_{\overleftrightarrow{ij}} = C_{\overleftrightarrow{ij}} + c_{\overleftrightarrow{ij}} \left(T_{ji} + T_{ij}\right) \tag{4}$$

The equilibrium transport prices and quantity for routes ij and ji with the round trip effect are now no longer independently determined:

$$\begin{aligned}
T^*_{ji} &= \frac{1}{c_{\overleftrightarrow{ij}} d^i + c_{\overleftrightarrow{ij}} d^j + d^i d^j} \left[\left(d^j + c_{\overleftrightarrow{ij}}\right) D^i - c_{\overleftrightarrow{ij}} D^j - d^j C_{\overleftrightarrow{ij}} \right] \\
T^*_{ij} &= \frac{1}{c_{\overleftrightarrow{ij}} d^i + c_{\overleftrightarrow{ij}} d^j + d^i d^j} \left[\left(d^i + c_{\overleftrightarrow{ij}}\right) D^j - c_{\overleftrightarrow{ij}} D^i - d^i C_{\overleftrightarrow{ij}} \right] \\
Q^* \equiv Q^*_{ji} = Q^*_{ij} &= \frac{1}{c_{\overleftrightarrow{ij}} d^i + c_{\overleftrightarrow{ij}} d^j + d^i d^j} C_{\overleftrightarrow{ij}} + \frac{1}{\left(d^j + c_{\overleftrightarrow{ij}}\right) d^i} D^i + \frac{1}{\left(d^i + c_{\overleftrightarrow{ij}}\right) d^j} D^j
\end{aligned} \tag{5}$$

First, the equilibrium transport price on route ji (T^*_{ji}) is intuitively increasing in destination country i's demand intercept for j (D^i) but decreasing in the fixed cost of round trip transport ($C_{\overleftrightarrow{ij}}$). Additionally, it is now a function of the origin country i's demand parameters as well: it is decreasing in the origin country j's demand intercept for i's good (D^j). This latter prediction is due to the round trip effect. If transport firms only provide one-way services and not have to re-position their containerships or airplanes, the transport price on route ji would just be a function of the transport demand and supply parameters for route ji. Instead, since these transport firms commit to a round trip journey due to re-positioning needs, the transport price is also a function of return direction route ij's demand. The same

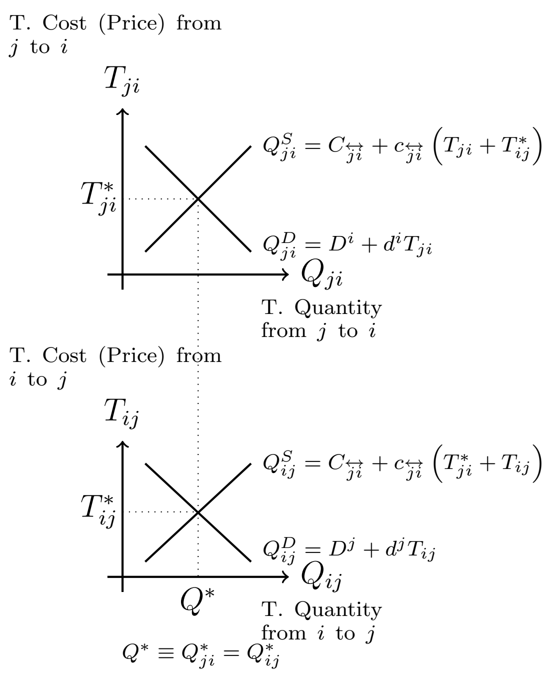
[13]If demand between these markets are asymmetric enough, there may be some transport firms going empty one way (Ishikawa and Tarui (2016)). This paper acknowledges that this assumption is for simplification purposes and figure A.2 in the Appendix shows that the number of containers going back and forth between countries are not always the same. Potential modeling modifications can and have been made in order to accommodate this feature, for example a search framework. The theory section elaborates.

[14]It is noted here that the costs involved in transport for route ij and ji are assumed to be the same. It is possible to relax this assumption to allow for varying directional costs in addition to the round trip marginal cost without changing the main results.

applies for the transport price on route ij (T^*_{ji}). The equilibrium quantity of transport services for both routes is increasing in the demand intercepts in both countries (D^i and D^j) and the round trip fixed cost of transport ($C_{\overleftrightarrow{ij}}$) but decreasing in both countries' demand slopes and the round trip marginal cost ($c_{\overleftrightarrow{ij}}$).

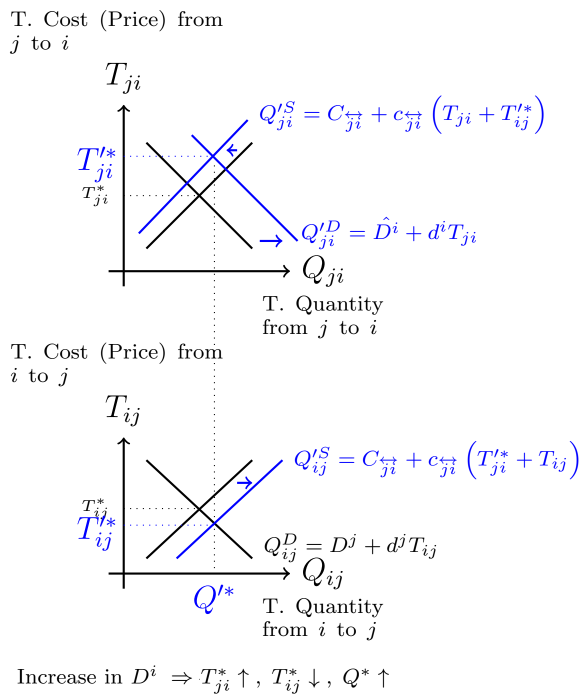
Both the transport markets for routes ji and ij are illustrated in figure 4. Similar to the previous figure, the top graph is the transport market for route ji and the bottom graph is for route ij. In the presence of the round trip effect, both these markets are now linked via transport supply and the equilibrium transport quantity is the same. In addition, the supply curve in both markets is a function of the opposite direction transport price on top of its own price and the fixed and marginal costs of transport.

Figure 4: Transport markets between countries i and j are linked in the presence of the round trip effect



Now suppose there is a positive demand shock on route ji where i's demand for j's good increases while holding the other parameters constant. This increases D^i which raises the equilibrium transport price on route ji (equation (5)) as well as the equilibrium transport quantity. Through the round trip effect, the equilibrium quantity on route ij also increases. Since the demand on route ij has not changed, this increased transport quantity will decrease the transport price on return route ij (equation (5)). As such, in the presence of the round trip effect, a positive demand shock on route ji does not just increase the equilibrium transport price and quantity on that route, it also decreases the equilibrium transport price on the return route ij. Figure 5 illustrates this demand shock graphically where Q'^D_{ji} is the new demand curve after the shock on i's demand intercept for j ($\hat{D}^i > D^i$). Q'^S_{ij} is the new transport supply on return route ij which results in a lower equilibrium transport price T'^*_{ij}. The demand shock and the new lower return route ij transport price will also shift the transport supply on route ji (Q'^S_{ji}). As shown earlier, this demand shock would have no effect on the return direction route in the absence of the round trip effect.

Figure 5: A positive demand shock on route ji ($\hat{D}^i > D^i$) increases the price on its own route and the quantity in both routes as well as *decreases* the return route price



This simple two-country model highlights the round trip effect mechanism that can link the two-way trade of locations via transportation. The first implication is that between two countries, freight rates are negatively correlated since they adjust so that the amount of transport quantity going in both directions are balanced. I show evidence of this negative correlation in the data section. The second implication is that shocks on a country's imports from its partner will have spillovers onto its exports to the same partner. The same applies vice versa for shocks on a country's exports. While I have illustrated a positive spillover from a positive demand shock in figure 5, the opposite is also true. A negative shock on a country's imports from its partner—like an increase in import tariffs—will generate negative spillovers onto a country's exports to the same partner. This means that an import tariff increase could translate into an export tax via the round trip effect. My theory section further explores this point.

3 Theoretical Framework

In this section I study the theoretical implications of endogenous transport costs and the round trip effect. I first start with an Armington trade model with exogenous transport cost and then incorporate a transportation industry constrained to service a round trip into the model. Next, I present two testable predictions from the round trip transport and trade model which I will take to the data in the next section. Lastly, I describe the comparative statics from trade shocks for the round trip model and compare them to the exogenous transport cost model.

The trade model I use is an augmented Armington model from Hummels, Lugovskyy and Skiba (2009). They study the impact of market power in the shipping industry on trade outcomes without the presence of the round trip effect. I make three modifications. First, I incorporate the round trip constraint into their shipping firm's profit function. Second, I allow for countries to be heterogeneous. They assume that countries are symmetric. Third, I assume perfectly competitive transport firms. This is mainly to maintain simplicity in a first pass of modeling the transport industry with the round trip effect.[15]

3.1 Model Setup

I assume that the world consists of $j = 1, 2, ...M$ potentially heterogeneous countries where each country produces a different variety of a tradeable good. Consumers consume varieties of the good from all countries as well as a homogeneous numeraire good. The quasilinear

[15]Another reason is the persistent over-capacity in the container shipping market during my sample period, up to as much as 30 percent more space on ships than cargo (various issues of the Review of Maritime Transport, UNCTAD, and The Wall Street Journal, September 2016. The worlds seventh-largest container shipping line, South Korean Hanjin Shipping, filed for bankruptcy in September 2016 (The Wall Street Journal). Moreover, while enforcement of price-setting conference rates on global routes were possible in past because member contract rates were publicly available, the Shipping Act of 1984 limited the amount of information available on these contracts and The Ocean Shipping Reform Act of 1998 made them confidential altogether (price setting conferences publish suggested freight rates and ancillary charges for its members (for example the Transpacific Stabilization Agreement). Conference members are now able to deviate from conference rates without repercussion. As such, I conclude that transport firms can be reasonably approximated by perfect competition during my sample period.

utility function of a representative consumer in country j is

$$U_j = q_{j0} + \sum_{i=1}^{M} a_{ij} q_{ij}^{(\sigma-1)/\sigma}, \quad \sigma > 1 \tag{6}$$

where q_{j0} is the quantity of the numeraire good consumed by country j, a_{ij} is j's preference parameter for the variety from country i (route ij),[16] q_{ij} the quantity of variety consumed on route ij, while σ is the price elasticity of demand.[17] The numeraire good, interpreted as services here, is costlessly traded and its price is normalized to one.

Assuming that each country is perfectly competitive in producing their variety and that labor is the only input to production, the delivered price of country i's good in j (p_{ij}) reflects its delivered cost which includes i's domestic wages (w_i), the ad-valorem tariff rate that j imposes on i ($\tau_{ij} \geq 1$), and a per unit transport cost to ship the good route ij (T_{ij}):

$$p_{ij} = w_i \tau_{ij} + T_{ij} \tag{7}$$

3.2 Exogenous transport cost

In the exogenous transport cost model, the transport cost is equal to the marginal cost to ship a good variety one way. This marginal cost is exogenously determined and is assumed to be c_{ij}.

3.2.1 Equilibrium with exogenous transport cost

The delivered price of country i's good in j (p_{ij}^{Exo}) is

$$p_{ij}^{Exo} = w_i \tau_{ij} + c_{ij} \tag{8}$$

An increase in the marginal transport cost (c_{ij}), tariff (τ_{ij}), or domestic price (w_i) will increase the equilibrium price of i's good in country j. Following Behrens and Picard (2011) and Hummels, Lugovskyy and Skiba (2009), I assume that one unit of transport service is required to ship one unit of good. However, this assumption is relaxed when I estimate this model.[18]

[16] This preference parameter can also be interpreted as the attractiveness of country i's product to country j (Head and Mayer (2014)).

[17] Similar to Hummels, Lugovskyy and Skiba (2009), σ is the price elasticity of demand: $\frac{\partial q_{ij}^{Exo}}{\partial p_{ij}^{Exo}} \frac{q_{ij}^{Exo}}{p_{ij}^{Exo}} = -\sigma$ (equation (9)).

[18] I include a loading factor to translate between the number of containers and the quantity of traded goods.

The utiliy-maximizing quantity of i's variety consumed in j on route ij (q_{ij}^{Exo}) is derived from the condition that the price ratio of i's variety relative to the numeraire is equal to the marginal utility ratio of that variety relative to the numeraire:[19]

$$q_{ij}^{Exo} = \left[\frac{\sigma}{\sigma - 1} \frac{1}{a_{ij}} \left(w_i \tau_{ij} + c_{ij} \right) \right]^{-\sigma} \tag{9}$$

An increase in j's preference for i's good (a_{ij}) will increase the equilibrium quantity. On the other hand, an increase in i's wages, j's import tariff on i, and the transport marginal cost on route ij will decrease the equilibrium quantity.

The equilibrium trade value of i's good in j (X_{ij}^{Exo}) is the product of the delivered price (p_{ij}^{Exo}) and quantity (q_{ij}^{Exo}) on route ij:

$$X_{ij}^{Exo} \equiv p_{ij}^{Exo} q_{ij}^{Exo} = \left[\frac{\sigma}{\sigma - 1} \frac{1}{a_{ij}} \right]^{-\sigma} \left[\left(w_i \tau_{ij} + c_{ij} \right) \right]^{1-\sigma} \tag{10}$$

Similar to the equilibrium quantity, an increase in j's preference for i's good will increase the equilibrium trade value while i's wages, j's import tariff on i, and the marginal cost of transport on route ij will decrease the trade value.

3.3 Endogenous transport cost and the round trip effect

Here I endogenize transportation by introducing the round trip effect into the transport market. The profit function of a perfectly competitive transport firm servicing the round trip between i and j ($\pi_{\overset{\leftrightarrows}{ij}}$) is based on Behrens and Picard (2011):

$$\pi_{\overset{\leftrightarrows}{ij}} = T_{ij} q_{ij} + T_{ji} q_{ji} - c_{\overset{\leftrightarrows}{ij}} \max\{q_{ij}, q_{ji}\} \tag{11}$$

where I assume that one unit of good requires one transport unit for simplicity.[20] q_{ij} is the quantity of goods shipped on route ij while $c_{\overset{\leftrightarrows}{ij}}$ is the marginal cost of serving the round trip

[19] This equilibrium quantity differs from a standard CES demand because it is relative to the numeraire rather than relative to a bundle of the other varieties. If this model is not specified with a numeraire good, this quantity expression would include a CES price index that is specific to each country (in this case country j). I follow Hummels, Lugovskyy and Skiba (2009) in controlling for importer fixed effects in my empirical estimates. This fixed effect can be interpreted as the price of the numeraire good or as the CES price index in the more standard non-numeraire case. Stemming from this, the balanced trade condition between countries is satisfied by the numeraire good.

[20] As mentioned before, a loading factor will be introduced in the estimation of this model to translate between the number of containers and quantity of traded goods.

between i and j like the cost of hiring a captain or renting a ship.[21]

There are two possible equilibrium outcomes from this model depending on whether the equilibrium transport services between the countries are balanced or not. The first equilibrium is an interior solution where the transport market is able to clear at positive freight rates in both directions and the quantity of transport services (containers in this case) are balanced between the countries. The second equilibrium is a corner solution where the market is able to clear at positive freight rates in one direction while the other market has an excess supply of transport firms. The transport freight rate of the excess supply direction is zero. As confirmed in the data section, my freight rate data is positive suggesting that the first equilibrium is the most relevant, so I focus on that equilibrium here.[22]

3.3.1 Optimality conditions

From the profit function of transport firms in (11), the optimal freight rates on route ij and return route ji will add up to equal the marginal cost of the round trip between i and j:

$$T_{ij} + T_{ji} = c_{\overleftrightarrow{ij}} \tag{12}$$

which implies that the freight rates between i and j are negatively correlated with each other conditional on the round trip marginal cost $c_{\overleftrightarrow{ij}}$. With my data set on port-level container freight rates, I provide suggestive empirical evidence for this negative relationship.

From utility-maximizing consumers in (6) and profit-maximizing manufacturing firms in (7), the optimal trade value of country i's good in j as follows:

$$X_{ij} = \left(\frac{\sigma}{\sigma - 1}\frac{1}{a_{ij}}\right)^{-\sigma} (w_i \tau_{ij} + T_{ij})^{1-\sigma}, \quad \sigma > 1 \tag{13}$$

It is decreasing in wages in i, j's import tariffs on i, and the transport cost from i to j.[23] These relationships are fairly intuitive and expected.

Combining both the optimality conditions for freight rates between i and j in (12) as well

[21]The round trip cost between i and j is made up of both one-way costs: $c_{\overleftrightarrow{ij}} \equiv c_{ij} + c_{ji}$. This cost assumption does not explicitly include fuel and loading or unloading cost. However, the freight rates used in my empirical section does include fuel adjustment fees and port fees.

[22]In reality, not all containers are at capacity on all routes (an example of this is the US to China route). In order to account for empty containers, I develop a search model for transport firms and exporting firms using the exporting framework in Chaney (2008) and the search framework in Miao (2006). The predictions of that model is similar to that of the balanced equilibrium here. For simplicity, I present results from the balanced equilibrium model. The search model is available upon request.

[23]The negative relationship is due to the price elasticity of demand, $\sigma > 1$.

as the relationship between trade value and freight rates in (13), the trade value of country i's good in j is positively correlated with the return direction freight rates from j to i:

$$X_{ij} = \left(\frac{\sigma}{\sigma - 1}\frac{1}{a_{ij}}\right)^{-\sigma} (w_i\tau_{ij} + c_{i,j} - T_{ji})^{1-\sigma} \quad \sigma > 1 \tag{14}$$

Absent the round trip effect, one would not expect a systematic relationship between a country's imports from a particular partner and its export transport cost to the same partner. The same applies to a country's exports and import transport cost. With my container freight rates data matched to data on containerized trade, I provide suggestive empirical evidence for this positive correlation.[24]

3.3.2 Equilibrium with endogenous transport cost and the round trip effect

The equilibrium freight rate for route ij under the round trip effect (T^R_{ij}) can be derived from the balanced container condition:

$$T^R_{ij} = \frac{1}{1 + A_{ij}}\left(c_{\overleftrightarrow{ij}}\right) - \frac{1}{1 + A^{-1}_{ij}}(w_i\tau_{ij}) + \frac{1}{1 + A_{ij}}(w_j\tau_{ji}) \quad \text{where} \quad A_{ij} = \frac{a_{ji}}{a_{ij}} \tag{15}$$

where A_{ij} is the ratio of preference parameters between i and j. The first term shows that the freight rate is increasing in the marginal cost of servicing the round trip route ($c_{\overleftrightarrow{ij}}$). The second term shows that it decreases with destination country j's import tariff on i (τ_{ij}) and origin i's wages (w_i). The third term, due to the round trip effect, shows that the freight rate is increasing in the origin country i's import tariff on j (τ_{ji}) as well as destination j's wages (w_j). The second term provides a mitigating effect on shocks on route ij while the third term provides the same mitigating effect but on shocks on the opposite route ji.

In the case of countries i and j being symmetric, the preference parameters would be the same: $a_{ij} = a_{ji}$. As such, the freight rates each way between i and j will be the same–one half of the round trip marginal cost: $T^{Symm}_{ij} = T^{Symm}_{ji} = \frac{1}{2}c_{\overleftrightarrow{ij}}$.

The equilibrium price of country i's good in j is

$$p^R_{ij} = \frac{1}{1 + A_{ij}}\left(w_j\tau_{ji} + w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right) \quad \text{where} \quad A_{ij} = \frac{a_{ji}}{a_{ij}} \tag{16}$$

[24]The positive relationship is due to price elasticity of demand, $\sigma > 1$:

$$\frac{\partial X_{ij}}{\partial T_{ji}} = -(1-\sigma)\left(\frac{\sigma}{\sigma - 1}\frac{1}{a_{ij}}\right)^{-\sigma} (w_i\tau_{ij} + c_{i,j} - T_{ji})^{-\sigma} > 0$$

In contrast to equation (8), the price of i's good in country j is increasing in the marginal cost of round trip transport $c_{\overleftrightarrow{ij}}$, as well as the wages in both origin and destination countries (w_i and w_j) and both countries' import tariffs on each other (τ_{ij} and τ_{ji}). The fact that country j's import price from i is a function of its own wages and its import tariff on j is due to the round trip effect.

The equilibrium quantity and value of goods on route ij is

$$\begin{aligned} q_{ij}^{R} &= \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\frac{1}{1+A_{ij}}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)\right]^{-\sigma} \\ X_{ij}^{R} &= \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\right]^{-\sigma}\left[\frac{1}{1+A_{ij}}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)\right]^{1-\sigma} \quad \text{where } A_{ij}=\frac{a_{ji}}{a_{ij}} \end{aligned} \tag{17}$$

Here both quantity and trade value from i to j is decreasing in the marginal cost of transport, j's wages and i's import tariff on j, as well as i's wages and j's import tariff on i. In the case of symmetric countries, the prices, quantities, and values between i and j will be the same as well.[25]

These equilibrium outcomes highlight a novel mechanism due to the round trip effect: a country's imports and exports to a particular trading partner is linked through transportation. For example, when country i increases its import tariff on country j (τ_{ji}), not only will its own imports from j be affected, but its exports to j as well (equation (17)). The comparative statics section below elaborates.

3.4 Comparative statics

I first describe the trade predictions from a change in the home country's import tariff on its trading partner. I compare the predictions when freight rates are exogenous and when freight rates are endogenous with the round trip effect. Then I describe the trade predictions from a change in the home country's preference on goods from its trading partner. Lastly, I summarize the trade predictions from these two models.

When there is an increase in country j's import tariff on country i's goods (τ_{ij}), an exogenous transport cost model will predict only changes in j's imports from i. The price of j's imports from i will become more expensive (equation (8)) while its import quantity and

[25]The symmetric prices are $p_{ij}^{Symm} = p_{ji}^{Symm} = \frac{1}{2}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)$ while the quantities are $q_{ij}^{Symm} = q_{ji}^{Symm} = \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\frac{1}{2}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)\right]^{-\sigma}$. Symmetric trade values are $X_{ij}^{Symm} = X_{ji}^{Symm} = \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\right]^{-\sigma}\left[\frac{1}{2}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)\right]^{1-\sigma}$.

value from i will fall (equations (9) and (10)).

When transport cost is endogenized with the round trip effect, however, j's import tariff increase will predict changes in j's imports from and exports to i. This is due to the response from j's imports and export freight rates to i. First, country j's import freight rate will fall to mitigate the impact of the tariff (equation (15)). This decrease is not enough to offset j's net import price increase from i (equation (16)) and j's import quantity and value falls (equation (17)).

Second, the impact of j's import tariff also spills over to j's exports to i due to the round trip effect. The fall in j's import quantity from i translates directly in the fall in transport quantity in the opposite direction from i to j. All else equal, the corresponding fall in transport quantity from j to i due to the round trip effect results in an increase in j's export freight rate to i.[26] Country j's export price to i increases from the rise in export freight rate while its export quantity and value to i decreases.[27] The following lemma can be shown:[28]

Lemma 1. *When transport costs are assumed to be exogenous, an increase in the origin country j's import tariffs on its trading partner i's goods only affects its imports from its partner. Its import price from its partner will rise while its import quantity and value will fall.*

$$\frac{\partial p_{ij}^{Exo}}{\partial \tau_{ij}} > 0 \ , \ \frac{\partial q_{ij}^{Exo}}{\partial \tau_{ij}} < 0 \ \textit{and} \ \frac{\partial X_{ij}^{Exo}}{\partial \tau_{ij}} < 0$$

When transport cost is endogenous and determined on a round trip basis, this import tariff increase will affect both the origin country's imports and exports to its partner. On the import side, the origin country's import freight rate falls in addition to the effects under the exogenous model.

$$\frac{\partial T_{ij}^{R}}{\partial \tau_{ij}} < 0 \ , \ \frac{\partial p_{ij}^{R}}{\partial \tau_{ij}} > 0 \ , \ \frac{\partial q_{ij}^{R}}{\partial \tau_{ij}} < 0 \ \textit{and} \ \frac{\partial X_{ij}^{R}}{\partial \tau_{ij}} < 0$$

On the export side, the exogenous trade model does not predict any changes. However, the endogenous model predicts a fall in the origin country's export freight rate and price to its

[26] The equilibrium freight rate on route ji is $T_{ji}^{R} = \frac{1}{1+A_{ji}}\left(w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right) - \frac{1}{1+A_{ji}^{-1}}\left(w_j\tau_{ji}\right)$ where $A_{ji} = \frac{a_{ij}}{a_{ji}}$.

[27] The equilibrium price of country j's good in i is $p_{ji}^{R} = \frac{1}{1+A_{ji}}\left(w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right)$, the equilibrium quantity of goods on route ji is $q_{ji}^{R} = \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ji}}\frac{1}{1+A_{ji}}\left(w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right)\right]^{-\sigma}$, and the equilibrium trade value of goods shipped from j to i is $X_{ji}^{R} = \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ji}}\right]^{-\sigma}\left[\frac{1}{1+A_{ji}}\left(w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right)\right]^{1-\sigma}$ where $A_{ji} = \frac{a_{ij}}{a_{ji}}$.

[28] See Appendix for proof.

partner while its export quantity and value increases.

$$\frac{\partial T_{ji}^R}{\partial \tau_{ij}} > 0 \ , \ \frac{\partial p_{ji}^R}{\partial \tau_{ij}} > 0 \ , \ \frac{\partial q_{ji}^R}{\partial \tau_{ij}} < 0 \ and \ \frac{\partial X_{ji}^R}{\partial \tau_{ij}} < 0$$

Next, I consider an increase in country j's preference for country i's good (a_{ij}). In a model with exogenous transport cost, this increase in j's preference for i will again only affect j's imports from i. It will increase j's import quantity and value from i (equations (9) and (10)) while leading j's import price from i unchanged (equation (8)).

In the endogenous transport cost model with the round trip effect, an increase in country j's preference for country i's goods does not just affect its imports from i but also its import freight rate from i. This is similar to the trade predictions from the tariff increase discussed previously. Country j's import freight rate will rise, in this case, to mitigate the impact of the preference increase (equation (15)). Country j's import price from i will also increase (equation (16)). Even though j's imports from i is more expensive from equation (16), the net change in j's import quantity and value from i is positive (equation (17)).

Similar to the tariff case, the preference increase for j's imports from i also has spillover effects on j's exports to i. In order to meet the increased transport demand for j's imports from i, more transport firms enter the market which lowers j's export freight rate to i (footnote 26). This translates into a fall in j's export price to i which increases j's export quantity and value to i (footnote 27). The following lemma can be shown:[29]

Lemma 2. *When transport costs are assumed to be exogenous, an increase in origin country j's preference for its trading partner i's goods only affects its imports from its partner. Its import quantity and value from i will increase while leaving its import price from i unchanged.*

$$\frac{\partial p_{ij}^{Exo}}{\partial a_{ij}} = 0 \ , \ \frac{\partial q_{ij}^{Exo}}{\partial a_{ij}} > 0 \ and \ \frac{\partial X_{ij}^{Exo}}{\partial a_{ij}} > 0$$

When transport cost is endogenous and determined on a round trip basis, this preference increase will affect both the origin country's imports and exports to its partner. On the import side, the home country's import transport cost and price from its partner rises on top of the import changes predicted by the exogenous model.

$$\frac{\partial T_{ij}^R}{\partial a_{ij}} > 0 \ , \ \frac{\partial p_{ij}^R}{\partial a_{ij}} > 0 \ , \ \frac{\partial q_{ij}^R}{\partial a_{ij}} > 0 \ and \ \frac{\partial X_{ij}^R}{\partial a_{ij}} > 0$$

[29]See Appendix for proof.

On the export side, the home country's export transport cost and export price to its partner falls while its export quantity and value increases.

$$\frac{\partial T_{ji}^{R}}{\partial a_{ij}} < 0 \ , \ \frac{\partial p_{ji}^{R}}{\partial a_{ij}} < 0 \ , \ \frac{\partial q_{ji}^{R}}{\partial a_{ij}} > 0 \ \textit{and} \ \frac{\partial X_{ji}^{R}}{\partial a_{ij}} > 0$$

There are two main differences between the trade predictions of the exogenous transport cost model and the round trip effect model. The first is that the transport costs in the round trip model will mitigate the effects of trade shocks. In the example of an increase in the origin country's tariff on its trading partner, the origin country's import transport cost falls as well. Similarly, when the origin country's preference for its partner's goods increase, the origin country's import transport cost increases.

This first point can be generated in a transport model with rising costs. However, the transport industry in this model is assumed to be perfectly competitive and have constant costs. Therefore this prediction is solely generated by the round trip effect.

The second difference is that any shocks on the origin country's imports from its partner will have spillover effects on the origin country's exports to the same partner. This applies for shocks to the origin country's exports to its partner as well. This prediction, using a partial equilibrium Armington trade model, is a novel result due to the round trip effect. In the case of Lemma 1, an import tariff will therefore also translate into an export tax. The following proposition can be stated:

Proposition 1. *The round trip effect mitigates trade shocks on the origin country's imports from its trading partner via its import transport cost and generates spillovers of this shock onto the origin country's exports to the same partner. The same applies for trade shocks on the origin country's exports to its trading partner. A model with exogenous transport costs will not predict both these effects. An increase in the origin country's tariffs on its trading partner decreases both its imports from and exports to the same partner. The same applies inversely for a positive preference shock.*

Lerner (1936) symmetry predicts that a country's unilateral tariff increase on one partner will act as an export tax and reduce its exports to all its partners. My trade and transportation model predicts a distinct and more specific channel which impacts the country's exports to the same partner. Lerner symmetry would not predict this bilateral effect. Moreover, the Lerner symmetry prediction relies on the balanced trade condition within a general equilibrium setting. My model is partial equilibrium and do not require this condition.

4 Data

In this section, I first introduce a novel high frequency data set on port-level container freight rates. Matched with data on trade in containers, the combined data set will be used to estimate the elasticity of containerized trade with respect to freight rates in the next section. I then present summary statistics on this matched data set and then include ocean distance between ports as well as aggregate container volume flows. Third, I provide suggestive empirical evidence for my theoretical predictions due to the round trip effect: (1) the presence of a negative correlation between port-pair freight rates over time, and (2) the presence of a positive correlation between containerized trade value and opposite direction freight rates. Both these relationships contribute to the empirical presence of the round trip effect.

4.1 Container freight rates and containerized trade

Drewry Maritime Research (Drewry) compiles port-level container freight rate data from importer and exporter firms located globally.[30] To my knowledge, this data set is the only source of container freight rates on all major global routes.[31] The ports in this data set are the biggest globally and handle more than one million containers per year. These monthly or bimonthly spot market rates are for a standard 20-foot container.

While it is certainly the case that long-term contracts are used in the container market, I choose to use spot container freight rates instead due to the fact that long-term container contracts are confidentially filed with the Federal Maritime Commission (FMC) and protected against the Freedom of Information Act (FOIA).[32] Moreover, shorter-term contracts are increasingly favored due to over-capacity in the market.[33] Longer term contracts are also increasingly indexed to spot market rates due to price fluctuations.[34] Furthermore, most

[30]Many thanks to Nidhin Raj, Stijn Rubens, and Robert Zamora at Drewry for all their help. Drewry obtains this data from 28 shippers in Europe, Middle East, North America, South America and Asia.

[31]Worldfreightrates.com also publishes port-level freight rates. However, some of the rates from this website are generated. Marcelo Zinn, the owner of worldfreightrates.com, explained that their data is estimated from a complex proprietary algorithm based on real time rates. I was not able to ascertain the proportion of real versus generated data from Mr. Zinn. Drewry collects data on the actual prices paid by firms.

[32]I filed a FOIA request with the FMC on April 2015 for long-term container contracts. It was rejected on June 2015. According to the rejection, the information I seek is prohibited from disclosure by the Shipping Act, 46 U.S.C. §40502(b)(1). This information is being withheld in full pursuant to Exemption 3, 5 U.S.C. §552(b)(3) of the FOIA which allows the withholding of information prohibited from disclosure by another federal statute.

[33]Conversation with Roy J. Pearson, Director, Office of Economics & Competition Analysis at the Federal Maritime Commission, January 2015.

[34]Container Rate Indexes Run in Contracts, But Crawl in Futures Trading, Journal of Commerce, January

firms split their cargo between long-term contracts and the spot market to smooth volatility and take advantage of spot prices.[35] Freight forwarding companies like UPS or FedEx offer hybird models that allow for their customers to switch to spot rate pricing when spot rates fall below their agreed-upon contract rates.[36] As such, I take the position that spot prices play an important role in informing long-term contracts and can shed light on the container transport market.

In order to study the trade impact of these container freight rates, I match my freight rate data to containerized trade data. While containers carry the two-thirds of world trade by value (World Shipping Council), they do not carry all types of products. Cars and oil, for example, are not transported via containers. As such, in order to compare apples to apples, I focus my analysis on trade in containers. Since containerized trade data is not readily available for all other countries apart from the United States, my analysis is limited to US trade in this paper. Drewry collects freight-rate data on the three of the largest US container ports (Los Angeles and Long Beach, New York, and Houston) that handle 16.7 million containers annually combined—more than half of the annual US container volume (MARAD). There are 68 port pairs which include these three US ports.

Monthly containerized US trade data at the port level is available from USA Trade Online at the six-digit Harmonized System (HS) product code level. It includes the trade value and weight between US ports and its foreign partner countries.[37] My level of observation is at the US port, foreign partner country, and product level, but for ease of exposition I will refer to both destination and origin locations as a country. Both freight rates and trade value data are converted into real terms.[38] Containerized trade account for 62% of all US vessel trade value in 2015.[39] My matched freight rates and trade data set represents about half of total US containerized trade value in 2014 (USA Trade Online).[40] The time period of this matched data set is from January 2011 to June 2016.

2014

[35]Conversation with Roy J. Pearson, Director, Office of Economics & Competition Analysis at the Federal Maritime Commission, January 2015.

[36]Container lines suffer brutal trans-Pacific contract season, Journal of Commerce, June 2016.

[37]Since my freight rates data is at the port-to-port level, I have to aggregate my data to the US port and foreign country level. See Data Appendix for further details.

[38]I use the seasonally adjusted Consumer Price Index for all urban consumers published by the Bureau of Labor Statistics.

[39]Shipping vessels that carry trade without containers include oil tankers, bulk carriers, and car carriers. Bulk carriers transport grains, coal, ore, and cement.

[40]This is a conservative estimate particularly for Europe since Drewry does not collect data on adjacent ports even though they are in different countries. See the Data Appendix for more details.

4.2 Summary Statistics

Table 1 shows the summary statistics for US freight rates, as well as containerized trade value, trade weight, and trade value per weight. As a first pass, this data set is broken down by US exports, US imports, and total US exports plus imports along the same dyad. These variables, on average, are higher on the US imports direction than the US exports direction. While US containerized import value is intuitively on average higher than the export value since US is a net-importer, my data set shows that US imports also face on average higher freight rates than US exports. US import weight is higher than US export weight as well. When value is divided by weight to construct a crude measure of quality, the value per weight of US imports is still on average higher than US exports.

Containerized trade requires containers in order to be transported. As such, the containerized trade value elasticity with respect to freight rates, which I estimate in the following section, can also be interpreted as the demand elasticity for containers. It is therefore important to highlight that the demand for containers, being a demand that is derived from the underlying demand for trade that is transported in containers, moves closely with the demand for trade that is transported in containers. I confirm this link by introducing a data set on container volumes from the United States Maritime Administration (MARAD).[41] This data set is much more aggregated than my data–it is at the country and annual level–so it requires that I aggregate my data set, which drastically reduces the number of my observations.[42] Figure 6 shows that containerized trade value and container volume have a positive and significant correlation within routes (coefficient of 0.5 with robust standard errors clustered at the route level of 0.16).[43]

Table 2 presents the summary statistics of the aggregated data set. The translation of containerized trade into number of containers can be shown where the average number of containers, measured as a unit capacity of a container ship (Twenty Foot Equivalent Unit, TEU), are higher for US imports than exports (table 2). With the number of containers, I can calculate the average value and weight per container. The average value per container and weight per container for US imports is higher than exports. The larger ratio between the import and export value per container compared to weight per container is in line with the value per weight statistics where higher quality goods are being imported by the US versus

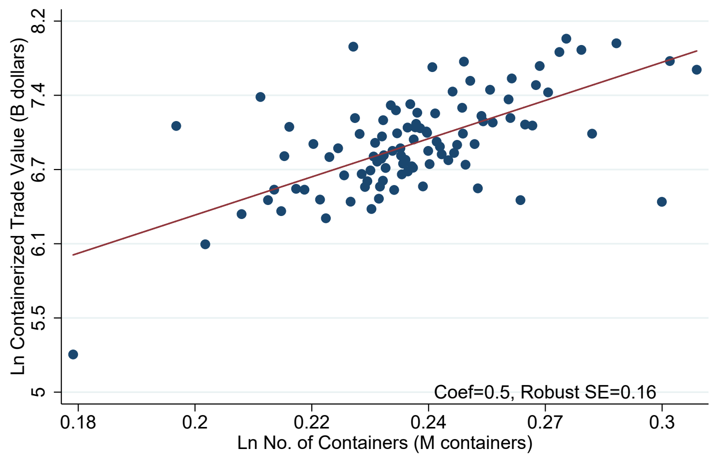
[41]MARAD obtains this data from the Port Import Export Reporting Service (PIERS) provided by the IHS Markit.

[42]I use annual total US containerized imports and exports trade and the average of container freight rates for the different US ports.

[43]Containerized trade weight and container volume also have a positive and significant correlation within routes (figure A.3).

Figure 6: Containerized trade value (X_{ijt}) and container volume (Q_{jit}) are positively correlated within routes

$$\ln X_{ijt} = \beta_0 + \beta_1 \ln Q_{jit} + d_{\overleftrightarrow{ij}} + \gamma_t + \epsilon_{ijt}$$



Robust standard errors clustered by route.
Year and route level controls were included. All variables are in log.
Source: Drewry, USA Trade Online, and MARAD (Annual 2011-2015)

exported.

In the last row of table 2, I calculate the ad-valorem equivalent of freight rates by dividing it with the value per container. The average iceberg cost for container freight rates is 8%.[44] The iceberg cost for US imports at 9% is higher than the iceberg cost for US exports at 6%. However, this variable belies two endogenous components: freight rates and trade value. Container freight rates and containerized trade value are jointly determined since they are market outcomes. This paper will study the freight rate and value variables as such.

Both the summary statistics in tables 1 and 2 affirms the "shipping the good apples out" phenomenon first introduced by Alchian and Allen (1964) and extended by Hummels and Skiba (2004)–the presence of per unit transportation costs lowers the relative price of higher-quality goods. Table 1 shows the presence of higher US import freight rates as well as higher import value per weight relative to exports. Similarly, table 2 shows that the value per container for imports are higher than exports as well.

4.3 Suggestive Evidence

My novel data set on container freight rates, matched with containerized trade data, is uniquely positioned to provide suggestive evidence for my theoretical predictions from the

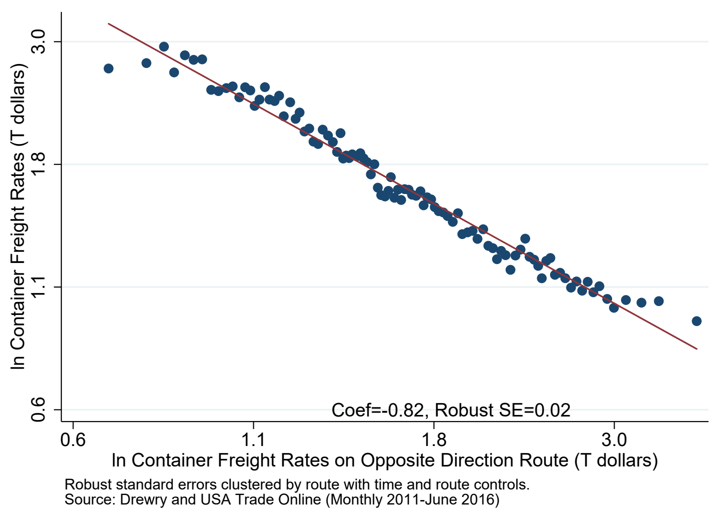
[44]This average measure is in the ballpark with the 6.7% container freight per value average in Rodrigue, Comtois and Slack (2013).

previous section. I document them below.

Suggestive Evidence 1. *A positive deviation from the average freight rates from i to j is correlated with a negative deviation from the average opposite direction freight rates from j to i*

As mentioned earlier, carriers like containerships and airplanes are re-used resulting in the need for them to travel in round trips to origin locations. This means that the transport firm cannot separate the cost of servicing each direction of the trip (Pigou and Taussig (1913); Jara-Diaz (1982); Dejax and Crainic (1987); Demirel, Van Ommeren and Rietveld (2010)). From my theoretical framework in the previous section, optimal freight rates between a given port pair will add up to equal the marginal cost of a round trip (equation (12)). This means that, conditional on the round trip marginal cost, freight rates between port pairs are negatively correlated. I show this inverse relationship within port pairs in my freight rates data set (figure 7).[45] A one percent deviation from the average container freight rates from i to j is correlated across time with a negative deviation of 0.8 percent from the average container freight rates from j to i.

Figure 7: Correlation between freight rates within port pairs
$$\ln T_{ijt} = \beta_0 + \beta_1 \ln T_{jit} + d_{ij} + \gamma_t + \epsilon_{ijt}$$



It is worth emphasizing that this inverse relationship is not typically predicted in the

[45] Route fixed effects, which are directional dyad fixed effects, are included in the regression used to construct this figure. As such, this figure is identified from the time variation within routes. If the fixed effects were at the dyad, non-directional level, then a mechanical negative correlation could arise. However, this is not the case here.

trade literature. If freight rates can be approximated by distance and therefore is symmetric, as assumed in some of the literature, one would expect the correlation in figure 7 and table 3 to be zero. If freight rates were exogenous, one might expect no correlation or a noisy estimate. In fact, as I noted in my introduction, when Samuelson (1954) introduced the iceberg transport cost he provided two caveats. First, if transport costs varied with trade volume, then transport costs would not be constants. Second, since realistically there are joint costs of a round trip for transportation, the going and return transport costs will tend to move in opposite directions depending on the demand levels.[46] I confirm his caveats here.

Furthermore, the presence of this inverse relationship means that container routes can generally be represented by the port-pairs in my data. One contributing reason for this is the significant increase in average container ship sizes—container-carrying capacity has increased by about 1200% since 1970.[47] The increase in average ship size has resulted in downward pressure on the average number of port calls per route because larger ships face greater number of hours lost at port. Ducruet and Notteboom (2012) shows that the number of European port calls per loop on the Far East-North Europe trade has decreased from 4.9 ports of call in 1989 down to 3.35 in December 2009. Second, this size increase has also generated a proliferation of hub-and-spoke networks (also known as hub and feeder networks) which also decreases the number of port calls per route: 85 percent of container shipping networks are of the hub-and-spoke form (Rodrigue, Comtois and Slack (2013)) and 81 percent of country pairs are connected by one transhipment port or less (Fugazza and Hoffmann (2016)).[48]

The round trip effect can be also shown using container quantities directly. Figure A.2 in the appendix highlights a positive relationship between container volume gap and freight rate gap between countries. As the number of containers going back and forth between countries increases, the freight rate gap between these countries increases as well. [49]

Suggestive Evidence 2. *A positive deviation from the average containerized trade value*

[46]It is acknowledged here that systematic current and wind conditions can contribute to this inverse relationship. Chang et al. (2013) show that the strong western boundary current of the North Pacific can be utilized by ships to save transit time and thus fuel. They estimate time savings of 1-8 percent when riding favorable currents or avoiding unfavorable currents. These modest time saving estimates lead to me conclude that the highly negative and significant relationship in figure 7 is not solely driven by currents.

[47]Container ship design, World Shipping Council.

[48]18 percent of country pairs are directly connected (zero transhipment port) and almost 100 percent of country pairs are connected by two transhipment ports or less (Fugazza and Hoffmann (2016)). This paper abstracts from modeling the hub and spoke network directly and focuses only on hub linkages.

[49]It is acknowledged here that the container volume gap between countries are not explicitly modeled and is assumed to be equal in the theory section for simplicity. However, this assumption can be relaxed with the addition of a search framework. The theory section elaborates.

from i to j is correlated with a positive deviation from the average opposite direction freight rates from j to i. The same applies for containerized trade weight while the opposite applies for value per weight.

Using the matched data set of freight rates and containerized trade, I show that a country's imports and exports with a particular partner are linked via its outgoing and return transport costs with that partner. First, intuitively, containerized trade value and weight decreases with freight rates on the same route while value per weight increases with freight rates (table 4). The last point confirms the Alchian-Allen effect.

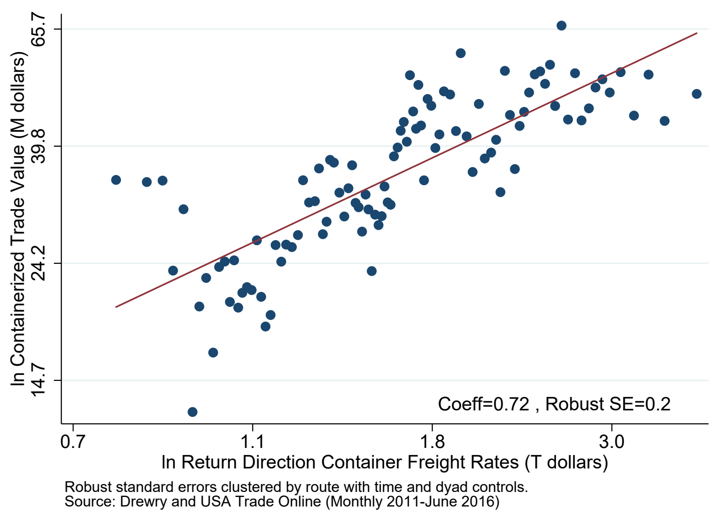
Since freight rates are negatively correlated within a route as established in the first stylized fact, table 5 shows that containerized trade value and weight on the outgoing direction *increases* with opposite direction freight rates. Specifically, within dyad, a one percent deviation from the average return direction freight rates (from j to i) is correlated across time with a 0.7 percent increase in average aggregate containerized trade value (from i to j, column (1) and figure 8). In column (2), a within dyad one percent increase from the average return direction freight rates (from j to i) is correlated across time with a 1.1 percent increase in average aggregate containerized trade weight (from i to j). Correspondingly in column (3), table 5 shows that the value per weight on the outgoing direction *decreases* with opposite direction freight rates. A within dyad one percent increase from the average return direction freight rates (from j to i) is correlated across time with a 0.4 percent decrease in average aggregate containerized trade quality (from i to j).

These findings can be attributed to the round trip effect. Absent this effect, there should be no systematic relationship between containerized trade on the outgoing direction and freight rates on the incoming direction. The same applies for trade on the incoming direction and freight rates on the outgoing direction. It is, however, acknowledged here that the dominance of processing trade can also contribute to this relationship.[50] While table 6 shows that my results are robust to removing the main country that conducts processing trade with the US, China,[51] I will be careful to isolate the round trip effect from the processing trade effect in the following empirical section.

[50] Processing trade refers to the fragmented production process which allows firms to perform only intermediate stages of production by processing imported inputs for re-exporting (Manova and Yu (2016), Yu (2015)). In the example of US and China processing trade, US exports inputs to China which assembles them into final goods for re-export to the US. A decrease in the transport cost from US to China will decrease the input cost which can potentially translate into larger re-export value or weight back to the US.

[51] The processing trade share of China exports to US by value is more than 50 percent in 2004 (Hammer (2006)).

Figure 8: Correlation between containerized trade value and opposite direction freight rates
$\ln X_{ijt} = \beta_0 + \beta_1 \ln T_{jit} + d_{\overleftrightarrow{ij}} + \gamma_t + \epsilon_{ijt}$



5 Empirical Approach

In this section, I present my strategy for estimating the elasticity of containerized trade with respect to container freight rates. This elasticity will be subsequently used in my counterfactual calculations. I introduce my estimating equation, detail the endogeneity issue from an ordinary least squares (OLS) estimation, and propose an instrumental variable (IV) using the round trip effect insight to address the potential bias. I then discuss the validity of my identification approach.

5.1 Identification of the impact of freight rates on trade

I estimate the relationship between container freight rates and containerized trade for product n (where n is a 2-digit HS product code) on route ij at time t as follows:[52]

$$\ln X_{ijnt} = \alpha \ln T_{ijt} + S_{it} + M_{jt} + d_{\overleftrightarrow{ijn}} + \varepsilon_{ijnt} \tag{18}$$

where X_{ijnt} is the containerized trade on route ij of product n at time t and T_{ijt} is the container freight rate on route ij at time t.[53] Following the canonical trade flow determinants in

[52] As mentioned earlier, since trade in containers require containers, this estimating equation can also be interpreted as a log linear demand estimation for containers.

[53] Containers are generally considered a commodity which do not vary by product. This is particularly true for my container spot market rates data. See the data section for a more detailed discussion.

gravity equations (Head and Mayer, 2014),[54] I control for the time varying export propensity of exporter country i such as production costs with an exporter-by-time fixed effect (S_{it}) and for the time-varying importer country j's determinants of import propensity with an importer-by-time fixed effect (M_{jt}). These fixed effects also control for shocks to these countries. The dyad-by-product level fixed effect, $d_{\overleftrightarrow{ijn}}$, accounts for time-invariant product-level comparative advantage differences across country pairs in addition to time-invariant bilateral characteristics like distance, shared borders and languages.[55] Since the variation in tariff rates during my sample period is small—an average annual percentage point change of 0.2 from 2011 to 2016,[56] $d_{\overleftrightarrow{ijn}}$ can also control for the constant tariff rate differences across countries that can contribute to differences in trade levels. The error term is ε_{ijnt}. To address potential auto-correlation in my panel data set, I report standard errors adjusted for clustering within routes. In my results, I include a specification with separate controls for dyad ($d_{\overleftrightarrow{ij}}$) and product ($\gamma_n$) fixed effects.

My specification exploits the panel nature of my data set and observed per unit freight rates in order to identify the containerized trade elasticity with respect to freight rates. To my knowledge, this is the first paper to use transportation-mode specific panel data and its corresponding observed transport cost to identify a mode-specific trade elasticity with respect to transport cost. The only other paper closest to my methodology is Shapiro (2016) who uses ad-valorem shipping cost across multiple modes.

The elasticity of containerized trade with respect to freight rates, α, is the parameter of interest here. As mentioned earlier, the main challenge for this exercise is that container freight rates and trade are jointly determined. As such, an OLS estimation of α in (18) will suffer from simultaneity bias. Furthermore, this bias will be downward due to two factors. The first is due to the simple endogeneity of transport costs. An unobserved positive trade shock in ε_{ijnt} will simultaneously increase freight rates T_{ijt} and containerized trade X_{ijnt}. This results in a positive correlation between T_{ijt} and X_{ijnt} which masks the negative impact of freight rates on trade. The second factor is due to the round trip effect. Between a dyad, routes with higher demand, and thus higher container volume and trade value, will face

[54] The key difference between my estimating equation and typical gravity models is that gravity models are estimated using ad-valorem trade costs while my container freight rates data is at the per-unit level. As such, I am estimating the elasticity of containerized trade with respect to per unit freight rates and not a general trade elasticity with respect to trade cost.

[55] Similar specifications at the country-country level have been done by Baier and Bergstrand (2007) to estimate the effects of free trade agreements on trade flows and Shapiro (2015) to estimate the trade elasticity with respect to ad-valorem trade cost.

[56] Additionally, almost 80 percent of the tariff rate changes are below 0.25 percentage points. See table A.4 in Data Appendix.

relatively higher freight rates compared to routes with lower demand. This further contributes to the positive correlation between T_{ijt} and X_{ijnt}. In order to consistently estimate α, I require a transport supply shifter that is independent of transport demand.

My proposed transport supply shifter to identify product-level containerized trade demand for route ij is its opposite direction aggregate containerized trade shocks (on route ji). Aggregate trade shocks on opposite direction route ji will affect the aggregate supply of containers in its own route *and* the original direction route (ij) due to the round trip effect. The latter provides an aggregate transport supply shifter to identify the product-level containerized trade demand for route ij. Figure 5 from earlier illustrates this. a positive trade shock for route ji in the top graph increases its corresponding transport demand. As transport supply on route ji responds, the round trip effect implies that the aggregate transport supply in the original direction (route ij) will also increase. This latter aggregate increase in transport supply can identify the containerized trade demand for route ij conditional on demand shifts between the routes being uncorrelated. The basic idea here, then, is to utilize the round trip insight and instrument for T_{ijt} in equation (18) with its opposite direction trade X_{jit} .

This approach is problematic, however, if demand shocks between countries i and j are not independent. Examples of this violation include exchange rate fluctuations, processing trade, and the signing of any free trade agreements between countries.[57] As such, I construct a Bartik-type instrument that predicts the opposite direction trade on route ji but is independent of the unobserved demand determinants on route ij.

5.2 Predicted trade instrument

To introduce my instrument, I start by showing a series of transformations on country j's total exports to i across all products:

$$X_{jit} = \sum_{N} X_{jint} \tag{19}$$

[57] A fall in j's currency relative to i will induce an increase in trade demand on route ji but this will also affect the opposite direction trade demand as well. Using my original example of US-China processing trade, a shock that increases demand for inputs from US to China (like a fall in input prices) will also affect the trade demand for processed finished products from China to US using these inputs. Lastly, a free trade agreement requires that both countries reduce their tariffs and so this will induce simultaneous increases in trade demand between both these countries.

The sum of j's exports to i at time t, X_{jint}, is the sum of all products n that j exports to i at time t. Multiplying and dividing by country j's total exports of product n to all of its partners in set A—the set of countries in my instrument group—yields the following:

$$X_{jit} = \sum_N X_{jint} = \sum_N X_{jAnt} \times \frac{X_{jint}}{X_{jAnt}} \equiv \sum_N X_{jAnt} \times \omega_{jint} \tag{20}$$

where the first term is j's total exports of n to its trading partners in set A and the second term $\omega_{jint} \equiv \frac{X_{jint}}{X_{jAnt}}$ is j's export share of product n to i.

My predicted trade measure for j's exports to i, in the spirit of Bartik (1991), is the lagged-weighted sum of country j's exports to all its partners except for i. The weights are the product shares of products that j exported to i in January 2003, the earliest month available in my data set, and the sum is country j's exports to all of its partners except for country j at present time:

$$Z_{jit} \equiv \sum_N X_{j,A\setminus i,nt} \times \frac{X_{jint^b}}{X_{jAnt^b}} \equiv \sum_N X_{j,A\setminus i,nt} \times \omega_{jint^b} \tag{21}$$

where the first term is the sum of j's exports of product n to all its partners except for i at present time t ($X_{j,A\setminus i,nt} = \sum_A X_{jAnt} - X_{jint}$). The second term is j's lagged product-level export shares to i, at least eight years prior in January 2003 (time t^b). The instrument Z_{jit} is obtained by summing both these terms across all products.

This instrument in (21) differs from the expression in (20) in two respects. First, in place of the present-time product trade shares—the first term in (20), I use the earliest shares available in my data set from at least eight years prior–January 2003. This modification is to mitigate the simultaneity bias from using contemporaneous import shares. Second, in place of country j's total exports of product n to all of its trading partners, I remove country i from this sum. This is in order to avoid a mechanical correlation between the instrument and j's direct exports to i.[58]

5.3 Validity of identification approach

My IV strategy is to use the predicted trade on a route (Z_{jit}) to identify its return direction product level trade demand (X_{ijnt}). Trade on route ji (X_{jit}) is correlated with its return

[58] My predicted trade measure centers around the US due to the availability of US containerized trade data. For clarity of exposition above I have assumed that the US is country j and used country j's exports in my explanation above. However, if the US is country i in the example above I will use US imports from all its partners to construct my instrument.

direction freight rates (T_{jit}) due to the round trip effect as established earlier. Since Z_{jit} predicts X_{jit}, the predicted trade measure Z_{jit} should correlated with the return direction freight rates T_{ijt} as well.

In order for my IV strategy to be valid, the predicted trade on a route (Z_{jit}) has to be generally uncorrelated with unobserved changes in product-level demand on the return direction route (corr(Z_{jit}, ε_{ijnt}) = 0). Since the construction of Z_{jit} excludes present-time j exports to country i, it is no longer a function of bilaterally correlated present-time demand shocks between i and j.[59] I address potential violations in the following ways.

First, I include fixed effects that control for national monthly variation in container demand by importer, exporter, and fixed differences across dyad and products. These national and dyad level controls are actually at the foreign country and US port level so these fixed effects will also absorb any US port-level variation that is correlated with trade determinants. Therefore, my identification assumption here is that the deviation in the predicted trade measure for route ij from importer and exporter trends at the foreign country and US port level, as well as the fixed comparative advantage between i and j, is uncorrelated with the deviation in unobserved product-level demand changes.

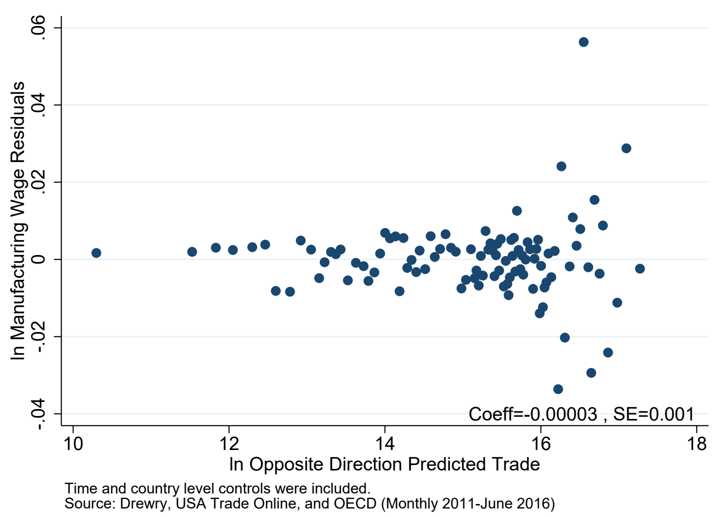
One potential threat to my identification is correlated product-level demand shocks across countries like in the case of supply chains. Take the example of China, who is the top world exporter of steel. China exports steel to the US and UK. UK, in turn, processes the steel into a finished product like steel cloth or saw blades to export to the US. My instrument to identify US demand for steel products from the UK (route $UK - US$) is the predicted trade for return route $US - UK$ (Z_{US-UK}), which is the sum of US weighted exports to all its trading partners except the UK (equation (21)). This means that Z_{US-UK} includes US exports to China. Now say that China experiences a supply shock, like an increase in steel manufacturing wages, which raises the input price of their steel. There will be two effects from steel becoming more expensive. The first is that US demand for Chinese steel will fall. The second effect is US demand for UK steel products that use Chinese steel as inputs will also fall. Through the round trip effect, US exports to China on route $US - C$ will also fall which is included in my instrument Z_{US-UK}. This means that my instrument is correlated with the original steel supply shock in China which affects the unobserved US demand for steel products from the UK. In order to make sure that supply chains are not driving my results, I restrict my instrument group (set A in equation (21)) to high-income

[59]Since Z_{jit} excludes X_{jint} for all products, any shocks that affect j's demand for i (ε_{ijnt}) that will also affect i's demand for j is no longer part of Z_{jit}. These shocks include the examples raised earlier: exchange rate fluctuations, processing trade, and the signing of any free trade agreements between countries.

OECD countries following the intuition of Autor, Dorn and Hanson (2013), Autor et al. (2014), Dauth, Findeisen and Suedekum (2014), as well as Galle, Rodrıguez-Clare and Yi (2015).[60]

While I do not directly observe ε_{ijnt}, I can approximate it by using manufacturing wages since most manufactured products are transported via containers (Korinek (2008)). Manufacturing wages are inputs to production and therefore are correlated with unobserved product-level demand determinants. The absence of correlation between my predicted trade measure and this approximation of ε_{ijnt} is shown in figure 9, a visualized regression of my predicted trade measure and manufacturing wages. Specifically, country j's predicted exports to i on route ji is uncorrelated with country i's manufacturing wages which can approximate i's unobserved product-level demand determinants for j. The absence of a correlation here is supportive of the validity of my exclusion restriction.

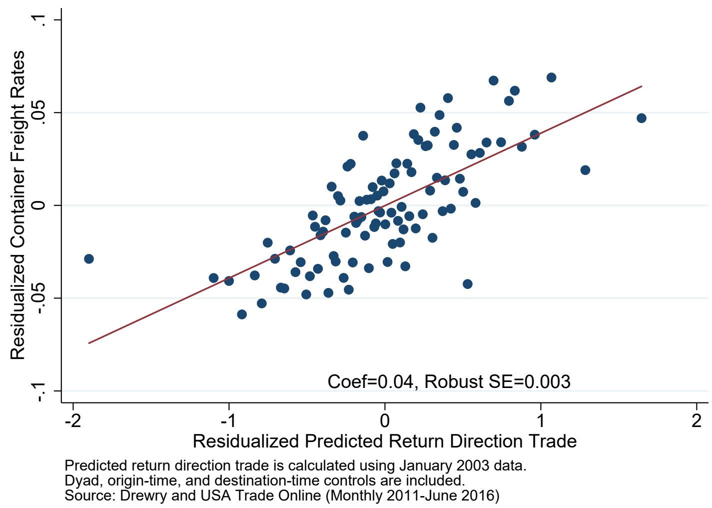
Figure 9: Correlation between instrument and approximation of demand determinants



To provide evidence that this Bartik-style predicted trade measure has sufficient power to identify the desired effects, I present my first stage results in figure 10. Controlling for constant bilateral differences across routes as well as time-varying importer and exporter characteristics, a 10 percent increase in my predicted trade measure corresponds to a significant and positive 0.6 percent increase in the opposite direction container freight rate.

[60]In robustness checks in the following section, I remove products whose production process is typically fragmented as compiled by Fort (2016). I find that my estimates retain the same sign and are within a confidence interval of my baseline results.

Figure 10: First stage regression results



6 Impact of Freight Rates on Trade

This section presents the results from my OLS estimates as well as two-stage least squares IV regressions. Trade outcomes are aggregated to the HS2 product level and measured in value, weight, and value per weight. I first present my estimates with only OECD countries due to my instrument group restriction to OECD countries in order to address supply chain concerns. I also compare my estimates to the literature. Next, I discuss my results when expanding my second stage to include all countries in my sample size. Lastly, I discuss various robustness checks.

6.1 Main Results

Column (1) in table 7 presents the OLS estimates with separate controls for importer-by-time, exporter-by-time, dyad, and products. A one percent increase in container freight rates is correlated with a significant 0.7 percent decrease in trade value. This estimate is robust to controlling for comparative advantage with dyad-by-product fixed effects–a one percent increase in container freight rates corresponds to a significant 0.5 percent decrease in trade value (column (2)). After addressing the potential simultaneity bias with my predicted return direction trade instrument, the IV estimates are, as expected, more pronounced in magnitude (First stage results are in table 18). Column (3) in table 7 shows that a one percent increase in per unit container freight rates decreases containerized trade value by 3.7 percent with separate product and dyad controls. This result is robust to including dyad-by-product controls (column (4))–a one percent increase in freight rates decreases trade value by 2.8 percent.

Table 8 uses containerized trade weight as the outcome. The weight estimates are overall larger than the value estimates. This is a reflection of trade weight being a closer proxy to quantity while value contains both quantity and price. Prices tend to increase with freight rates while the opposite is true for quantity. The OLS estimates in column (1) show that a one percent increase in freight rates correspond to a one percent decrease in trade weight. With the inclusion of dyad-by-product controls, the estimate decreases slightly—a one percent increase in freight rates decrease trade weight by 0.8 percent (column (2)). In my IV estimates (First stage results are in table 19), a one percent increase in container freight rates decreases containerized weight by 4.8 percent (column (3)). With dyad-by-product controls, this estimate decreases slightly—a one percent increase in container freight rates decreases trade weight by 3.6 percent (column (4)).

My trade value estimates are not directly comparable to the literature since, to my knowledge, no other paper has estimated containerized trade value elasticities with respect to per unit freight rates. However, my containerized weight elasticities are in line with the literature. In addition, my general finding that my IV approach yields trade elasticity estimates that are roughly five times more sensitive than my OLS estimates is in line with Baier and Bergstrand (2007). They find a similar five-fold increase in the effect of free trade agreements (FTAs) on trade flows after taking into account of the endogeneity of FTAs.

Since weight and volume can be close proxies for each other, my OLS containerized trade weight estimates are comparable to the volume elasticities for other transport modes highlighted in the transportation literature's handbook chapters (De Palma et al. (2011); Oum, Waters and Yong (1992)). Their aggregate volume elasticity with respect to transport cost is between -0.8 to -1.6 for air, -0.7 to -1.1 for truck, and -0.4 to -1.2 for rail.[61] Using region-level aggregate container volumes and freight rates data for three regions (US, Europe, and Asia), Friedt and Wilson (2015) finds much smaller volume elasticities–a one percent increase in freight rates result in less than 0.2 percent decreases in container volume on dominant and secondary routes. They address the potential endogeneity concerns using the group mean

[61] I compare my OLS weight estimates to the volume elasticities from the transport literature because Oum, Waters and Yong (1992) reveals that many freight demand models ignore the endogeneity issue when measuring the price elasticity of freight demand and conclude that the reported elasticity values may be biased. De Palma et al. (2011) suggests that in further transport demand analysis research, "the interaction between supply and demand could be taken into consideration." (p. 752, De Palma et al. (2011))

Panel Dynamic OLS estimator (Pedroni (1999); Pedroni (2004)) and acknowledge that the much more aggregated nature of their data set means that they are not able to include country-specific controls. Since my data is at a much finer detail as well as at a higher frequency, I am able to exploit its panel nature and include a richer set of controls.

Table 9 presents my containerized value per weight elasticity with respect to freight rates. Containerized value per weight can be calculated using the value and weight variables. This gives me a crude measure of product quality although I will not be able to distinguish whether higher quality means a higher quality product within the same classification category or across product categories. The OLS estimate in column (1) in table 9 shows that a one percent increase in container freight rates increases the product quality in containers by about 0.4 percent. When controlling for dyad-by-products, a one percent increase in freight rates increases product quality by 0.3 percent (column (2)). In my IV estimates (First stage results are in table 20), a one percent increase in freight rates increases containerized quality by 1.1 percent. This estimate decreases slightly with dyad-by-product controls—a one percent increase in freight rates increases containerized quality by 0.8 percent. My value per weight IV estimates are comparable to Hummels and Skiba (2004) who finds a price elasticity with respect to freight cost between 0.8 to 1.41. They address the endogeneity concern using two sets of instruments: distance and shipment weight as well as lagged values of prices.

Overall, the first stage results suggest that my instrument is strong with F-statistics above the standard threshold of 10 suggested by Staiger and Stock (1994). My results are robust and qualitatively similar if I expand my sample beyond OECD countries to include the full set of countries in my data set, although the instrument has less power here since it is constructed only with OECD countries. These estimates have the same signs and are within one standard error of my baseline estimates. Table 10 presents the trade value elasticities, table 11 presents the trade weight elasticities, and table 12 presents the trade quality elasticities.

6.2 Robustness Checks

These results are also robust to removal of products typically fragmented in the production process. I remove these products to make sure that my results are not sensitive to products within supply chains. Fort (2016) constructs a data set on plant-level decisions to fragment production in the US at the four-digit NAICS industry level. I remove the products in industries with a majority of production fragmentation after matching the four-digit NAICS industry to HS product codes using the concordance system from the Census Bureau.[62] The removed products constitute about 13 percent of total overall containerized value (US imports and exports) which can explain the lower power in my instrument.[63] I find that my estimates retain the same sign and are within the confidence interval of my baseline results. Table 13 presents the trade value elasticities, table 14 presents the trade weight elasticities, and table 15 presents the trade quality elasticities.

These results are robust to product aggregation as well. Tables 16 and 17 present the results of my data set aggregated to the total trade across products and route level. While the OLS trade value estimate in table 16 is negative, it is insignificant. However after instrumenting, the IV trade value estimate is significant and larger than the more disaggregated data set presented earlier—a one percent increase in container freight rates decrease total route trade value by 4.1 percent. This estimate has the same sign and is within one standard error of my baseline result. Similar to aggregate trade value, the OLS estimate in table 17 shows that container freight rates correspond to a negative but insignificant decrease in aggregate trade weight. However, the IV estimate for containerized trade weight is also significant and larger than the disaggregated estimates—a one percent increase in container freight rates decrease total route trade weight by 6.3 percent.

To ensure that the historical data—January 2003—used to construct the instrument is not driving my results, I construct the same instrument using January 2009 data and obtain qualitatively similar results. These results are in the Data Appendix.

In this section, I present my containerized trade value, weight, and quality elasticities with respect to freight rates. I first present my OLS and then my IV estimates, which account for the endogeneity of transport costs and trade as well as the round trip effect. My results are robust to different specifications and aggregation. I find that the general magnitude difference between my OLS and IV estimates are in line with the literature. My trade weight and quality elasticities generally conform to estimates in the literature even though my trade value elasticities are not directly comparable. In the following section, I present my theoretical framework which incorporates a transportation industry into an Armington trade model. I use my elasticity estimates as well as the following theoretical model to simulate a counterfactual increase in US import tariffs in order to quantify the trade prediction differences between my model and a model with exogenous transport costs.

[62] Fort (2016) shows that a significant fraction of plants do not fragment their production in an industry (average of 30 percent), while the lowest industry participation rate is 8 percent and the highest is over 60 percent. The Census Bureau website is used for concordance.

[63] 102,677 observations and a total of $229 billion dollars.

7 Counterfactual

The theory model in the previous section allows me to determine how US trade quantities, value, as well as freight rates evolve due to different trade policy scenarios in the presence of the round trip effect. Utilizing the trade elasticities from my IV results along with my model, I can analyze the following scenario: an increase in US import tariff on its OECD partners, from its current trade-weighted effectively applied average of 1.6 percent,[64] to 5 percent. Comparing the simulated trade prediction from my model to predictions from a model with exogenous transport costs allows me to quantify their outcome differences.

I obtain tariff rates from the trade-weighted effectively applied tariff rates for manufactures from the World Bank's World Integrated Trade Solution (WITS) database. The domestic input prices are approximated by hourly manufacturing wages from the OECD following Eaton and Kortum (2002). The use of OECD wages limits the countries I include in my counterfactual analysis. The round trip marginal cost for each country pair is the sum of the freight rates going both ways (equation (12)).

The price elasticity of demand, σ, is calculated using the trade value demand elasticity from my empirical results. From the theory section, the elasticity of trade value with respect to transport cost is:

$$\frac{\partial X_{ijpt}}{\partial T_{ijt}} \frac{T_{ijt}}{X_{ijpt}} = (1-\sigma)\frac{T_{ij}}{w_i \tau_{ij} + T_{ij}} \equiv \alpha \tag{22}$$

This elasticity is equivalent to the estimated demand elasticity in my empirical section (α). In order to obtain σ, I approximate the freight rate share of price ($\frac{T_{ij}}{w_i \tau_{ij} + T_{ij}}$) with the estimate by Irarrazabal, Moxnes and Opromolla (2015). They calculate that per unit trade cost is about 14 percent of the median price.[65] The price elasticity of demand calculated from equation (22) is 21.7.

This price elasticity of demand estimate, taking into account the endogeneity of transport cost and trade, implies a four- to five-fold increase in my estimates when transport costs are assumed to be exogenous.[66] This increase is in line with Baier and Bergstrand (2007) who finds a similar five-fold increase in the effect of free trade agreements (FTAs) on trade flows after taking into account of the endogeneity of FTAs. Trefler (1993) estimates a ten-fold increase in the impact of nontariff trade barriers (NTBs) when trade protection is modeled

[64] This average tariff rate is trade-weighted and only includes manufactures and OECD countries.

[65] It is acknowledged here that per unit trade cost does not just include transport cost but also quotas and per unit tariffs.

[66] My OLS trade value elasticity with respect to freight rates is -0.5 which translates into an OLS price elasticity of demand of -4.5 (table 7).

endogenously compared to when it is treated as exogenous. Furthermore, both my weight and quality elasticities are in the ballpark of other studies.[67] This gives me confidence that my estimate, while larger than typically seen in the literature, is not unreasonable.[68]

Given the parameters above, the remaining two parameters are chosen to match the observed trade value and freight rates in my data set given the equilibrium conditions below for each country pair. The first one is the preference parameter a_{ij} which captures j's preference for i's good. The second parameter is loading factor l_{ij} for route ij which is introduced here in order to match the containerized trade value for its own route to the container volume between countries i and j—both routes ij and ji.[69] The loading factor enters into the goods price (equation (7)) as well as the profit function of the transport firms (equation (11)):

$$\begin{aligned} p_{ij} &= w_j \tau_{ij} + T_{ij}/l_{ij} \\ \pi_{i,j} &= T_{ij} l_{ij} Q_{ij} + T_{ji} l_{ji} Q_{ji} - c_{\overleftrightarrow{ij}} \max\{l_{ij}Q_{ij}, l_{ji}Q_{ji}\} \end{aligned}$$

where Q_{ij} is the number of containers on route ij. The equilibrium container volume between countries i and j are the same: $Q^*_{ij} = Q^*_{ji}$.

The equilibrium freight rates and containerized trade value, with the addition of loading factor l, are as follows:

$$\begin{aligned} T^*_{ij} &= \frac{l_{ji}}{Y_{ij}+1} w_j \tau_{ji} + \frac{c_{\overleftrightarrow{ij}}}{1+Y_{ij}} - \frac{1}{l_{ij}} \frac{1}{1+Y_{ji}^{-1}} w_i \tau_{ij} \\ X^*_{ij} = p_{ij} Q_{ij} &= \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\right]^{-\sigma} \left[\frac{1}{1+Y_{ij}}\left(w_i\tau_{ij} + \frac{l_{ji}}{l_{ij}}\left(w_j \tau_{ji} + c_{\overleftrightarrow{ij}}\right)\right)\right]^{1-\sigma} \\ \text{where } Y_{ij} &= \frac{a_{ji}}{a_{ij}}\left(\frac{l_{ji}}{l_{ij}}\right)^{1+1/\sigma} \end{aligned} \tag{23}$$

Since my model is just identified, I am able to match exactly the observed freight rates

[67] My containerized weight elasticities are in line with volume elasticities found using air, truck, and rail (Clark et al. (2005); Oum, Waters and Yong (1992)). My quality elasticities are similar to Hummels and Skiba (2004).

[68] That being said, there are a few reasons that this estimate could be large. First, there could be potential substitution across US ports (LA/LB, NY, and Houston). If the freight rates out of the Houston port increases, an exporter could choose to export out of the New York port. Typically these elasticities are estimated at the country level and these types of substitution would not apply. Second, there could be potential substitution across months. My data is at the monthly or bimonthly level. If the freight rates for one month increases, an importer could wait until the next month to import their goods. The literature typically estimates these elasticities at the annual level which makes these types of substitution less applicable.

[69] Since my model assumes that the equilibrium quantity of container volume is the same between countries, both these parameters will adjust in order to achieve this.

and trade value data. Using my estimated parameters, my out of sample fit for 2015 data is a correlation of 0.6 for trade value and 0.7 for freight rates (figure A.7 in the Appendix).

7.1 Increase in US import tariffs

Table 24 shows that trade predictions from an increase in US import tariffs on its trading partners to 5 percent (the average US import tariff is 1.6 percent).[70] The first two rows, labeled as "Round Trip", show predicted percent changes in import and export freight rates, trade quantity, and trade value for the endogenous transport cost and round trip effect model. The second two rows, labeled as "Exogenous", show the predicted changes for a model with exogenous transport cost.

As expected from Proposition 1 in the theory section, the round trip model predicts that US import freight rates will fall to mitigate the tariff increase. Even though import freight rates are now smaller, US import value and quantity still decreases as shown in Lemma 1. Furthermore, Proposition 1 predicts that the round trip effect generates spillovers from this tariff increase onto US exports and it is seen here. US export freight rates increase while US export value and quantity decrease.

The last two rows of table 24 shows the trade predictions from the same import tariff increase if transport costs were exogenous. As shown in Lemma 1, this model predicts no changes in import freight rates since they are exogenous while US import value and quantity falls due to to the tariff increase. This model also predicts no change on export freight rate and trade. Comparing the two models, the two obvious observations are that (1) the exogenous transport cost model predicts no changes in freight rates when US import tariffs increase while the round trip model does and (2) the exogenous transport cost model predicts no changes in export trade value and quantity while the round trip model does. Furthermore, the exogenous model over-predicts the fall in import trade value and quantity relative to the round trip model. The exogenous model over-predicts the average import value increase by 37 percent. Overall, the exogenous model under-predicts the average import and export changes by 35 percent. These estimates are robust.[71]

These differences in trade predictions have important policy implications. If a country chooses to pursue protectionist policies by increasing their import tariffs in order to protect

[70] This average tariff rate is low because it is trade-weighted and only includes manufactures as well as OECD countries. The simple average effectively applied US tariff rates for all products and across all partner countries in 2014 is 2.96 percent (WITS).

[71] Specifically, these estimates are robust to using a price elasticity of 5 which is the elasticity suggested by Head and Mayer (2014).

their local industries, a trade model with exogenous transport cost will predict a fall in their imports with no other effects. This will increase average US trade balance with all its partners. However, a trade model with endogenous transport cost and the round trip effect will paint a very different picture: while its imports falls so will its exports. The average US trade balance here will decrease by 11 percent instead.

8 Conclusion

This paper provides a microfoundation for transport costs by incorporating one of its key institutional features, the round trip effect. This paper is the first, to my knowledge, to study both the theoretical and empirical implications of the round trip effect for trade outcomes.

I first incorporate a transportation sector with the round trip effect into an Armington trade model. I show that the round trip effect mitigates shocks on a country's trade with its partner and generates spillovers onto its opposite direction trade. This translates a country's import tariffs into a potential tax on its exports with the same partner. This is a novel prediction and has important policy implications.

Using a novel high frequency bilateral data set on container freight rates, I present descriptive evidence on the round trip effect and its implications for distance and trade between countries. Due to limited availability of port-level freight rates data, this is the first paper to highlight the round trip effect. I provide suggestive empirical evidence for two main predictions from my theory model: (1) that freight rates negatively correlated within port pairs, and (2) a country's imports from its partner is positively correlated with its export transport cost to the same partner. The same apply for a country's exports and its import transport cost. Both these correlations indicate the presence of the round trip effect.

I develop an identification strategy utilizing the round trip effect to estimate the containerized trade elasticity with respect to freight rates. I find that a one percent increase in average freight rates will decrease average containerized trade value by 2.8 percent, decrease average containerized trade weight by 3.6 percent, and increase average containerized trade quality by 0.8 percent. While my transport mode-specific trade value elasticity is novel to the literature, my weight and quality elasticities are within the ballpark of the findings in the transportation and trade literature.

In order to estimate the magnitude of the potential export tax from protectionist policies like import tariffs, I estimate my trade and transportation model using my trade elasticity and simulate a counterfactual where the US increases its import tariffs on all of its partners.

I show that this tariff increase will not just decrease US imports but also US exports to these partners. A trade model with exogenous transport costs would over-predict the import decrease by 37 percent but not predict the export decrease at all. Overall, the exogenous model would under-predict the total trade changes by 35 percent.

Future work includes using the entire set of port-level freight rates in my data. This means that I have to determine the set of products that are typically transported in containers. I plan on using the US containerized trade data as a guide in order to identify these products.

I also plan on relaxing the perfect competition assumption in the future to study the effects of market power in transportation in the presence of the round trip effect. Concentration in the containership industry has increase over the years through capacity-sharing alliances. However, since there are economies of scale to transportation, these alliances have potential efficiency gains from increased capacity utilization on each ship. Given these factors, I intend to examine if containership companies should be allowed to form further alliances.

Additionally, I plan to study the hub and spoke shipping network. The trend towards massive containerships has led to the development of hub and spoke shipping networks as well as major transshipment hubs like Singapore and Hong Kong. This has potentially interesting spillover benefits for the transshipment hub countries.

9 Tables

Table 1: Summary statistics of matched data set of container freight rates, and trade per month

	US Exports	US Imports	Full Sample
Freight Rate ($)	1399	2285	1842
	(689)	(758)	(849)
Value ($ bn)	.117	.422	.27
	(.21)	(1.8)	(1.3)
Weight (kg bn)	.0521	.0811	.0666
	(.13)	(.33)	(.25)
Value per Wt.	4.01	4.27	4.14
	(2.6)	(4.5)	(3.6)
Observations	2842	2842	5684

Standard deviation in parentheses.
Since the panel is balanced, the average ocean distance for both US exports and imports is the same, 8061 n.m.
Sources: Drewry, USA Trade Online, sea-distances.org (Monthly 2011-June 2016).

Table 2: Summary Statistics of aggregate data set matched with container volumes per year

	US Exports	US Imports	Full Sample
Containers (TEU)	387,345	725,741	556,543
	(583,175)	(1,918,346)	(1,424,442)
Value per TEU	25,138	41,280	33,209
	(10,273)	(19,368)	(17,453)
Weight per TEU	8,956	10,549	9,753
	(1,665)	(7,507)	(5,483)
Iceberg Cost	.062	.091	.076
	(.03)	(.15)	(.11)
Observations	103	103	206

Standard deviation in parentheses.
There are several levels of aggregation: (1) port-level aggregated up to country-level and (2) monthly aggregated up to yearly.
Iceberg cost is the ratio of freight rates to value per container ($\frac{\text{Freight Rates}}{\text{Value per TEU}}$).
Sources: Drewry, USA Trade Online, and MARAD (Yearly 2011-2015).

Table 3: Regression of container freight rate within port-pairs

	(1) ln Freight Rates	(2) ln Freight Rates
ln Opposite Dir FR	-0.205*	-0.814***
	(0.0778)	(0.0202)
ln Distance	0.587***	
	(0.0718)	
Observations	4033	4033
Route FE		Y
Time FE	Y	Y
R^2	0.235	0.818
F	34.52	1620.6

Route-level clustered standard errors (SE) in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(1) has distance and time controls while (2) has route and time controls.

Sources: Drewry and sea-distances.org (Monthly 2006-Jun 2016)

Table 4: Regression of containerized trade on freight rates

	(1) ln Value	(2) ln Weight	(3) ln Value/Wgt
ln Freight Rate	-0.701**	-1.086***	0.385***
	(0.241)	(0.207)	(0.0729)
Observations	5684	5684	5684
R^2	0.740	0.749	0.393
F	8.449	27.46	27.95

Robust standard errors clustered by route in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Time and dyad level fixed effects were included.
Source: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 5: Regression of containerized trade on return freight rates

	(1) ln Value	(2) ln Weight	(3) ln Value/Wgt
ln Return FR	0.723**	1.076***	-0.353***
	(0.238)	(0.204)	(0.0736)
Observations	5658	5658	5658
R^2	0.741	0.749	0.386
F	9.196	27.85	23.03

Robust standard errors clustered by route in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Time and dyad level fixed effects were included.
Source: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 6: Regression of containerized trade on return freight rates without China

	(1) ln Value	(2) ln Weight	(3) ln Value/Wgt
ln Return FR	1.028***	1.283***	-0.255***
	(0.233)	(0.208)	(0.0740)
Observations	5268	5268	5268
R^2	0.711	0.701	0.373
F	19.54	38.03	11.86

China is excluded from this sample.
Robust standard errors clustered by route in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Time and dyad level fixed effects were included.
Source: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 7: Containerized Trade Value Demand Estimates for OECD Countries

	ln Trade Value			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	-0.676***	-0.520***	-3.651***	-2.795**
	(0.148)	(0.133)	(0.949)	(0.903)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	116887	116887	116887	116887
First Stage F			12.38	10.70

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value is aggregated to the HS2 level. Table 18 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries. Second stage is run on OECD countries only as well.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 8: Containerized Trade Weight Demand Estimates for OECD Countries

	ln Trade Weight			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	-1.061***	-0.837***	-4.790***	-3.631***
	(0.196)	(0.177)	(1.126)	(0.969)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	116887	116887	116887	116887
First Stage F			12.38	10.70

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade weight is aggregated to the HS2 level. Table 19 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries. Second stage is run on OECD countries only as well.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 9: Containerized Trade Quality Demand Estimates for OECD Countries

	ln Trade Value per Weight			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	0.384***	0.317***	1.138***	0.836***
	(0.0695)	(0.0681)	(0.224)	(0.226)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	116887	116887	116887	116887
First Stage F			12.38	10.70

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table 20 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries. Second stage is run on OECD countries only as well.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 10: Containerized Trade Value Demand Estimates for all Countries

	ln Trade Value			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	-0.532***	-0.460***	-3.873**	-2.884**
	(0.0969)	(0.110)	(1.232)	(0.956)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	261249	261249	261249	261249
First Stage F			8.433	7.750

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value is aggregated to the HS2 level. Table 21 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries. Second stage is run on all countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 11: Containerized Trade Weight Demand Estimates for all Countries

	ln Trade Weight			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	-0.716***	-0.633***	-5.222**	-4.072**
	(0.118)	(0.133)	(1.613)	(1.256)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	261249	261249	261249	261249
First Stage F			8.433	7.750

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to the use of heteroskedasticity- and autocorrelation-consistent standard errors as well as clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade weight is aggregated to the HS2 level. Table 22 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries. Second stage is run on all countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 12: Containerized Trade Quality Demand Estimates for all Countries

	ln Trade Value per Weight			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	0.184***	0.173***	1.349**	1.188**
	(0.0365)	(0.0377)	(0.427)	(0.382)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	261249	261249	261249	261249
First Stage F			8.433	7.750

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table 23 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries. Second stage is run on all countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 13: Containerized Trade Value Demand Estimates for all Countries without fragmented products

	ln Trade Value			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	-0.533***	-0.467***	-5.979*	-4.346*
	(0.0980)	(0.111)	(2.695)	(2.023)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	258532	258532	258532	258532

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Products that are typically fragmented (as identified in Fort (2016)) are removed from sample.
All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table A.3 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 14: Containerized Trade Weight Demand Estimates for all Countries without fragmented products

	ln Trade Weight			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	-0.724***	-0.643***	-7.769*	-5.978*
	(0.118)	(0.133)	(3.452)	(2.689)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	258532	258532	258532	258532

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Products that are typically fragmented (as identified in Fort (2016)) are removed from sample.
All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table A.4 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 15: Containerized Trade Quality Demand Estimates for all Countries without fragmented products

	ln Trade Value per Weight			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	0.191***	0.176***	1.790*	1.631*
	(0.0358)	(0.0375)	(0.808)	(0.766)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	258532	258532	258532	258532

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Products that are typically fragmented (as identified in Fort (2016)) are removed from sample.
All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table A.5 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 16: Containerized Trade Value Demand Estimates using Aggregate Data for OECD Countries

	(1) ln Trade Value	(2) ln Trade Value	(3) ln Freight Rate
ln Freight Rate	-0.132	-4.137**	
	(0.307)	(1.506)	
ln Opp Dir Predicted Trade Value			0.0391**
			(0.0138)
Ex-Time & Im-Time FE	Y	Y	Y
Dyad FE	Y	Y	Y
Regression	OLS	IV	First-Stage
Observations	2307	2307	2307
R^2	0.953	0.906	0.964
F	0.187	7.542	7.969

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the dyad level (two-way route). All variables are in logs. Trade value is aggregated to route level.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries. Second stage is run on OECD countries only as well.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 17: Containerized Trade Weight Demand Estimates using Aggregate Data for OECD Countries

	(1) ln Trade Weight	(2) ln Trade Weight	(3) ln Freight Rate
ln Freight Rate	-0.415	-6.319**	
	(0.464)	(2.205)	
ln Opp Dir Predicted Trade Value			0.0391**
			(0.0138)
Ex-Time & Im-Time FE	Y	Y	Y
Dyad FE	Y	Y	Y
Regression	OLS	IV	First-Stage
Observations	2307	2307	2307
R^2	0.903	0.800	0.964
F	0.801	8.209	7.969

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the dyad level (two-way route). All variables are in logs. Trade weight is aggregated to route level.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries. Second stage is run on OECD countries only as well.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 18: First-Stage Regressions of Containerized Trade Value Demand Estimates for OECD countries (table 7)

	(1) ln Freight Rate	(2) ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0406**	0.0370**
	(0.0115)	(0.0113)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	116887	116887
R^2	0.970	0.972
F	12.38	10.70

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value is aggregated to the HS2 level. Table 7 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 19: First-Stage Regressions of Containerized Trade Weight Demand Estimates for OECD countries (table 8)

	(1) ln Freight Rate	(2) ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0406**	0.0370**
	(0.0115)	(0.0113)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	116887	116887
R^2	0.970	0.972
F	12.38	10.70

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade weight is aggregated to the HS2 level. Table 8 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 20: First-Stage Regressions of Containerized Trade Quality Demand Estimates for OECD countries (table 9)

	(1) ln Freight Rate	(2) ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0406**	0.0370**
	(0.0115)	(0.0113)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	116887	116887
R^2	0.970	0.972
F	12.38	10.70

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table 9 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 21: First-Stage Regressions of Containerized Trade Value Demand Estimates for all countries (table 10)

	(1) ln Freight Rate	(2) ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0227**	0.0227**
	(0.00781)	(0.00817)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	261249	261249
R^2	0.973	0.975
F	8.433	7.750

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value is aggregated to the HS2 level. Table 10 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 22: First-Stage Regressions of Containerized Trade Weight Demand Estimates for all countries (table 11)

	(1)	(2)
	ln Freight Rate	ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0227**	0.0227**
	(0.00781)	(0.00817)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	261249	261249
R^2	0.973	0.975
F	8.433	7.750

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade weight is aggregated to the HS2 level. Table 11 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 23: First-Stage Regressions of Containerized Trade Quality Demand Estimates for all countries (table 12)

	(1)	(2)
	ln Freight Rate	ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0227**	0.0227**
	(0.00781)	(0.00817)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	261249	261249
R^2	0.973	0.975
F	8.433	7.750

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table 12 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table 24: Trade Predictions from an Increase in US Import Tariff to 5 percent on All Trading Partners

		Freight Rate	Trade Quantity	Trade Value
Round Trip	Import	-0.6%	-14.6%	-12.4%
	Export	+0.7%	-16.5%	-15.0%
Exogenous	Import	0	-23.0%	-19.7%
	Export	0	0	0

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A Appendix

A.1 Data Appendix

A.1.1 Container freight rates

These monthly or bimonthly Drewry spot market rates are for a full container sized at either 20 or 40 feet. In this study I focus only on 20 feet containers. These containers are for dry freight, which means that they do not need to be refrigerated. Breakdowns are also available for some of these freight rates. They include the base ocean rate, the terminal handling charge at the origin and destination ports, and the bunker fuel surcharge.

The container freight rates, published by Drewry Maritime Research, as well as the containerized trade value, published by USA Trade Online, were converted into real terms using the seasonally adjusted Consumer Price Index for all urban consumers published by the Bureau of Labor Statistics (series ID CPIAUCSL).

The port pairs in my Drewry data set are between the three US ports (New York, Houston, Los Angeles and Long Beach) and the following ports: Australia (Melbourne), Brazil (Santos), Central China (Shanghai), Hong Kong, India (Nhava Sheva), Japan (Yokohama), Korea (Busan), Malaysia (Tanjung Pelepas), New Zealand (Auckland), North China (Tianjin), North Continent Europe (Rotterdam), Philippines (Manila), Russia (St Petersburg), Singapore, South Africa (Durban), South China (Yantian), Taiwan (Kaohsiung), Thailand (Laem Chabang), Turkey (Istanbul), U.A.E (Jebel Ali), UK (Felixstowe), Vietnam (Ho Chi Minh), and West Med (Genoa)

Since the freight rate data is at the port level while the containerized trade data is at the US-port and foreign country level, I have some non-US port pairs in the same country that are redundant. In these cases, I chose the freight rates from the port with the longest time series. One example is US and China freight rates. Drewry collects data on the freight rates between the port of New York and South China (Yantian), Central China (Shanghai), and North China (Tianjin). However, I only observe the containerized trade between the port of New York and China from USA Trade Online. In such cases, I choose the freight rate with the longest time series–in this case South China (Yantian).

According to Drewry, their freight rate data set can be applied to adjacent container ports as well. I have not done this. An example is the port of Rotterdam. Since this port is in the Netherlands, I have matched the freight rates to and from this port to the US containerized trade data with Netherlands. However, this port represents the Drewry's "Hamburg-Le Havre range" which includes Antwerp (Belgium), Rotterdam, Le Havre (France), Hamburg

(Germany), Zeebrugge (Belgium), and Bremerhaven (Germany). As such, I could have also matched these freight rates to US trade with Belgium, France, and Germany. Another example is the port of Genoa is Drewry's benchmark for the (Western) Mediterranean region which includes Valencia and Barcelona (Spain). I could have also matched the Genoa freight rates to US trade with Italy as well as Spain. I choose to restrict my data set initially and match the freight rates literally to the country where their ports are in.

While it is acknowledged here that long-term contracts are used in the container market, my choice to use spot container freight rates instead is due to the fact that long-term container contracts are confidentially filed with the Federal Maritime Commission (FMC) and protected against the Freedom of Information Act (FOIA).[72] Moreover, some industry experts have explained that shorter-term contracts are increasingly favored due to over-capacity in the market.[73] Longer term contracts are also increasingly indexed to spot market rates due to price fluctuations.[74] Furthermore, most firms split their cargo between long-term contracts and the spot market to smooth volatility and take advantage of spot prices. There are freight forwarders, forwarding companies like UPS or FedEx, who offer hybird models that allow for their customers to switch to spot rate pricing when spot rates fall below their agreed-upon contract rates.[75] As such, I conclude that spot prices play a big role in informing long-term contracts and can shed light on the container transport market.

A.1.2 Container volume data

Container volume data from MARAD may include loaded and empty containers which have an associated freight charge. Since transport firms do not charge to re-position their own containers, these are newly manufactured containers bought by other firms. In order to remove empty containers from this data set, I utilize the product-level containerized trade data from USA Trade Online. The HS6 product code for containers are 860900. Since I observe the trade weight of these containers, I can calculate the number of newly manufactured containers by assuming an empty TEU container weight of 2300kg. I then subtract these new

[72] I filed a FOIA request with the FMC on April 2015 for long-term container contracts. It was rejected on June 2015. According to the rejection, the information I seek is prohibited from disclosure by the Shipping Act, 46 U.S.C. §40502(b)(1). This information is being withheld in full pursuant to Exemption 3, 5 U.S.C. §552(b)(3) of the FOIA which allows the withholding of information prohibited from disclosure by another federal statute.

[73] Conversation with Roy J. Pearson, Director, Office of Economics & Competition Analysis at the Federal Maritime Commission, January 2015.

[74] Container Rate Indexes Run in Contracts, But Crawl in Futures Trading, Journal of Commerce, January 2014

[75] Container lines suffer brutal trans-Pacific contract season, Journal of Commerce, June 2016.

containers from the MARAD container volume data.

A.1.3 Container freight rates and distance

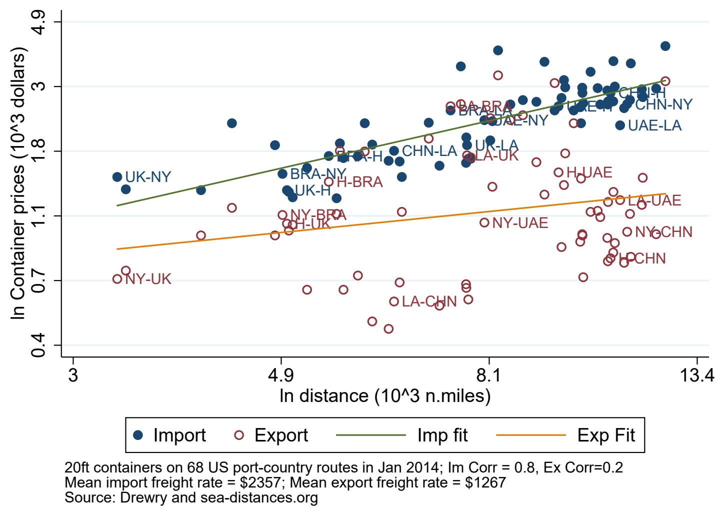
Freight rates are not well-approximated by distance. As a first pass, I plot both US container import and export freight rates against distance for January 2014 (figure A.1).[76] These freight rates are observed twice for each distance since one is the cost to import a container to the US while the other is the cost to export a container from the US. One example is the United Kingdom and New York pair, labeled as UK and NY and to the left of figure A.1. The freight rate from the UK to NY (the solid dot, "UK-NY") is higher than the return freight rate from NY to UK (the hollow dot, "NY-UK"). The first observation is that the US export freight rates are almost two times lower than the US import freight rates. The average export freight rates are \$1267 while the import freight rates are \$2357. The second observation is that the correlation between the US export freight rates with distance is four times lower than the correlation between import freight rates with distance (0.2 for exports compared to 0.8 for imports). While both sets of freight rates are increasing with distance–the correlations are positive–the use of one set of freight rates over the other will predict an entirely different coefficient of freight rates on distance.

Using the matched freight rates and trade data set, I define the headhaul route of a dyad as the route with higher freight rates and the route with lower freight rates as the backhaul route. I then regress these freight rates on distance and distance in quartiles and show that there are significant differences in the correlation of these freight rates and distance. First, I divide the data set into headhaul and backhaul directions. In table A.1, I regress freight rates on distance in the headhaul sample (column (1)) and the backhaul sample (column (2)). In column (1), a one percent increase in distance is significantly correlated with a 0.76 percent increase in headhaul freight rates. In column (2), a one percent increase in distance is significantly correlated with a 0.4 percent increase in backhaul freight rates. The coefficient for headhaul freight rates is almost two times larger than the backhaul freight rates and I can reject the hypothesis that these coefficients are equal at the one percent level ($\chi^2 = 316$).

I then bin the distance variable into quartiles in columns (3) and (4). In column (3), the

[76] I use the ocean distance between ports. The website sea-distances.org measures the distance between sea ports in nautical miles–distances at sea. It is a more accurate measure of the actual distance a containership would have to travel than just a straight line between ports. One example is the trip from Shanghai to New York. The calculated distance between these two ports in Google Maps is 6399 nautical miles (11851 km) while sea-distances.org shows that a containership would have to travel almost twice that–10582 nautical miles–since the ship would have to journey down south and up north again in order to pass through the Panama Canal.

Figure A.1: Correlation between freight rates and distance by US import and export direction



headhaul freight rates are monotonically increase with distance.[77] In column (4), however, the relationship is not so clear. The backhaul freight rates have a negative, albeit insignificantly different from zero, coefficient of 0.03 with respect to the second quartile distance (ocean distance average of 7098 n.m.). Furthermore, the backhaul freight rate coefficient of 0.09 with respect to the fourth quartile distance (ocean distance average of 11092 n.m.) is smaller than the coefficient of 0.48 with respect to the third quartile (average of 9384 n.m.), but is also insignificantly different from zero.[78] Comparing across columns (3) and (4), each of the corresponding headhaul and backhaul coefficients are statistically different at the one percent level for the second and fourth quartiles.[79] Similarly with figure A.1, while both sets of freight rates are generally increasing with distance, they predict different correlation coefficients.[80] I conclude from the evidence presented here that, the use of distance does not

[77] The headhaul freight rate coefficient with respect to the second quartile distance is significantly different from the coefficient with respect to the third quartile distance (F=16) and fourth quartile distance (F=23). However, I cannot reject the hypothesis that the coefficient of headhaul freight rates with respect to the third and fourth quartile distances are equal (F=0.4).

[78] The backhaul freight rate coefficient with respect to the second quartile distance is not significantly different from the coefficient with respect to the third quartile distance (F=6) and from the fourth quartile distance (F=0). The coefficient of backhaul freight rates with respect to the third and fourth quartile distances are statistically different (F=11).

[79] $\chi^2 = 24$ for the second quartile distance and $\chi^2 = 418$ for the fourth quartile distance. The third quartile distance is not statistically different $\chi^2 = 1$.

[80] Similar conclusions can be drawn when the data set is split into US imports and exports. See table A.2

approximate freight rates well. Asturias and Petty (2013) also finds that container freight rates and distance are not strongly correlated.[81]

A.1.4 Containerized trade data

Containerized trade data is from USA Trade Online. The containerized import value data excludes US import duties, freight, insurance and other charges incurred in bringing the merchandise to the US. The containerized exports value data are valued on a free alongside ship (FAS) basis, which includes inland freight, insurance and other charges incurred in placing the merchandise alongside the ship at the port of export. The containerized shipping weight data represents the gross weight in kilograms of shipments, including the weight of moisture content, wrappings, crates, boxes, and containers.

A.2 Theory Appendix

Proof of Lemma 1 This lemma can be proven via direct calculation. In the exogenous transport cost model, the derivative of j's import price from i with respect to its import tariff on i is positive (equation (8)): $\frac{\partial p_{ij}^{Exo}}{\partial \tau_{ij}} = w_i > 0$. From equation (9), the derivative of j's import quantity from i with respect to its import tariff on i is negative: $\frac{\partial q_{ij}^{Exo}}{\partial \tau_{ij}} = -\sigma w_i \left(w_i \tau_{ij} + T_{ij}\right)^{-\sigma-1} \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\right]^{-\sigma} < 0$. From equation (10), the derivative of j's import quantity from i with respect to its import tariff on i is also negative: $\frac{\partial X_{ij}^{Exo}}{\partial \tau_{ij}} = -\left(\sigma-1\right) w_i \left(w_i \tau_{ij} + T_{ij}\right)^{-\sigma} \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\right]^{-\sigma} < 0$.

In the endogenous transport cost model with the round trip effect, an increase in j's import tariff on i decreases j's import transport cost from i. The derivative of the transport cost from i to j with respect to j's import tariff on i is negative (equation (15)): $\frac{\partial T_{ij}^{R}}{\partial \tau_{ij}} = -\frac{1}{1+A_{ij}} w_i < 0$.

The increase in j's import tariff on i will also decrease the price of j's imports from i through its import transport cost decrease. The derivative of the price of country i's good in country j with respect to j's import tariff on i is positive (equation (16)) and the same magnitude as the the derivative of the transport cost from i to j with respect to j's import tariff on i: $\frac{\partial p_{ij}^{R}}{\partial \tau_{ij}} = \frac{1}{1+A_{ij}} w_i > 0$.

Country j's equilibrium import quantity from i will decrease with the increase of j's import tariff on i, as does its equilibrium trade value from i. From equation (17), the derivative of the trade quantity from i to j with respect to j's import tariff on i is negative: $\frac{\partial q_{ij}^{R}}{\partial \tau_{ij}} = -\sigma w_i \left(\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\left(\frac{1}{1+A_{ij}}\right)\right)^{-\sigma} \left(w_j \tau_{ji} + w_i \tau_{ij} + c_{ij}\right)^{-\sigma-1} < 0$. From equation (17), the

in the Data Appendix.

[81] Using one-way container freight rates, they find a correlation of -0.08 between freight rates and distance.

derivative of the trade value from i to j with respect to j's import tariff on i is negative: $\frac{\partial X_{ij}^R}{\partial \tau_{ij}} = -(\sigma-1)\, w_i \left(\frac{1}{1+A_{ij}}\right)^{1-\sigma} \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ij}}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{ij}\right)\right]^{-\sigma} < 0$.

Due to the round trip effect, an increase in j's import tariff on i also affects j's exports to i. First, j's export transport cost to i increases in order to compensate for the fall in inbound transport demand from i to j. The derivative of the transport cost from j to i with respect to j's import tariff on i is positive (footnote 26): $\frac{\partial T_{ji}^R}{\partial \tau_{ij}} = \frac{1}{1+A_{ij}^{-1}} w_i > 0$. Unlike the comparative statics involving j's preference of i's goods, the amount of decrease in j's import transport cost from i is no longer the same as the amount of increase in j's export transport cost to i.

The increase in j's import tariff on i also increases j's export price to i. The derivative of j's export price to i with respect to j's import tariff on i is positive (footnote 27): $\frac{\partial p_{ji}^R}{\partial \tau_{ij}} = \frac{1}{1+A_{ij}^{-1}} w_i > 0$. This export price increase is the same amount as j's import transport cost increase.

Lastly, the increase in j's import tariff on i decreases j's export quantity and value to i. The derivative of j's export quantity to i with respect to j's import tariff on i is negative (footnote 27): $\frac{\partial q_{ji}^R}{\partial \tau_{ij}} = -\sigma w_i \left(\frac{\sigma}{\sigma-1}\frac{1}{a_{ji}}\left(\frac{1}{1+A_{ij}^{-1}}\right)\right)^{-\sigma} \left(w_j\tau_{ji}+w_i\tau_{ij}+c_{ij}\right)^{-\sigma-1} < 0$. The derivative of j's export value to i with respect to j's preference for i's good is negative (footnote 27): $\frac{\partial X_{ji}^R}{\partial \tau_{ij}} = -(\sigma-1)\, w_i \left(\frac{1}{1+A_{ij}^{-1}}\right)^{1-\sigma} \left[\frac{\sigma}{\sigma-1}\frac{1}{a_{ji}}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{ij}\right)\right]^{-\sigma} < 0$.

Proof of Lemma 2 This lemma can be proven via direct calculation. In the exogenous transport cost model, the derivative of j's import quantity from i with respect to j's preference for i's good is positive (equation (9)): $\frac{\partial q_{ij}^{Exo}}{\partial a_{ij}} = \sigma a_{ij}^{\sigma-1}\left[\frac{\sigma}{\sigma-1}\left(w_i\tau_{ij}+T_{ij}\right)\right]^{-\sigma} > 0$. The derivative of j's import value from i with respect to j's preference for i's good is also positive (equation (10)): $\frac{\partial X_{ij}^{Exo}}{\partial a_{ij}} = \sigma a_{ij}^{\sigma-1}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}\left(w_i\tau_{ij}+T_{ij}\right)^{1-\sigma} > 0$. Country j's import price from i does not change with its preference for i's good (equation (8)): $\frac{\partial p_{ij}^{Exo}}{\partial a_{ij}} = 0$.

In the endogenous transport cost and round trip effect model, I first establish that the derivative of the loading factor and preference ratio from i to j with respect to j's preference for i's good is negative, $\frac{\partial A_{ij}}{\partial a_{ij}} = -\frac{1}{a_{ij}} A_{ij} < 0$. The derivative of the loading factor and preference ratio from j to i with respect to j's preference for i's good is positive, $\frac{\partial A_{ji}}{\partial a_{ij}} = \frac{1}{a_{ij}} A_{ij}^{-1} > 0$.

An increase in j's preference for i's good increases j's import transport cost from i. The derivative of the transport cost from i to j with respect to j's preference for i's good is positive (equation (15)): $\frac{\partial T_{ij}^R}{\partial a_{ij}} = \frac{1}{a_{ij}}\frac{1}{1+A_{ij}}\frac{1}{1+A_{ij}^{-1}}\left[w_i\tau_{ij}+w_j\tau_{ji}+c_{ij}\right] > 0$.

The increase in j's preference for i's good will also increase the price of j's imports from

i through the increase in j's import transport cost from i. The derivative of the price of country i's good in country j with respect to j's preference for i's good is positive (equation (16)) and the same as the the derivative of the transport cost from i to j with respect to j's preference for i's good: $\frac{\partial p_{ij}^R}{\partial a_{ij}} = \frac{1}{a_{ij}} \frac{1}{1+A_{ij}} \frac{1}{1+A_{ij}^{-1}} \left[w_i \tau_{ij} + w_j \tau_{ji} + c_{ij}\right] > 0$.

Even though the increase in j's preference for i raises the price of its imports from i, j's equilibrium import quantity from i still increases as does its equilibrium trade value from i. From equation (17), the derivative of the trade quantity from i to j with respect to j's preference for i's good is positive: $\frac{\partial q_{ij}^R}{\partial a_{ij}} = \sigma \left(\frac{1}{a_{ij}}\right)^{1-\sigma} \left(\frac{1}{1+A_{ij}}\right)^{1-\sigma} \left[\frac{\sigma}{\sigma-1} \left(w_j \tau_{ji} + w_i \tau_{ij} + c_{ij}\right)\right]^{-\sigma} > 0$. From equation (17), the derivative of the trade value from i to j with respect to j's preference for i's good is positive: $\frac{\partial X_{ij}^R}{\partial a_{ij}} = \left(\sigma + A_{ij}\right) \left(\frac{1}{a_{ij}}\right)^{1-\sigma} \left(\frac{1}{1+A_{ij}}\right)^{2-\sigma} \left[\frac{\sigma}{\sigma-1}\right]^{-\sigma} \left(w_j \tau_{ji} + w_i \tau_{ij} + c_{ij}\right)^{1-\sigma} > 0$.

Due to the round trip effect, an increase in j's preference of i's good also affects j's exports to i. First, j's export transport cost to i decreases in order to compensate for the increase in inbound transport demand from i to j. The derivative of the transport cost from j to i with respect to j's preference for i's good is negative (footnote 26): $\frac{\partial T_{ji}^R}{\partial a_{ij}} = -\frac{1}{a_{ij}} \frac{1}{1+A_{ij}} \frac{1}{1+A_{ij}^{-1}} \left[w_i \tau_{ij} + w_j \tau_{ji} + c_{ij}\right] < 0$. The amount of increase in j's import transport cost from i is the same as the amount of decrease in j's export transport cost to i.

The increase in j's preference of i's good also decreases j's export price to i. The derivative of j's export price to i with respect to j's preference for i's good is negative (footnote 27): $\frac{\partial p_{ji}^R}{\partial a_{ij}} = -\frac{1}{a_{ij}} \frac{1}{1+A_{ij}} \frac{1}{1+A_{ij}^{-1}} \left[w_i \tau_{ij} + w_j \tau_{ji} + c_{ij}\right] < 0$. This export price decrease is the same amount as j's import price increase due to the same amount of j's export and import transport cost changes.

Lastly, the increase in j's preference of i's good increases j's export quantity and value to i. The derivative of j's export quantity to i with respect to j's preference for i's good is positive (footnote 27): $\frac{\partial q_{ji}^R}{\partial a_{ij}} = \sigma \frac{1}{a_{ij}} \frac{1}{1+A_{ij}} \left(\frac{1}{1+A_{ij}^{-1}}\right)^{-\sigma} \left[\frac{\sigma}{\sigma-1} \frac{1}{a_{ji}} \left(w_j \tau_{ji} + w_i \tau_{ij} + c_{ij}\right)\right]^{-\sigma} > 0$. The derivative of j's export value to i with respect to j's preference for i's good is positive (footnote 27): $\frac{\partial X_{ji}^R}{\partial a_{ij}} = \left(\sigma - 1\right) \frac{1}{a_{ij}} \frac{1}{1+A_{ij}} \left(\frac{1}{1+A_{ij}^{-1}}\right)^{1-\sigma} \left[\frac{\sigma}{\sigma-1} \frac{1}{a_{ji}}\right]^{-\sigma} \left(w_j \tau_{ji} + w_i \tau_{ij} + c_{ij}\right)^{1-\sigma} > 0$.

A.3 Additional Tables and Figures

Figure A.2: Positive correlation between container volume gap and freight rate gap between countries

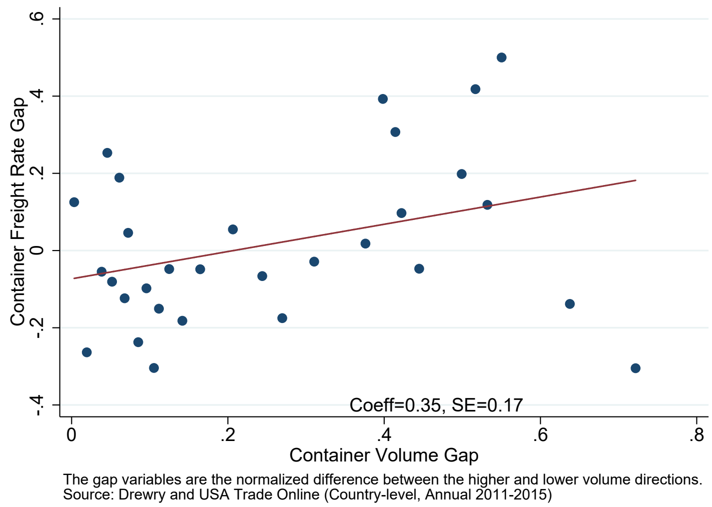
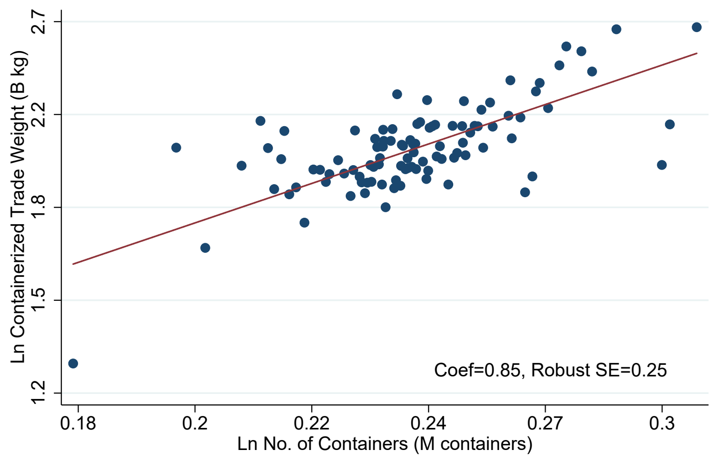


Figure A.3: Containerized trade weight (X_{ijt}) and container volume (Q_{jit}) are positively correlated within routes

$$\ln X_{ijt} = \beta_0 + \beta_1 \ln Q_{jit} + d_{\underset{ij}{\leftrightarrow}} + \gamma_t + \epsilon_{ijt}$$



Robust standard errors clustered by route.
Year and route level controls were included. All variables are in log.
Source: Drewry, USA Trade Online, and MARAD (Annual 2011-2015)

Table A.1: Regression of container freight rates on distance

	(1)	(2)	(3)	(4)
	ln FR	ln FR	ln FR	ln FR
ln Distance	0.655***	0.401**		
	(0.0691)	(0.119)		
ln 2nd Q Dist			0.174*	0.0288
			(0.0840)	(0.187)
ln 3rd Q Dist			0.499***	0.483***
			(0.0686)	(0.117)
ln 4th Q Dist			0.536***	0.0916
			(0.0620)	(0.113)
Observations	2855	2829	2855	2829
Direction	Head	Back	Head	Back
R^2	0.516	0.185	0.520	0.269
F	89.84	11.36	30.67	6.501

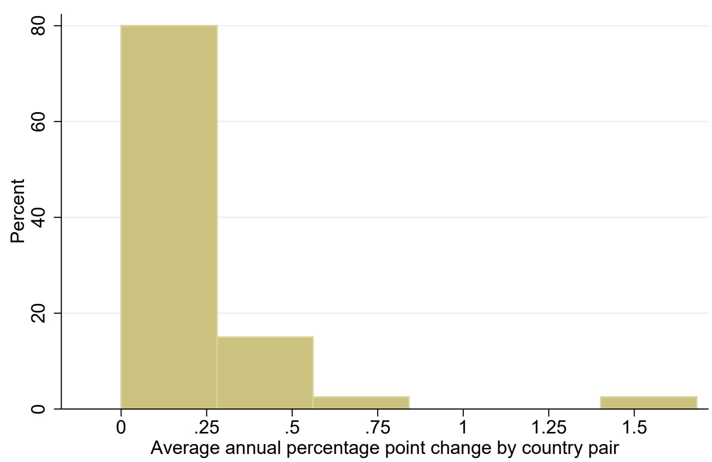
Robust standard errors clustered by dyad in parentheses. All variables are in logs.
scriptsize * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
The headhaul route (Head) of a dyad is the route with higher freight rates than the backhaul direction (Back).
Date fixed effects are included for all the regressions above.
Sources: Drewry and sea-distances.org (Monthly 2006-Jun 2016)

Table A.2: Regression of container freight rates on distance

	(1) Freight R	(2) Freight R	(3) Freight R	(4) Freight R
Distance	0.622	0.380		
	(0.0105)	(0.0146)		
2nd Quartile Dist			0.173	0.102
			(0.0117)	(0.0212)
3rd Quartile Dist			0.480	0.451
			(0.0102)	(0.0159)
4th Quartile Dist			0.531	0.162
			(0.00959)	(0.0143)
Observations	4033	4033	4033	4033
Direction	Im	Ex	Im	Ex
R^2	0.529	0.199	0.544	0.251
F	3543.9	678.4	1267.4	277.4

Robust standard errors in parentheses. All variables are in logs.
Date fixed effects are included for all the regressions above.
Sources: Drewry and sea-distances.org (Monthly 2006-Jun 2016)

Figure A.4: Tariff rates are mostly constant for country pairs during my sample period



Average change is 0.18 percentage points (sd 0.29).
Effectively applied average tariff rates for manufactures (average tariff is 4.2%, sd 3%).
Source: World Integrated Trade Solution (WITS), World Bank (Annual 2011-2016)

Figure A.5: Robustness Check: First stage regression results using 2009 data

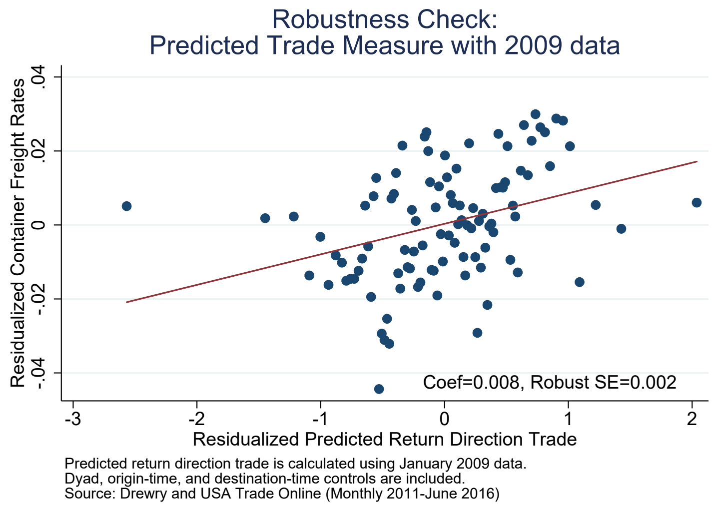


Table A.3: Robustness Check: First-Stage Regressions of Containerized Trade Value Demand Estimates for All Countries without Fragmented Products (table 13)

	(1) ln Freight Rate	(2) ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0144	0.0143
	(0.00740)	(0.00760)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	258532	258532
R^2	0.973	0.975
F	3.801	3.540

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Products that are typically fragmented (as identified in Fort (2016)) are removed from sample.
All variables are in logs. Trade value is aggregated to the HS2 level. Table 13 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table A.4: Robustness Check: First-Stage Regressions of Containerized Trade Weight Demand Estimates for All Countries without Fragmented Products (table 14)

	(1)	(2)
	ln Freight Rate	ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0144	0.0143
	(0.00740)	(0.00760)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	258532	258532
R^2	0.973	0.975
F	3.801	3.540

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Products that are typically fragmented (as identified in Fort (2016)) are removed from sample.
All variables are in logs. Trade weight is aggregated to the HS2 level. Table 14 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table A.5: Robustness Check: First-Stage Regressions of Containerized Trade Quality Demand Estimates for All Countries without Fragmented Products (table 15)

	(1)	(2)
	ln Freight Rate	ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0144	0.0143
	(0.00740)	(0.00760)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	258532	258532
R^2	0.973	0.975
F	3.801	3.540

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Products that are typically fragmented (as identified in Fort (2016)) are removed from sample.
All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table 15 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2003 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table A.6: Robustness Check: Containerized Trade Value Demand Estimates for OECD Countries with 2009 instrument

	ln Trade Value			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	-0.640***	-0.503***	-1.919*	-1.044
	(0.147)	(0.131)	(0.715)	(0.670)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	118030	118030	118030	118030
First Stage F			27.12	26.43

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to the use of heteroskedasticity-consistent standard errors as well as clustering at the route and products, dyad (two-way route), as well as dyad with product levels. All variables are in logs. Trade value is aggregated to the HS2 level. Table A.9 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2009 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects; Prod-Ex-T FE is product, exporter country, and time fixed effects; Prod-Im-T FE is product, importer country, and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Figure A.6: Model fit

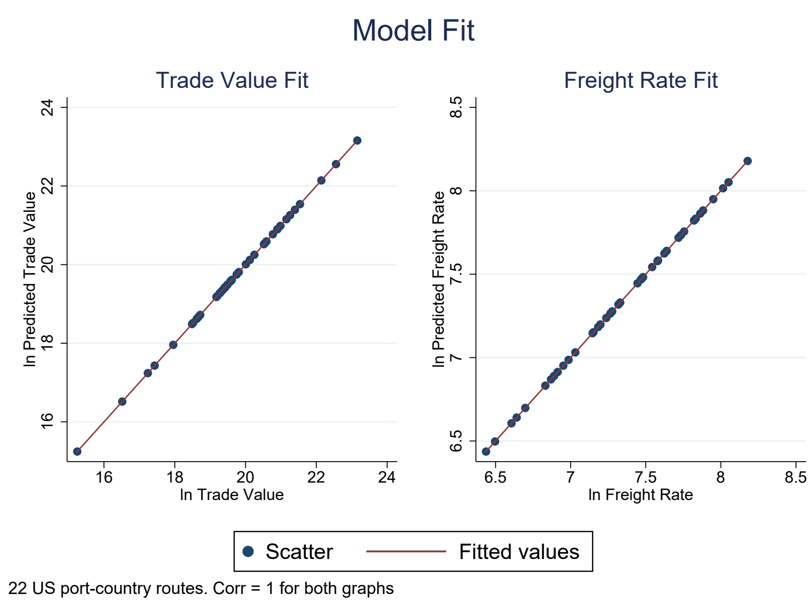


Table A.7: Robustness Check: Containerized Trade Weight Demand Estimates for OECD Countries with 2009 instrument

	ln Trade Weight			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	-1.014***	-0.808***	-2.436**	-1.302
	(0.195)	(0.175)	(0.878)	(0.778)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	118030	118030	118030	118030
First Stage F			27.12	26.43

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to the use of heteroskedasticity-consistent standard errors as well as clustering at the route and products, dyad (two-way route), as well as dyad with products levels. All variables are in logs. Trade weight is aggregated to the HS2 level. Table A.10 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2009 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects; Prod-Ex-T FE is product, exporter country, and time fixed effects; Prod-Im-T FE is product, importer country, and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Figure A.7: Out of Sample Fit

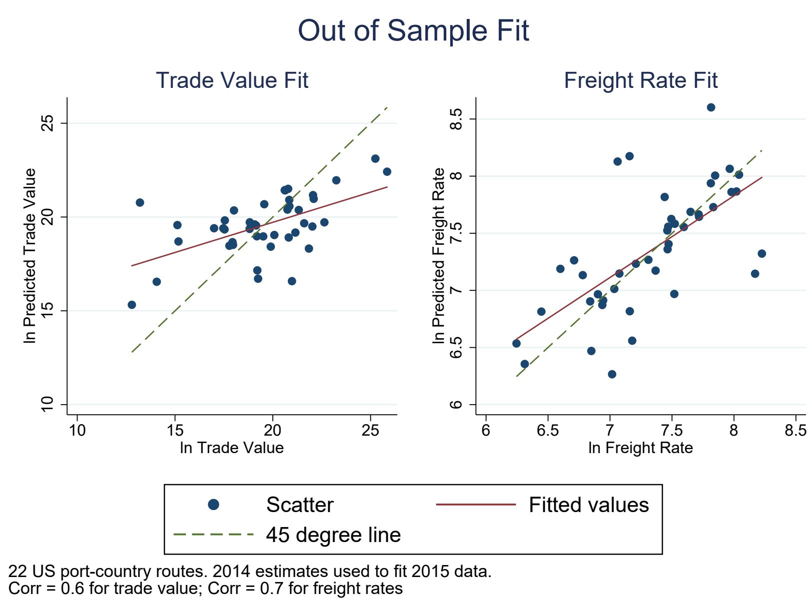


Table A.8: Robustness Check: Containerized Trade Value per Weight Demand Estimates for OECD Countries with 2009 instrument

	ln Trade Value per Weight			
	(1)	(2)	(3)	(4)
	OLS	OLS	IV	IV
ln Freight Rate	0.374***	0.305***	0.518*	0.258
	(0.0688)	(0.0675)	(0.200)	(0.185)
Ex-Time & Im-Time FE	Y	Y	Y	Y
Dyad FE	Y		Y	
Product FE	Y		Y	
Dyad-Product FE		Y		Y
Observations	118030	118030	118030	118030
First Stage F			27.12	26.43

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to the use of heteroskedasticity-consistent standard errors as well as clustering at the route and product, dyad (two-way route), as well as dyad with product level. All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table A.11 presents the first stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2009 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects; Prod-Ex-T FE is product, exporter country, and time fixed effects; Prod-Im-T FE is product, importer country, and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table A.9: Robustness Check: First-Stage Regressions of Containerized Trade Value Demand Estimates for OECD Countries with 2009 instrument (table A.6)

	(1)	(2)
	ln Freight Rate	ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0511***	0.0485***
	(0.00981)	(0.00943)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	118030	118030
R^2	0.971	0.973
F	27.12	26.43

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value is aggregated to the HS2 level. Table A.6 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2009 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects; Prod-Ex-T FE is product, exporter country, and time fixed effects; Prod-Im-T FE is product, importer country, and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table A.10: Robustness Check: First-Stage Regressions of Containerized Trade Weight Demand Estimates for OECD Countries with 2009 instrument (table A.7)

	(1) ln Freight Rate	(2) ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0511***	0.0485***
	(0.00981)	(0.00943)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	118030	118030
R^2	0.971	0.973
F	27.12	26.43

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade weight is aggregated to the HS2 level. Table A.7 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2009 data using only OECD countries.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects; Prod-Ex-T FE is product, exporter country, and time fixed effects; Prod-Im-T FE is product, importer country, and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)

Table A.11: Robustness Check: First-Stage Regressions of Containerized Trade Quality Demand Estimates for OECD Countries with 2009 instrument (table A.8)

	(1)	(2)
	ln Freight Rate	ln Freight Rate
ln Opp Dir Predicted Trade Value	0.0511***	0.0485***
	(0.00981)	(0.00943)
Ex-Time & Im-Time FE	Y	Y
Dyad FE	Y	
Product FE	Y	
Dyad-Product FE		Y
Observations	118030	118030
R^2	0.971	0.973
F	27.12	26.43

Robust standard errors in parentheses are clustered by route.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. All variables are in logs. Trade value per weight is aggregated to the HS2 level. Table A.8 presents the second stage regressions.
The predicted trade instrument is constructed at the HS4 level with Jan 2009 data.
Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects; Prod-Ex-T FE is product, exporter country, and time fixed effects; Prod-Im-T FE is product, importer country, and time fixed effects.
Sources: Drewry and USA Trade Online (Monthly 2011-June 2016)