A. Online Appendix
The Round Trip Effect: Endogenous Transport Costs and International Trade

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A. Tables and Figures

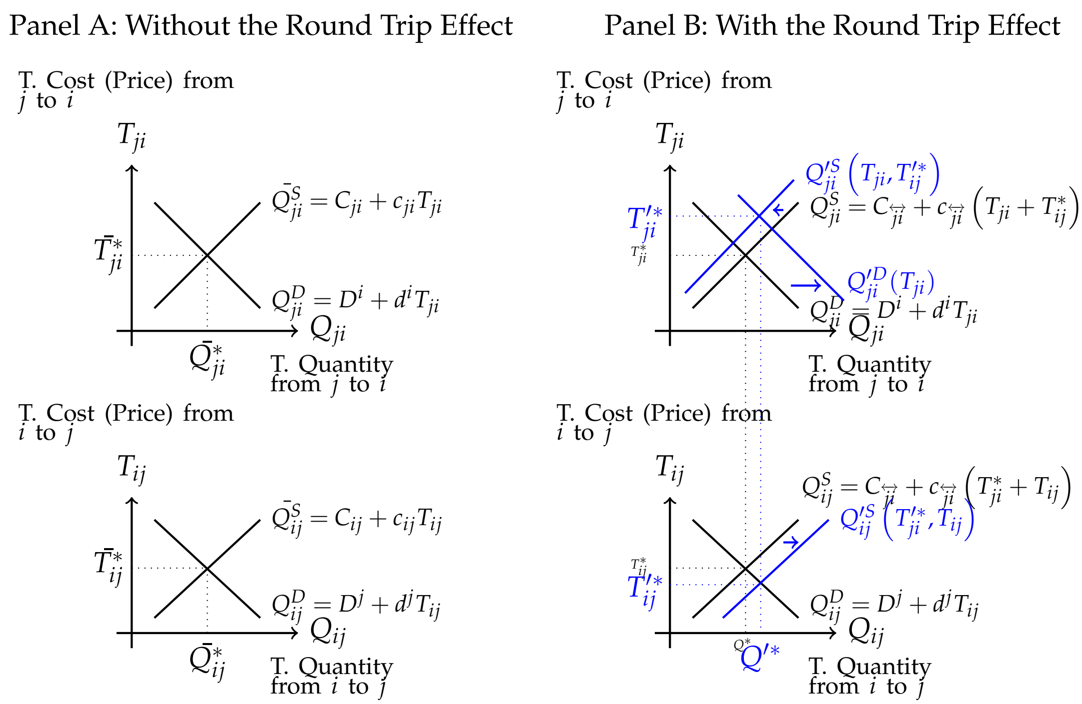

Figure A.1. : Transport markets between countries i and j in the absence (Panel A) and presence (Panel B) of the round trip effect

Note: See Appendix B.B for further details.

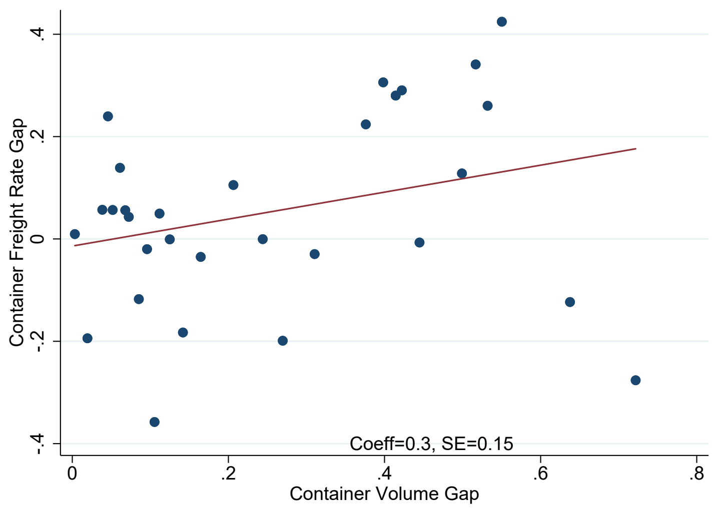

Figure A.2. : Positive correlation between container volume and freight rate gaps

Note: The gap variables are the normalized difference between the higher and lower volume directions.
Source: Drewry, Census Bureau, and author's calculations.

Table A.1—: Regression of container freight rates within port-pairs

	(1) ln Freight Rates	(2) ln Freight Rates	(3) ln Freight Rates	(4) ln Freight Rates
ln Opposite Dir FR	-0.179	-0.836	-0.823	-0.852
	(0.0846)	(0.0175)	(0.0271)	(0.0224)
ln Distance	0.623			
	(0.0873)			
Observations	3241	3241	1687	1552
Route FE		Y	Y	Y
Time FE	Y	Y	Y	Y
Routes			Balanced	Imbalanced
R^2	0.199	0.849	0.826	0.871
F	25.55	2284.8	919.4	1445.8

Note: Robust standard errors in parentheses are clustered by route. All variables are in logs. Column (1) has distance and time controls, Column (2) has route and time controls, Column (3) is restricted to only the second and third quartiles of the US trade imbalance distribution from year 2003 (more "Balanced" routes), and Column (4) is restricted to only the top and bottom quartiles of the US trade imbalance distribution from year 2003 (more "Imbalanced" routes).
Source: Drewry, Sea-distances.org, and author's calculations.

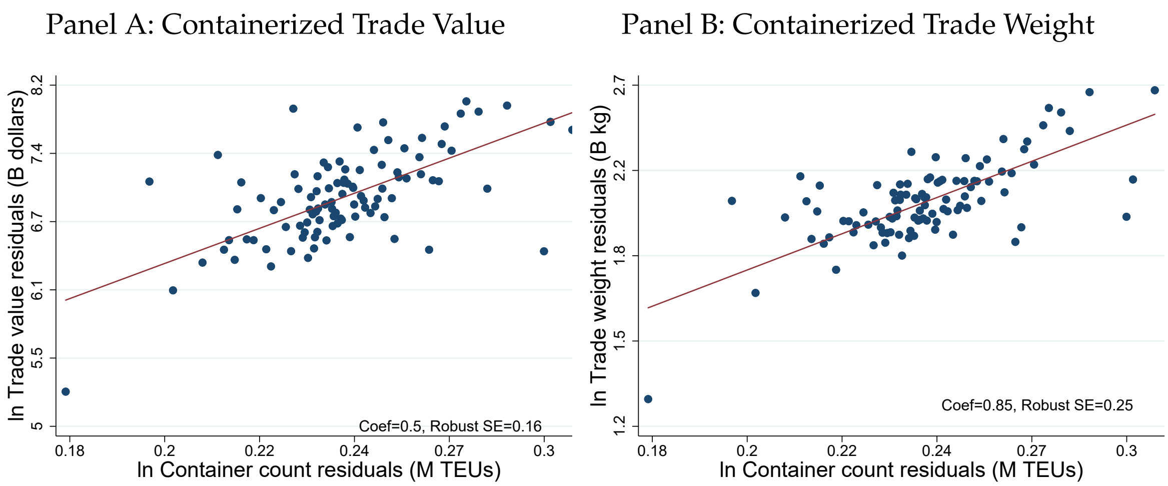

Figure A.3. : Containerized trade value and weight (X_{ijt}) are positively correlated with container volume (Q_{jit}) within routes

Source: Drewry, Census Bureau, MARAD, and author's calculations.

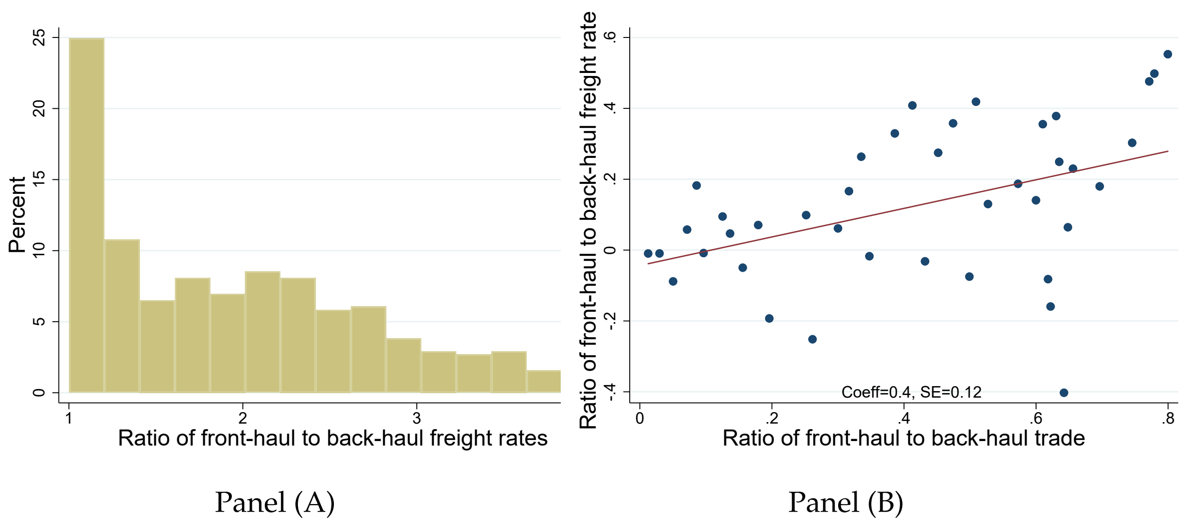

Figure A.4. : (A) Distribution of transport cost gaps and (B) Positive correlation between trade value and transport cost gaps

Note: Ratios are calculated as the normalized difference between the higher (front-haul) and lower (back-haul) values for each origin-destination pair. Panel (A) is at the port-pair level while Panel (B) is at the country level
Source: Drewry, Census Bureau, and author's calculations.

Table A.2—: Regression of freight rates on trade

	(1) ln Freight Rate	(2) ln Freight Rate	(3) ln Freight Rate
ln Value	-0.0881		
	(0.0230)		
ln Weight		-0.123	
		(0.0178)	
ln Value/Wgt			0.175
			(0.0420)
Observations	5684	5684	5684
R^2	0.521	0.558	0.524
F	14.74	48.02	17.31

Note: Robust standard errors clustered by route in parentheses. Time and dyad level fixed effects are included for each regression.
Source: Drewry, Census Bureau, and author's calculations.

Table A.3—: Regression of freight rates on opposite direction trade

	(1) ln Freight Rate	(2) ln Freight Rate	(3) ln Freight Rate
ln Opp Direction Value/Wgt	-0.160	-0.107	-0.172
	(0.0417)	(0.0365)	(0.0421)
Observations	5684	5294	5684
R^2	0.518	0.519	0.523
F	14.72	8.693	16.72
Without China		Y	
Without Fragmented Goods			Y

Note: Robust standard errors clustered by route in parentheses. Time and dyad level fixed effects are included for each regression. Column (2) replicate the regression in Column (1) but without China. Column (3) replicate the regression in Column (1) but without products that are typically fragmented in the production process.
Source: Drewry, Census Bureau, Fort (2017), and author's calculations.

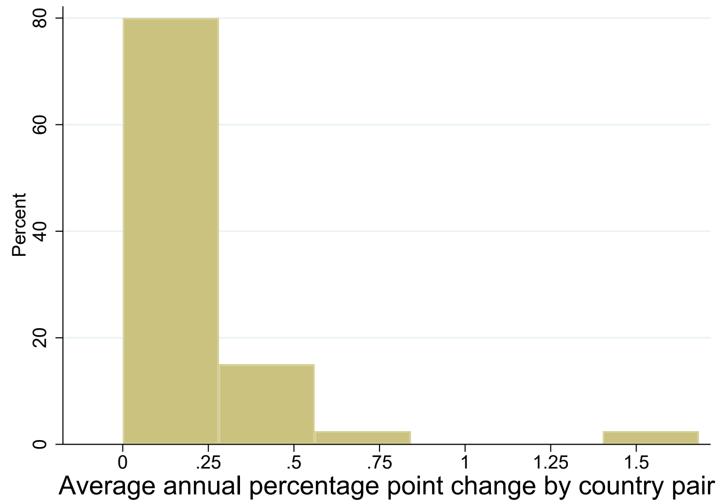

Figure A.5. : Distribution of tariff rates during the sample period

Note: 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 Bank WITS, and author's calculations.

Table A.4—: First-Stage Regressions of Containerized Trade Demand Estimates for OECD Countries

	(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
F	12.38	10.70

Note: Robust standard errors in parentheses are clustered by route. Results are robust to clustering at the route and product, dyad (two-way route), and dyad with products level. Trade outcome is aggregated to the HS2 level. 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. Second stage results are in Table 4.
Source: Drewry, Census Bureau, and author's calculations.

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

	(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
F	3.801	3.540

Note: Robust standard errors in parentheses are clustered by route. Products that are typically fragmented in the production process (as identified in Fort (2016)) are removed from sample. All variables are in logs. Trade value, weight, and value per weight are aggregated to the HS2 level. 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.
Source: Drewry, Census Bureau, and author's calculations.

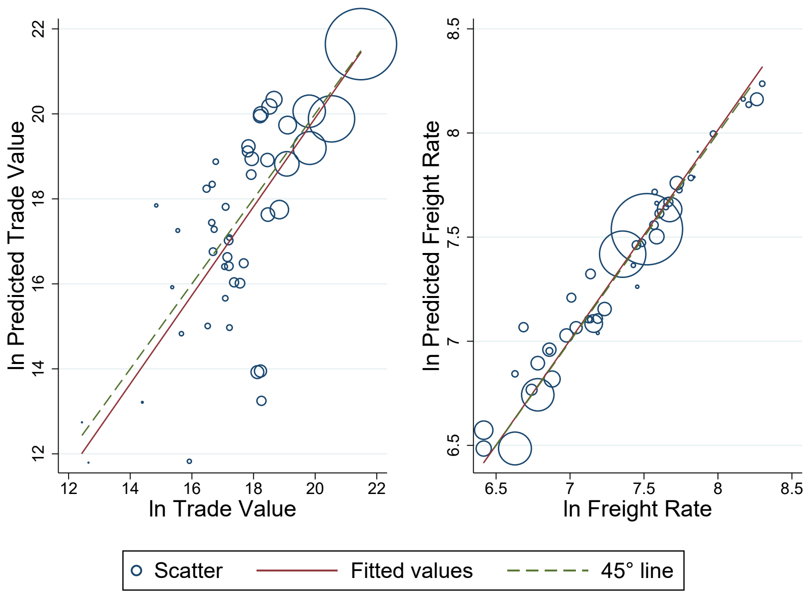

Figure A.6. : Out of Sample Fit

Note: Year 2014 parameter estimates are used to predict and fit year 2015 trade value (Panel (A)) and freight rates (Panel (B)) data.
Source: Authors' calculations using Census Bureau, Drewry, OECD, and World Bank WITS data.

B. Data Appendix

This section provides more information on the data sets in this paper as well as the use of spot market rates.

CONTAINER FREIGHT RATES AND TRADE DATA. — **Container freight rates data.** 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 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)

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.

Containerized trade data. The data on containerized trade is from the Census Bureau, 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.

Matched data set. 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 aggregate my freight rates data set to the US port and foreign country level to match the containerized trade data. This results in 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). All data 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).

When matching between port-level freight rates to port-country level trade data, there is the potential for measurement errors. However, due to the presence of scale economies in shipping, most countries have one major container port where most of their goods are shipped through. This applies to the majority of non-US ports in my dataset which means that generally the port-level freight rates are representative of the rates faced by the country. The only exception is very large countries with multiple big ports. In my dataset, this applies to only one country—China. In my data, there are 3 Chinese ports which handles more than 1 million containers annually so I chose the longest available time series to approximate for US-China trade. In cases where the dataset only covers one port for a region (like Africa—where there is only South Africa's port Durban), my estimate could potentially be a lower bound to the extent that neighboring countries' containers are transported to South Africa and then traded to the US through South Africa.

USE OF SPOT MARKET RATES. — This paper uses a data set on spot market freight rates. There are two main reasons for this: (1) data availability and (2) a variety of linkages between spot and contract rates during the period of this data set.

In the past, price-fixing agreements among carriers (known as conference agreements) on global shipping routes were successfully enforced because conference members are required to file their contract rates with the FMC and these rates were publicly available (Clyde and Reitzes, 1995). In recent years, however, the FMC has introduced several pro-competitive regulations to curtail the conferences' enforcement abilities: 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. Today, conference members are able to deviate privately from conference rates without repercussion. Unfortunately, the same regulations also enforce that these contract rates are off-limits to researchers. My FOIA request with the FMC on April 2015 for container contracts was rejected on the grounds that the information I seek is prohibited from disclosure by the Shipping Act, 46 U.S.C. §40502(b)(1).[1]

Additionally, there has been a period of persistent over-capacity in the container shipping industry which overlaps with my data period—2011 to 2016. The 2008 recession resulted in an idling of the existing shipping fleet, at the same time that another 70 percent

[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.

of that fleet was still scheduled for delivery by 2012 (Kalouptsidi, 2014). The recession and the time to build lags contributed to a persistent over-capacity in the container shipping industry, up to as much as 30 percent more space on ships than cargo, which contributed to the 2016 bankruptcy of the world's seventh-largest container shipping line (South Korea's Hanjin Shipping, The Wall Street Journal). At the same time, a number of strategies were implemented in the container shipping industry in order to smooth volatility. These include negotiations of shorter-term contracts and cargo splitting between both rates,[2] indexing of contract rates to spot rates (Journal of Commerce, 2014), and introduction of hybrid contracts to allow for easy switching to spot rates (Journal of Commerce, 2016).

HUB AND SPOKE NETWORKS AND TRANSSHIPMENT. — In this section, I explain how the presence of hub and spoke networks as well as transshipment affects the results in this paper.

Hub and spoke networks. The presence of this mechanism would mean that my result in Stylized Fact 2 can potentially be a lower bound estimate. I illustrate with an example: say Singapore is the hub, the Philippines is the spoke, and without loss of generality assume that Singapore exports more to the Los Angeles (LA) than the other way around (if trade were balanced then the estimates would be much less affected). Through the hub and spoke network, goods that LA is exporting to the Philippines would constitute a relatively higher share of the cargo on a ship going from LA to Singapore. This means that any shocks to LA-Singapore trade would be less correlated with Singapore-LA freight rates since they make up a smaller cargo share of the transport supply. The presence of this mechanism would weaken the correlation that I am finding in my Stylized Fact 2 which means that my current significantly positive estimate is a lower bound.

Transshipment. Similar to the explanation above, the presence of this mechanism could also potentially result in the correlation in Stylized Fact 2 being a lower bound estimate. To adopt the example above, Filipino exports to the LA would be transshipped in Singapore before being transported to the LA and LA exports to the Philippines would be transshipped in Singapore before its ultimate destination in the Philippines.

C. *Baseline Model Theory Appendix*

MODEL WITH EXOGENOUS TRANSPORT COST. — In the exogenous transport cost model, the cost of transport is the exogenously determined one-way marginal cost of shipping (c_{ij}). The delivered price of country i's good in j (p_{ij}^{Exo}) is as follows:

$$p_{ij}^{Exo} = w_i \tau_{ij} + c_{ij} \tag{A.1}$$

The utility-maximizing quantity of i's good consumed in j (q_{ij}^{Exo}) is derived from the condition that the price ratio of i's good relative to the numeraire is equal to the marginal

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

utility ratio of that good relative to the numeraire.[3] 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:

$$
\begin{aligned}
q_{ij}^{Exo} &= \left[\frac{\epsilon}{\epsilon - 1}\frac{1}{a_{ij}}\left(w_i\tau_{ij} + c_{ij}\right)\right]^{-\epsilon} \\
X_{ij}^{Exo} \equiv p_{ij}^{Exo}q_{ij}^{Exo} &= \left[\frac{\epsilon}{\epsilon - 1}\frac{1}{a_{ij}}\right]^{-\epsilon}\left[\left(w_i\tau_{ij} + c_{ij}\right)\right]^{1-\epsilon}
\end{aligned}
\tag{A.2}
$$

MODEL WITH ENDOGENOUS TRANSPORT COST & ROUND TRIP EFFECT: EQUILIBRIUM. — The utility-maximizing quantity of i's good consumed in j (q_{ij}) is derived from the condition that the price ratio of i's good relative to the numeraire is equal to the marginal utility ratio of that good relative to the numeraire:[4] $q_{ij} = \left[\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ij}}\left(T_{ij}\right)\right]^{-\epsilon}$ where 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 cost will decrease it.

The equilibrium freight rate for route ji is

$$
T_{ji}^{R} = \frac{1}{1 + A_{ji}}\left(w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right) - \frac{1}{1 + A_{ji}^{-1}}\left(w_j\tau_{ji}\right),\ A_{ji} = \frac{a_{ij}}{a_{ji}}
\tag{A.3}
$$

[3]From equation (A.2), ϵ is the price elasticity of demand: $\frac{\partial q_{ij}^{Exo}}{\partial p_{ij}^{Exo}}\frac{q_{ij}^{Exo}}{p_{ij}^{Exo}} = -\epsilon$. 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.

[4]From equation (A.2), ϵ is the price elasticity of demand: $\frac{\partial q_{ij}^{Exo}}{\partial p_{ij}^{Exo}}\frac{q_{ij}^{Exo}}{p_{ij}^{Exo}} = -\epsilon$. 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.

The equilibrium trade price, quantity, and value of country j's good in i is

$$
\begin{aligned}
p_{ji}^{R} &= \frac{1}{1+A_{ji}}\left(w_i\tau_{ij}+w_j\tau_{ji}+c_{\overleftrightarrow{ij}}\right)\\
q_{ji}^{R} &= \left[\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ji}}\frac{1}{1+A_{ji}}\left(w_i\tau_{ij}+w_j\tau_{ji}+c_{\overleftrightarrow{ij}}\right)\right]^{-\epsilon}\\
X_{ji}^{R} &= \left[\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ji}}\right]^{-\epsilon}\left[\frac{1}{1+A_{ji}}\left(w_i\tau_{ij}+w_j\tau_{ji}+c_{\overleftrightarrow{ij}}\right)\right]^{1-\epsilon}\\
&\text{where } A_{ji}=\frac{a_{ij}}{a_{ji}}
\end{aligned}
\tag{A.4}
$$

In the special case where countries i and j are symmetric, the preference parameters in both countries would be the same: $a_{ij}=a_{ji}\equiv a$. As such, the freight rates each way between i and j will be the same–one half of the round trip marginal cost: $T_{ij}^{Sym}=T_{ji}^{Sym}=\frac{1}{2}c_{\overleftrightarrow{ij}}$. The symmetric equilibrium prices, quantities, and values are a function of the domestic wages and tariffs in both countries as well as the round trip marginal cost:

$$
\begin{aligned}
p_{ij}^{Sym} = p_{ji}^{Sym} &= \frac{1}{2}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)\\
q_{ij}^{Sym} = q_{ji}^{Sym} &= \left[\frac{\epsilon}{\epsilon-1}\frac{1}{a}\frac{1}{2}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)\right]^{-\epsilon}\\
X_{ij}^{Sym} = X_{ji}^{Sym} &= \left[\frac{\epsilon}{\epsilon-1}\frac{1}{a}\right]^{-\epsilon}\left[\frac{1}{2}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)\right]^{1-\epsilon}
\end{aligned}
\tag{A.5}
$$

COMPARATIVE STATICS WITH PREFERENCE CHANGES. — Consider an increase in country j's preference for country i's good (a_{ij}). The exogenous transport cost model makes the same predictions where only j's imports from i increases, with the exception that import prices stay the same (equation (A.1)). In the endogenous model with the round trip effect, this preference change will impact both imports and exports like in the tariff case. The only difference here is that an increase in preferences would increase j's import prices from i (equation (8)). This import increase is less than the import increase in the exogenous model. The following lemma can be shown:[5]

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*

[5]See Theory Appendix for proof.

quantity and value from i will increase while leaving its import price from i unchanged.

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

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. The import quantity and value increase is larger under the exogenous model.

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

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.

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

D. *The Round Trip Effect with Imperfect Competition*

This section presents the theoretical implications of endogenous transport costs and the round trip effect in the baseline Armington trade model when the transport firm is imperfectly competitive—a monopoly. The setup of the model is skipped here since it is the same as the baseline model. Under imperfect competition, the mitigation and spillover impacts could be larger or smaller relative to the perfect competition, depending on whether the demand specification pass-through is greater or less than one. Below I first show the profit function for the round trip monopolist transport firm, then I solve for the equilibrium outcomes under both demand specifications.

THE ROUND TRIP EFFECT AND MONOPOLIST TRANSPORT FIRM. — The profit function of a monopolistic transport firm servicing the round trip between i and j ($\pi^{M}_{\overset{\leftrightarrow}{ij}}$) is as below:

$$\pi^{M}_{\overset{\leftrightarrow}{ij}} = T_{ij}\left(q_{ij}\right) q_{ij} + T_{ji}\left(q_{ji}\right) q_{ji} - c_{\overset{\leftrightarrow}{ij}} \max\{q_{ij}, q_{ji}\} \tag{A.6}$$

where all the notations follow from the model in the main theory model with the exception here that the supply of the monopolist transport firm affects the transport price along each route, $T_{ij}(q_{ij})$ and $T_{ji}(q_{ji})$.

A profit-maximizing transport monopolist (equation (A.6)) will produce where the marginal revenue (MR) of both its products—transport services from i to j and the return—equals the marginal cost of a round trip service between i and j $c_{\overleftrightarrow{ij}}$:

$$\underbrace{T'_{ij}\left(q_{ij}\right)q_{ij}+T_{ij}\left(q_{ij}\right)}_{\text{MR from shipping } i \text{ to } j}+\underbrace{T'_{ji}\left(q_{ji}\right)q_{ji}+T_{ji}\left(q_{ji}\right)}_{\text{MR from shipping } j \text{ to } i}=c_{\overleftrightarrow{ij}} \tag{A.7}$$

Since the demand for transport services is downward sloping, $T'_{ij}\left(q_{ij}\right)<0$ and $T'_{ji}\left(q_{ji}\right)<0$. The initial negative correlation of the freight rates between i and j with each other still holds, conditional on the round trip marginal cost $c_{\overleftrightarrow{ij}}$ as well as the demand responsiveness in both countries (price elasticity of demand, wages, and tariffs).

DEMAND PASS-THROUGH GREATER THAN ONE. — The utility function used in the theory section has a constant elasticity of demand (equation (1)) which has a pass-through of greater than one. Below I show the equilibrium results from this class of demand functions. Both the other two optimality conditions from equations (5) and (6) hold here.

Similar to the earlier model, the interior solution is assumed here where demand is symmetric enough in both directions such that the transport market is able to clear at positive freight rates both ways and the quantity of transport services are balanced between the countries. The equilibrium freight rate for route ij under the round trip effect (T^M_{ij}) when the transport firm is a monopolist can be derived from the market clearing condition for transport services:

(A.8)

$$T^M_{ij}=\frac{1}{1+A_{ij}}\frac{\sigma}{\sigma-1}c_{\overleftrightarrow{ij}}-\frac{1}{1+A_{ij}^{-1}}\left(A-\frac{1}{\sigma-1}\right)(w_i\tau_{ij})+\frac{1}{1+A_{ij}}\frac{\sigma}{\sigma-1}(w_j\tau_{ji}),\;\; A_{ij}=\frac{a_{ji}}{a_{ij}}$$

where A_{ij} is the ratio of preference parameters between i and j. The monopolist freight rate for route ij is a function of the same terms as the perfect competition rates: increasing in the marginal cost of servicing the round trip route, decreasing with the destination country j's import tariff on i (τ_{ij}) and origin i's wages (w_i), as well as increasing in the origin country i's import tariff on j (τ_{ji}), as well as destination j's wages (w_j). Since $\frac{\sigma}{\sigma-1}>1$ and $\frac{1}{\sigma-1}>0$, it can be directly calculated that the is higher than the rates under perfect competition.

The new equilibrium price of country i's good in j is still increasing in the marginal cost of round trip transport $c_{\overleftrightarrow{ij}}$, as well as the wages and import tariffs in both countries. This price is a function of j's own wages and the import tariff it faces from i due to the round trip effect:

$$p^M_{ij}=\frac{1}{1+A_{ij}}\frac{\sigma}{\sigma-1}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right),\;\; A_{ij}=\frac{a_{ji}}{a_{ij}} \tag{A.9}$$

This price is higher than when transport firms are perfectly competitive, reflecting the higher equilibrium freight rates earlier.

The new equilibrium trade quantity and value on route ij are lower than the competitive equilibrium quantity and value:

$$\begin{aligned} q_{ij}^M &= \left[\left(\frac{\sigma}{\sigma-1}\right)^2 \frac{1}{a_{ij}} \frac{1}{1+A_{ij}} \left(w_j\tau_{ji} + w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right)\right]^{-\sigma} \\ X_{ij}^M &= \left(\frac{\sigma}{\sigma-1}\right)^{2-\sigma} \frac{1}{a_{ij}}^{-\sigma} \left[\frac{1}{1+A_{ij}} \left(w_j\tau_{ji} + w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right)\right]^{1-\sigma}, \; A_{ij} = \frac{a_{ji}}{a_{ij}} \end{aligned} \tag{A.10}$$

When country j's import tariff on country i (τ_{ij}) increases, I showed earlier that there will be mitigating effects on j's import freight rates and spillover effects on j's export freight rates. Both of these result in an increase in the import and export prices as well as decreases in quantities and trade value. When the transport firm is a monopoly, both the mitigating and spillover effects are still present but the magnitudes are different: the mitigating effect is smaller while the spillover effect is bigger. Both of these result in bigger changes in prices, quantity, and value. The following lemma summarizes both the monopoly and comparative statics results from direct calculation:

Lemma 3. *When transport cost is endogenous, determined on a round trip basis by a monopolist transport firm, and under a demand function with pass-through greater than one, the equilibrium freight rates and prices are higher than when transport firms are competitive ($T_{ij}^M > T_{ij}^R$, $p_{ij}^M > p_{ij}^R$). The monopolist equilibrium trade quantities and value are lower than the competitive equilibria ($q_{ij}^M < q_{ij}^R$, $X_{ij}^M < X_{ij}^R$).*

An import tariff increase will affect both the origin country's imports and exports to its partner. The origin country's import freight rate is less responsive to tariffs than the competitive equilibrium—it falls by less. Import prices, quantity, and value are more responsive—prices increase by more while quantity and value falls by more:

$$\frac{\partial T_{ij}^M/\partial\tau_{ij}}{\partial T_{ij}^R/\partial\tau_{ij}} < 1\,,\; \frac{\partial p_{ij}^M/\partial\tau_{ij}}{\partial p_{ij}^R/\partial\tau_{ij}} > 1\,,\; \frac{\partial q_{ij}^M/\partial\tau_{ij}}{\partial q_{ij}^R/\partial\tau_{ij}} > 1 \;\textit{and}\; \frac{\partial X_{ij}^M/\partial\tau_{ij}}{\partial X_{ij}^R/\partial\tau_{ij}} > 1$$

On the export side, the origin country's export freight rate is more responsive to changes in tariffs—freight rates increases by more. Export prices, quantity, and value are also more responsive—prices increase by more while quantity and value falls by more:

$$\frac{\partial T_{ji}^M/\partial\tau_{ij}}{\partial T_{ji}^R/\partial\tau_{ij}} > 1\,,\; \frac{\partial p_{ji}^M/\partial\tau_{ij}}{\partial p_{ji}^R/\partial\tau_{ij}} > 1\,,\; \frac{\partial q_{ji}^M/\partial\tau_{ij}}{\partial q_{ji}^R/\partial\tau_{ij}} > 1 \;\textit{and}\; \frac{\partial X_{ji}^M/\partial\tau_{ij}}{\partial X_{ji}^R/\partial\tau_{ij}} > 1$$

DEMAND PASS-THROUGH LESS THAN ONE. — An example of a demand function with a pass-through that is less than one is the linear demand specification below. a_{ij} and b_{ij} are the demand intercept and slope respectively. I solve for the equilibrium under perfect competition first and then present the results under a monopoly transport firm.

$$p_{ij} = a_{ij} - b_{ij}q_{ij} \tag{A.11}$$

Under perfect competition and after substituting the profit-maximizing condition from the transport firm (equation (4)), the equilibrium freight rate for route ij under a linear demand function is as follows:

$$T^{R\prime}_{ij} = \frac{1}{1+B_{ij}}\left[B_{ij}(a_{ij} - w_i\tau_{ij}) + c_{\overleftrightarrow{ij}} - a_{ji} + w_j\tau_{ji}\right], \; B_{ij} = \frac{b_{ji}}{b_{ij}} \tag{A.12}$$

The equilibrium price of country i's good in j is increasing in the marginal cost of round trip transport $c_{\overleftrightarrow{ij}}$, as well as the wages and import tariffs in both countries. This price is a function of j's own wages and the import tariff it faces from i, which is due to the round trip effect:

$$p^{R\prime}_{ij} = \frac{B_{ij}}{1+B_{ij}}a_{ij} + \frac{1}{1+B_{ij}}\left(c_{\overleftrightarrow{ij}} - a_{ji} + w_j\tau_{ji} + w_i\tau_{ij}\right), \; B_{ij} = \frac{b_{ji}}{b_{ij}} \tag{A.13}$$

The equilibrium trade quantity and value on route ij are as follows:

$$\begin{aligned} q^{R\prime}_{ij} &= \frac{1}{1+B_{ij}}\frac{1}{b_{ij}}\left(a_{ij} - c_{\overleftrightarrow{ij}} + a_{ji} - w_j\tau_{ji} - w_i\tau_{ij}\right) \\ X^{R\prime}_{ij} &= p^{R\prime}_{ij}q^{R\prime}_{ij}, \; B_{ij} = \frac{b_{ji}}{b_{ij}} \end{aligned} \tag{A.14}$$

Under a monopoly transport firm and after substituting the equilibrium price from equation (2), we get the following:

$$T_{ij} = a_{ij} - b_{ij}q_{ij} - \tau_{ij}w_i \tag{A.15}$$

Substituting the equation above into the optimal condition for a profit-maximizing transport monopolist (equation (A.7)), the equilibrium freight rate for route ij under a linear demand function is as follows and is higher than the perfect competition freight rate (equation (A.12)):

$$T^{M\prime}_{ij} = \frac{1}{1+B_{ij}}\left[\left(B_{ij} + \frac{1}{2}\right)(a_{ij} - w_i\tau_{ij}) + \frac{1}{2}(c_{\overleftrightarrow{ij}} - a_{ji} + w_j\tau_{ji})\right], \; B_{ij} = \frac{b_{ji}}{b_{ij}} \tag{A.16}$$

The new monopoly equilibrium price of country i's good in j is higher than under perfect competition (equation (A.13)) when $\alpha_{ij} + \alpha_{ji} \geq c_{\overleftrightarrow{ij}} + w_j\tau_{ji} + w_i\tau_{ij}$:

$$p^{M\prime}_{ij} = \frac{B_{ij}}{1+B_{ij}}\alpha_{ij} + \frac{1}{2(1+B_{ij})}\left(\alpha_{ij} + c_{\overleftrightarrow{ij}} - \alpha_{ji} + w_j\tau_{ji} + w_i\tau_{ij}\right), \quad B_{ij} = \frac{\beta_{ji}}{\beta_{ij}} \tag{A.17}$$

The new equilibrium trade quantity and value on route ij are lower than the competitive equilibrium quantity and value (equation (A.14)):

$$\begin{aligned} q^{M\prime}_{ij} &= \frac{1}{1+B_{ij}}\frac{1}{2\beta_{ij}}\left(\alpha_{ij} - c_{\overleftrightarrow{ij}} + \alpha_{ji} - w_j\tau_{ji} - w_i\tau_{ij}\right) \\ X^{M\prime}_{ij} &= p^{M\prime}_{ij}q^{M\prime}_{ij}, \quad B_{ij} = \frac{\beta_{ji}}{\beta_{ij}} \end{aligned} \tag{A.18}$$

From direct calculations, the following lemma summarizes both the monopoly and perfect competition results:

Lemma 4. *When transport cost is endogenous, determined on a round trip basis by a monopolist transport firm, and under a demand function with pass-through less than one, the equilibrium freight rates and prices are higher than when transport firms are competitive ($T^{M\prime}_{ij} > T^{R\prime}_{ij}$, $p^{M\prime}_{ij} > p^{R\prime}_{ij}$). The monopolist equilibrium trade quantities and value are lower than the competitive equilibria ($q^{M\prime}_{ij} < q^{R\prime}_{ij}$, $X^{M\prime}_{ij} < X^{R\prime}_{ij}$).*

An import tariff increase will affect both the origin country's imports and exports to its partner. The origin country's import freight rate is less responsive to tariffs than the competitive equilibrium—it falls by less. Import prices, quantity, and value are more responsive—prices increase by more while quantity and value falls by more:

$$\frac{\partial T^{M\prime}_{ij}/\partial\tau_{ij}}{\partial T^{R\prime}_{ij}/\partial\tau_{ij}} < 1\,, \; \frac{\partial p^{M'}_{ij}/\partial\tau_{ij}}{\partial p^{R\prime}_{ij}/\partial\tau_{ij}} > 1\,, \; \frac{\partial q^{M'}_{ij}/\partial\tau_{ij}}{\partial q^{R\prime}_{ij}/\partial\tau_{ij}} > 1 \; \textit{and} \; \frac{\partial X^{M'}_{ij}/\partial\tau_{ij}}{\partial X^{R\prime}_{ij}/\partial\tau_{ij}} > 1$$

On the export side, the origin country's export freight rate is more responsive to changes in tariffs—freight rates increases by more. Export prices, quantity, and value are also more responsive—prices increase by more while quantity and value falls by more:

$$\frac{\partial T^{M\prime}_{ji}/\partial\tau_{ij}}{\partial T^{R\prime}_{ji}/\partial\tau_{ij}} > 1\,, \; \frac{\partial p^{M'}_{ji}/\partial\tau_{ij}}{\partial p^{R\prime}_{ji}/\partial\tau_{ij}} > 1\,, \; \frac{\partial q^{M'}_{ji}/\partial\tau_{ij}}{\partial q^{R\prime}_{ji}/\partial\tau_{ij}} > 1 \; \textit{and} \; \frac{\partial X^{M'}_{ji}/\partial\tau_{ij}}{\partial X^{R\prime}_{ji}/\partial\tau_{ij}} > 1$$

Combining the results from both lemmas 3 and 4, the following proposition can be stated:

Proposition 2. *Under the assumption of imperfectly competitive transport firms, the mitigation* *and spillover impacts from the round trip effects could be larger or smaller relative to the perfect competition case, depending on whether the demand specification pass-through is greater or less than one:*

(i) When the demand specification has a pass-through of greater than one, the round trip effects from tariff changes are amplified: $\frac{\partial T_{ij}^M/\partial \tau_{ij}}{\partial T_{ij}/\partial \tau_{ij}} < 1$, $\frac{\partial p_{ij}^M/\partial \tau_{ij}}{\partial p_{ij}/\partial \tau_{ij}} > 1$, $\frac{\partial q_{ij}^M/\partial \tau_{ij}}{\partial q_{ij}/\partial \tau_{ij}} > 1$, $\frac{\partial X_{ij}^M/\partial \tau_{ij}}{\partial X_{ij}/\partial \tau_{ij}} > 1$, $\frac{\partial T_{ji}^M/\partial \tau_{ij}}{\partial T_{ji}/\partial \tau_{ij}} > 1$, $\frac{\partial p_{ji}^M/\partial \tau_{ij}}{\partial p_{ji}/\partial \tau_{ij}} > 1$, $\frac{\partial q_{ji}^M/\partial \tau_{ij}}{\partial q_{ji}/\partial \tau_{ij}} > 1$ *and* $\frac{\partial X_{ji}^M/\partial \tau_{ij}}{\partial X_{ji}/\partial \tau_{ij}} > 1$

(ii) When the demand specification has a pass-through of less than one, the opposite is true.

E. Discussion on the bias between OLS and IV

In this section, I introduce a simple model that illustrates the two sources of bias in this paper, simultaneous equation bias and bias induced by the round trip effect, and show that they contribute to a larger difference between the OLS and IV estimates as predicted by my results. Next, I provide an analytical solution to the supply elasticity using this model. I then solve for the implied supply elasticity using my IV and OLS estimates and show that it is in the ballpark of available supply elasticities in the literature.

There are two sources of bias here as discussed in the paper: (1) simultaneous equation bias since the supply and demand for transport services on a particular route ij is simultaneously determined, and (2) bias induced by the round trip effect where transport supply for routes ij and ji are jointly determined, leading to a negative relationship between the transport prices on route ij and ji.

To incorporate the simultaneous equation bias, I introduce the variables Q_{ij} and T_{ij} (quantity and price) in the route ij market for transport services which are jointly determined by the demand equation:

$$\ln Q_{ij} = -\beta_1 \ln T_{ij} + e_1 \tag{A.19}$$

and the supply equation, which includes the round trip effect where transport supply for routes ij and ji are jointly determined (as predicted in the theory section):

$$\ln Q_{ij} = \beta_2 \ln \left(T_{ij} + T_{ji} \right) + e_2 \tag{A.20}$$

Assume $e = (e_1, e_2)$ satisfies $\mathbb{E}[e] = 0$ and $\mathbb{E}[ee'] = \begin{bmatrix} \mathbb{V}[e_1] & 0 \\ 0 & \mathbb{V}[e_2] \end{bmatrix}$ where $\mathbb{V}[\cdot] \geq 1$ is the variance of the errors in each regression.

The round trip effect results in a negative relationship between the transport prices on route ij and ji which introduces the second bias (as predicted from the profit maximization condition in the theory section equation (4)):

$$T_{ji} = -\beta_3 T_{ij} + c_{\overleftrightarrow{ij}} \tag{A.21}$$

where $c_{\overleftrightarrow{ij}}$ is the marginal cost servicing the round trip between i and j.

Substituting equation (A.21) into equation (A.20), we can rewrite the supply equation as a function of prices on route ij (T_{ij}):

$$\ln Q_{ij} = \beta_2 \ln\left(T_{ij} - \beta_3 T_{ij} + c_{\overleftrightarrow{ij}}\right) + e_2$$

Taking the first order Taylor series approximation for function $f(x) \equiv x - \beta_3 x + c_{\overleftrightarrow{ij}}$ where $x = \ln T_{ij}$ evaluated at point $\ln T_0$ and utilizing the chain rule, we have the following:

$$\ln\left(T_{ij} - \beta_3 T_{ij} + c_{\overleftrightarrow{ij}}\right) \approx \underbrace{\frac{(1-\beta_3)\,T_0}{(1-\beta_3)\,T_0 + c_{\overleftrightarrow{ij}}}}_{\equiv A<1} \ln T_{ij} + \mathbb{C}$$

where $\mathbb{C}$ is a constant.[6] The term A is less than 1 since from Figure 1 in Section 4 we know that $|\beta_3| < 1$, in levels as well as logs. This allows us to rewrite the supply equation (A.20) as

$$\ln Q_{ij} = A\beta_2 \ln\left(T_{ij}\right) + e_2$$

where A is the bias introduced by the round trip effect. We can then solve for Q_{ij} and T_{ij} in terms of the errors. In matrix notation,

$$\begin{aligned}
\begin{bmatrix} 1 & \beta_1 \\ 1 & -A\beta_2 \end{bmatrix} \begin{bmatrix} \ln Q_{ij} \\ \ln T_{ij} \end{bmatrix} &= \begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \\
\begin{bmatrix} \ln Q_{ij} \\ \ln T_{ij} \end{bmatrix} &= \begin{bmatrix} 1 & \beta_1 \\ 1 & -A\beta_2 \end{bmatrix}^{-1} \begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \\
&= \begin{bmatrix} \frac{1}{\beta_1 + A\beta_2}\left(A\beta_2 e_1 + \beta_1 e_2\right) \\ \frac{1}{\beta_1 + A\beta_2}\left(e_1 - e_2\right) \end{bmatrix}
\end{aligned}$$

Regressing $\ln Q_{ij}$ on $\ln T_{ij}$ (projection of $\ln Q_{ij}$ on $\ln T_{ij}$) yields $\ln Q_{ij} = \beta^* \ln T_{ij} + e^*$ with

[6]Constant $\mathbb{C} = f(\ln T_0) - \frac{(1-\beta_3)T_0}{(1-\beta_3)T_0 + c_{\overleftrightarrow{ij}}} \ln T_0$.

$\mathbb{E}[\ln T_{ij} e^*] = 0$ and the coefficient defined by projection as

$$\beta^* = \frac{\mathbb{E}[\ln T_{ij} \ln Q_{ij}]}{\ln T_{ij}^2} = \frac{A\beta_2 \mathbb{V}[e_1] - \beta_1 \mathbb{V}[e_2]}{\mathbb{V}[e_1] + \mathbb{V}[e_2]} \tag{A.22}$$

where β^* is the OLS coefficient from Table 4 which is neither the demand (β_1) nor supply (β_2) slope—the result of simultaneous equation bias. β^* approximates the average of β_1 and β_2 and as a result attenuates to zero. Holding constant the supply elasticity β_2, just the simultaneous equation bias would result in a larger difference between the IV and OLS estimates. Similarly, the round trip effect bias introduced by A decreases β_2 which would also result in a relatively larger difference between the IV and OLS estimates. Combined, both these sources of bias contribute to larger magnitude differences between the OLS and IV estimates, as predicted in my results ($|\beta_1| > |\beta^*|$).

Second, I provide an analytical solution to the supply elasticity (β_2) using this model. I then calibrate and solve for a comparable supply elasticity and show that it is in the ballpark of available supply elasticities in the literature. The analytical solution for the supply elasticity is below (equation (A.22)):

$$\beta_2 = \frac{1}{A\mathbb{V}[e_1]} \left[\left(\mathbb{V}[e_1] + \mathbb{V}[e_2] \right) \beta^* + \beta_1 \mathbb{V}[e_2] \right] \tag{A.23}$$

Next, I calibrate the equation above. The demand elasticity β_2 and OLS estimates β^* are taken directly from Table 4. In order to compare this elasticity to supply elasticities estimated in the literature, I convert β_2 to the appropriate units. I do this in two ways. First, supply elasticities in the literature is estimated as the elasticity of trade on route ij with respect to price on the same route. Here, β_2 is the elasticity of trade on route ij with respect to price on route ij as well as the inverse route ji (equation (A.20)). β_2 will therefore be larger than typical supply elasticities since prices are negatively correlated here due to the round trip effect. As such, I normalize A to one. Second, demand elasticity β_1 is estimated at the monthly level here while typical elasticities are estimated at the annual level. So I scale β_2 using the annual demand elasticity estimated in the paper (Table 6). Figure A.7 plots the elasticity estimates allowing for the error variance to range from 1 to 2 for both the demand and supply equations. Assuming the variance of the errors in the demand regression (Table 4) is approximately the same as the errors in the supply regression, the implied supply elasticity in this model is about 0.78. This is in the ballpark of Broda, Limao and Weinstein (2008) who estimates a median elasticity of supply of 0.6 across 15 importers annually over the period 1994-2003.

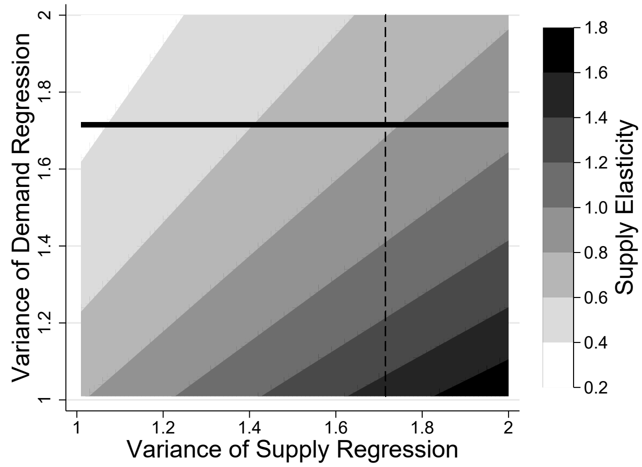

Figure A.7. : Supply elasticity estimate

Note: Horizontal line indicates the variance of the errors in the demand regression from Table 4 (1.17). Vertical dashed line indicates the same variance for comparison. Supply elasticity has been annualized.
Source: Authors' calculations.

F. *Counterfactual Appendix: Discussion on mitigation effects*

The over-prediction of the fall in imports between the counterfactual results in the exogenous and round trip model, known as the mitigation effects, are large and robust to using a different trade elasticity estimates. This is generally due to both trade elastiticies increasing the response to tariffs with and without the round trip endogenous adjustment proportionally. This section discusses the model and data features that drive this result. I confirm this result directly by first showing a high correlation of 0.9 of between the route-level mitigation effects using both elasticities (Figure A.8).

Analytically, we can also show that the counterfactual trade flow differences under the round trip model and exogenous model are similar under both elasticities. The route ij equilibrium trade value for the exogenous model (X_{ij}^{Exo}) and the round trip model (X_{ij}^{*}) are as follows:

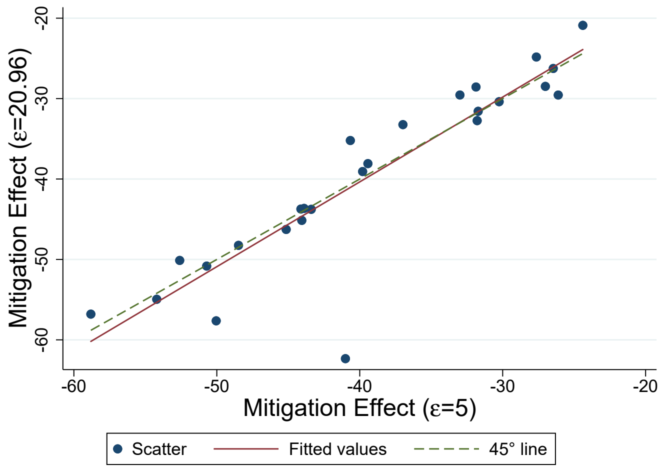

Figure A.8. : Robustness Check of Mitigation Effects

Note: Correlation of 0.9 for 26 routes. Mitigation effect on y-axis is calculated using a trade elasticity of 20.1 while the x-axis is calculated using a trade elasticity of 5.
Source: Authors' calculations using Census Bureau, Drewry, International Labor Organization (ILO), OECD, and WITS.

$$
\begin{aligned}
X_{ij}^{Exo} &= \left[\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ij}}\right]^{-\epsilon}\left[w_i\tau_{ij}+\frac{c_{ij}}{l_{ij}}\right]^{1-\epsilon} \\
X_{ij}^{*} &= \left[\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ij}}\right]^{-\epsilon}\left[\frac{1}{1+Y_{ij}}\left(w_i\tau_{ij}+\frac{1}{l_{ij}}\left(c_{\overleftrightarrow{ij}}+l_{ji}w_j\tau_{ji}\right)\right)\right]^{1-\epsilon}, \\
&\text{where } Y_{ij} = \frac{a_{ji}}{a_{ij}}\left(\frac{l_{ji}}{l_{ij}}\right)^{1+1/\epsilon}
\end{aligned} \tag{A.24}
$$

The two main parameters of interest are the preference parameters (a_{ji} and a_{ij}) and loading factors (l_{ij} and l_{ji}) for both routes. The preference parameters govern the utility preferences for goods on these routes while the loading factor converts the quantity of goods on these routes into a common unit (for example, a containership or a container).

The counterfactual changes only affects import tariffs (wlog say this is country j's perspective: a change in τ_{ij} to τ'_{ij}). The mitigation effect for each route is the difference between the counterfactual trade value changes for both scenarios, the exogenous and the round trip model:

$$
\begin{aligned}
\frac{\triangle X_{ij}^{Exo} - \triangle X_{ij}^{*}}{\triangle X_{ij}^{Exo}} &\equiv \frac{X_{ij}^{Exo}(\tau_{ij}') - X_{ij}^{Exo}(\tau_{ij}) - \left(X_{ij}^{*}(\tau_{ij}') - X_{ij}^{*}(\tau_{ij})\right)}{X_{ij}^{Exo}(\tau_{ij}') - X_{ij}^{Exo}(\tau_{ij})} \\
&= 1 - \left(\frac{1}{1+Y_{ij}}\right)^{1-\epsilon} \frac{\left(w_i\tau_{ij}' + \Gamma_{ij}\right)^{1-\epsilon} - \left(w_i\tau_{ij} + \Gamma_{ij}\right)^{1-\epsilon}}{\left(w_i\tau_{ij}' + \Gamma_{ij}^{Exo}\right)^{1-\epsilon} - \left(w_i\tau_{ij} + \Gamma_{ij}^{Exo}\right)^{1-\epsilon}} \\
&\text{where } Y_{ij} = \frac{a_{ji}}{a_{ij}}\left(\frac{l_{ji}}{l_{ij}}\right)^{1+1/\epsilon}, \Gamma_{ij} = \frac{1}{l_{ij}}\left(c_{\overleftrightarrow{ij}} + l_{ji}w_j\tau_{ji}\right), \\
&\text{and } \Gamma_{ij}^{Exo} = \frac{c_{ij}}{l_{ij}}
\end{aligned}
\tag{A.25}
$$

Here we can see that for relatively close values of trade elasticity ϵ, the mitigation effect changes will be roughly similar. This is particularly true because the first counterfactual changes in tariffs is small: a doubling in US import tariffs from a relatively low average of 1.33 percent. As a result of the small tariff changes, the third term in equation (A.25) below approximates one. The tariff changes in the second counterfactual are relatively larger which results in slightly bigger differences in the mitigation effects.

Lastly, I show that the unit-adjusted relative preferences for routes are driving the mitigation effects. A higher unit-adjusted relative preference for route ij means that consumers have a higher preference for ij goods compared to ji goods. This means that an increase in ij import tariffs (j's import tariffs on i) will have less of an impact on decreasing import flows due to this high relative preference. As a result, the mitigation impact from the round trip effect for route ij will be smaller. I confirm that this is the case by showing a highly positive correlation of 0.96 between the route-level unit-adjusted relative preferences against its mitigation effects.

Since the third term in equation (A.25) above approximates the difference in tariff levels, we can see that what will be driving the overall mitigation effect is the second term in the equation—$\left(\frac{1}{1+Y_{ij}}\right)^{1-\epsilon}$. We can interpret $\left[\frac{a_{ij}}{a_{ji}}\left(\frac{l_{ij}}{l_{ji}}\right)^{1+1/\epsilon}\right]$ as the unit-adjusted relative preference for a route by rewriting it as follows:

$$
\left(\frac{1}{1+Y_{ij}}\right)^{1-\epsilon} = \left(\frac{1}{1+\frac{a_{ji}}{a_{ij}}\left(\frac{l_{ji}}{l_{ij}}\right)^{1+1/\epsilon}}\right)^{1-\epsilon} = \left[1 + \left(\frac{a_{ij}}{a_{ji}}\left(\frac{l_{ij}}{l_{ji}}\right)^{1+1/\epsilon}\right)^{-1}\right]^{\epsilon-1}
$$

All else equal, a higher unit-adjusted preference for route ij's goods relative to opposite direction route ji will decrease this second term:

$$\frac{\partial\left(\frac{1}{1+Y_{ij}}\right)^{1-\epsilon}}{\partial\left[\frac{a_{ij}}{a_{ji}}\left(\frac{l_{ij}}{l_{ji}}\right)^{1+1/\epsilon}\right]} = (\epsilon-1)\left[1+\left(\frac{a_{ij}}{a_{ji}}\left(\frac{l_{ij}}{l_{ji}}\right)^{1+1/\epsilon}\right)^{-1}\right]^{\epsilon}\left[-\left(\frac{a_{ij}}{a_{ji}}\left(\frac{l_{ij}}{l_{ji}}\right)^{1+1/\epsilon}\right)^{-2}\right] < 0$$

Using the chain rule, the mitigation effect is decreasing in the unit-adjusted relative preference for a route:

$$\frac{\partial\frac{\triangle X_{ij}^{Exo}-\triangle X_{ij}^{*}}{\triangle X_{ij}^{Exo}}}{\partial\left[\frac{a_{ij}}{a_{ji}}\left(\frac{l_{ij}}{l_{ji}}\right)^{1+1/\epsilon}\right]} = \underbrace{\frac{\partial\frac{\triangle X_{ij}^{Exo}-\triangle X_{ij}^{*}}{\triangle X_{ij}^{Exo}}}{\partial\left(\frac{1}{1+Y_{ij}}\right)^{1-\epsilon}}}_{>0}\underbrace{\frac{\partial\left(\frac{1}{1+Y_{ij}}\right)^{1-\epsilon}}{\partial\left[\frac{a_{ij}}{a_{ji}}\left(\frac{l_{ij}}{l_{ji}}\right)^{1+1/\epsilon}\right]}}_{<0} < 0$$

All else equal, a higher unit-adjusted relative preference for route ij means that consumers have a higher preference for ij goods compared to ji goods. An increase in ij's import tariffs will then have less of an impact on decreasing import flows due to this high relative preference. As a result, the mitigation impact from the round trip effect will be smaller.

I show that this is indeed the case by plotting the route-level unit-adjusted relative preferences against its mitigation effects below (figure A.9). This relationship is positive and highly correlated with a coefficient of 0.96. Routes with high unit-adjusted relative preferences like Busan-NY, Shanghai-LA or Shanghai-Houston have lower mitigation effects relative to routes like Felixstowe-LA or Genoa-Houston.

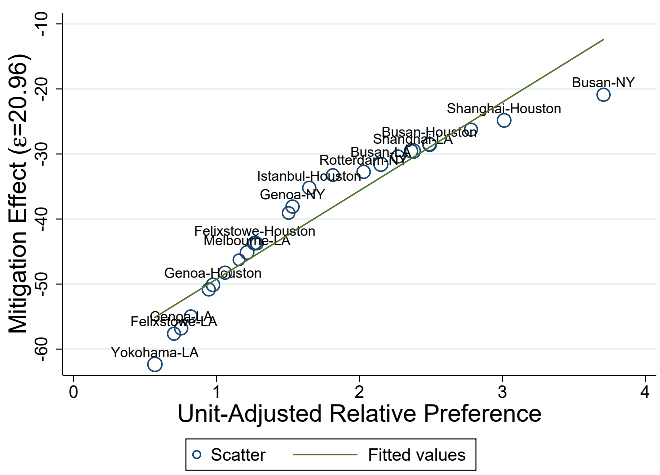

Figure A.9. : Positive Relationship between Mitigation Effects and Relative Preference

Note: Correlation of 0.96 for 26 routes. Weighted by total trade value by route.

Source: Authors' calculations using Census Bureau, Drewry, International Labor Organization (ILO), OECD, and WITS.

B. Online Appendix

A. Additional Tables and Figures

Table A.6—: Containerized Trade Demand Estimates for All Countries

	(1) OLS	(2) OLS	(3) IV	(4) IV
Panel A: ln Trade Value				
ln Freight Rate	-0.532	-0.460	-3.873	-2.884
	(0.0969)	(0.110)	(1.232)	(0.956)
Panel B: ln Trade Weight				
ln Freight Rate	-0.716	-0.633	-5.222	-4.072
	(0.118)	(0.133)	(1.613)	(1.256)
Panel C: ln Trade Value per Weight				
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
KP F-Stat			8.433	7.750

Note: Robust standard errors in parentheses are clustered by route. 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, weight, and value per weight are aggregated to the HS2 level. 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. Table A.7 presents the first stage regressions.

Source: Drewry, Census Bureau, and author's calculations.

Table A.7—: First-Stage Regressions of Containerized Trade Demand Estimates for All Countries (table A.6)

	(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

Note: Robust standard errors in parentheses are clustered by route. 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 outcome is aggregated to the HS2 level. 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.
Source: Drewry, Census Bureau, and author's calculations.

Table A.8—: Containerized Trade Value Demand Estimates using Aggregate Data for OECD Countries

	(1) OLS	(2) IV	(3) First-Stage
Panel A: ln Trade Value			
ln Freight Rate	-0.132	-4.137	
	(0.307)	(1.506)	
ln Opp Dir Predicted Trade Value			0.0391
			(0.0138)
Panel B: ln Trade Weight			
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
Observations	2307	2307	2307

Note: Robust standard errors in parentheses are clustered by route. Results are robust to clustering at the dyad level. All variables are in logs. Trade value and weight are 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. First stage F is 7.5 for Panel A and 8.2 for Panel B. Fixed Effects explanation: Ex-Time FE is exporter country and time fixed effects; Im-Time FE is importer country and time fixed effects
Source: Drewry, Census Bureau, and author's calculations.

Table A.9—: Containerized Trade Demand Estimates for OECD Countries with 2009 instrument

	(1) OLS	(2) OLS	(3) IV	(4) IV
Panel A: ln Trade Value				
ln Freight Rate	-0.640	-0.503	-1.919	-1.044
	(0.147)	(0.131)	(0.715)	(0.670)
Panel B: ln Trade Weight				
ln Freight Rate	-1.014	-0.808	-2.436	-1.302
	(0.195)	(0.175)	(0.878)	(0.778)
Panel C: ln Trade Value per Weight				
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
KP F-Stat			27.12	26.43

Note: Robust standard errors in parentheses are clustered by route. Results are robust to clustering at the route and products, dyad (two-way route), as well as dyad with product levels. All variables are in logs. Trade outcome 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 and Im-Time FE is importer country and time fixed effects.
Source: Drewry, Census Bureau, and author's calculations.

Table A.10—: First-Stage Regressions of Containerized Trade Demand Estimates for OECD Countries with 2009 instrument (table A.9)

	(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
F	27.12	26.43

Note: Robust standard errors in parentheses are clustered by route. 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. 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.
Source: Drewry, Census Bureau, and author's calculations.

B. *Simple Model to Illustrate the Round Trip Effect*

There are two transport markets, one going from origin j to destination i (*route ji*) and the other going back from i to j (*route ij*). I present both these markets without the round trip effect and then introduce the round trip effect and its implications.

I assume linear transport demand functions for both routes ji and ij:

$$Q^D_{ji} = D^i - d^i T_{ji} \text{ and } Q^D_{ij} = D^j - d^j T_{ij} \tag{B.1}$$

where Q^D_{ji} 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.

MODEL ABSENT THE ROUND TRIP EFFECT. — Following the demand assumption, I also assume linear transport supply. Absent the round trip effect, transport supply for both routes are separately determined:

$$\bar{Q}^S_{ji} = C_{ji} + c_{ji} T_{ji} \text{ and } \bar{Q}^S_{ij} = C_{ij} + c_{ij} T_{ij} \tag{B.2}$$

where $\bar{Q}^S_{ji}$ 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.[1]

[1] One interpretation is that there are a continuum of small transport firms providing transport between the two countries who face heterogenous marginal costs.

The equilibrium transport price and quantity for route ji and ij are:

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

where any demand and supply parameter changes on a route only affects the transport price and quantity of that route—a positive demand shock on route ji (D^i increase) will only affect the route ji transport price and quantity. Both these markets are illustrated in Panel A of figure A.1. The top graph is the transport market for route ji while the bottom graph is the transport market for return direction route ij.

MODEL WITH THE ROUND TRIP EFFECT. — In the presence 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.[2] As such, the supply of transport on both routes ($\overleftrightarrow{ij}$) will be the same.

The combined transport supply for both routes includes the fixed cost of transport ($C_{\overleftrightarrow{ij}}$) and the marginal cost of transport ($c_{\overleftrightarrow{ij}}$):[3]

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

The equilibrium transport prices and quantity for routes ij and ji with the round trip

[2]If demand between these markets are asymmetric enough, there may be some transport firms going empty one way ((Ishikawa and Tarui, 2018)). Potential modeling modifications can and have been made in order to accommodate this feature, for example a search framework. The theory section and online appendix B.E elaborates.

[3]These costs are assumed to be the same here. It is possible to relax this assumption without changing the main results.

effect are now no longer independently determined:

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

where the equilibrium transport price on route ji (T^*_{ji}) is 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: 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. The same 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 Panel B of figure A.1. 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.

Now suppose there is a positive demand shock on route ji where i's demand for j's good(D^i) increases while holding the other parameters constant. This raises the equilibrium transport price on route ji (equation (B.5)) as well as the equilibrium transport quantity. Through the round trip effect, the equilibrium quantity on opposite route ij also increases. Since the demand on opposite route ij has not changed, this increased transport quantity decreases its transport price (equation (B.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 opposite route ij. The blue lines in Panel B of figure A.1 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 opposite route ij which results in a lower equilibrium transport price T'^{*}_{ij}.[4]

C. Data Appendix

CONTAINER VOLUME DATA. — The container volume data from United States Maritime Administration (MARAD) comes from the Port Import Export Reporting Service (PIERS) provided by the IHS Markit. It 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 containers from the MARAD container volume data.

This data set is much more aggregated than my matched freight rates and containerized value/weight 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. In order to do this, I use the annual total US containerized imports and exports trade and the average of container freight rates for the different US ports.

Table A.11 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 A.11). 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

[4]The new lower opposite route transport price T'^{*}_{ij} will also shift the route ji supply (Q'^{S}_{ji}, equation (B.4)).

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 exported.

Table A.11—: Summary Statistics of aggregate data set matched with container volumes per year

	0	1	Total
Containers (TEU)	387,317	725,630	556,474
	(583,175)	(1917895)	(1424135)
Value per TEU	25,142	41,282	33,212
	(10,273)	(19,369)	(17,453)
Weight per TEU	8,958	10,549	9,754
	(1,666)	(7,507)	(5,483)
Iceberg Cost	.0618	.0898	.0758
	(.024)	(.14)	(.099)
Observations	103	103	206

Note: Standard deviation in parentheses. There are two 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 ($\frac{\text{Freight Rates}}{\text{Value per TEU}}$).
Source: Drewry, Census Bureau, MARAD, and author's calculations

In the last row of table A.11, 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%.[5] 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.

D. *Theory Proofs*

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 im-

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

port tariff on i is positive (equation (A.1)): $\frac{\partial p_{ij}^{Exo}}{\partial \tau_{ij}} = w_i > 0$. From equation (A.2), the derivative of j's import quantity from i with respect to its import tariff on i is negative: $\frac{\partial q_{ij}^{Exo}}{\partial \tau_{ij}} = -\epsilon w_i \left(w_i \tau_{ij} + c_{ij} \right)^{-\epsilon-1} \left[\frac{\epsilon}{\epsilon-1} \frac{1}{a_{ij}} \right]^{-\epsilon} < 0$. From equation (A.2), the derivative of j's import quantity from i with respect to its import tariff on i is also negative: $\frac{\partial X_{ij}^{Exo}}{\partial \tau_{ij}} = -(\epsilon - 1) w_i \left(w_i \tau_{ij} + c_{ij} \right)^{-\epsilon} \left[\frac{\epsilon}{\epsilon-1} \frac{1}{a_{ij}} \right]^{-\epsilon} < 0$.

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 (7)): $\frac{\partial T_{ij}^{R}}{\partial \tau_{ij}} = -\frac{1}{1+A_{ij}} w_i < 0$.

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 (8)) 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 (9), the derivative of the trade quantity from i to j with respect to j's import tariff on i is negative:

$$\frac{\partial q_{ij}^{R}}{\partial \tau_{ij}} = -\epsilon w_i \left(\frac{\epsilon}{\epsilon-1} \frac{1}{a_{ij}} (\frac{1}{1+A_{ij}} \right)^{-\epsilon} \left(w_j \tau_{ji} + w_i \tau_{ij} + c_{\overleftrightarrow{ij}} \right)^{-\epsilon-1} < 0$$

From equation (9), the derivative of the trade value from i to j with respect to j's import tariff on i is negative: $\frac{\partial X_{ij}^{R}}{\partial \tau_{ij}} = -(\epsilon - 1) w_i \left(\frac{1}{1+A_{ij}} \right)^{1-\epsilon} \left[\frac{\epsilon}{\epsilon-1} \frac{1}{a_{ij}} \left(w_j \tau_{ji} + w_i \tau_{ij} + c_{\overleftrightarrow{ij}} \right) \right]^{-\epsilon} < 0$.

The mitigating effects from the endogenous transport cost and round trip effect model is clear when comparing the import trade changes between the two models. The import quantity fall due to tariffs for the exogenous transport cost model is larger:

$$\frac{\partial q_{ij}^{Exo}/\partial\tau_{ij}}{\partial q_{ij}^{R}/\partial\tau_{ij}} = \frac{\left(w_i\tau_{ij}+c_{ij}\right)^{-\epsilon-1}}{\frac{1}{1+A_{ij}}\left(w_i\tau_{ij}+w_j\tau_{ji}+c_{\overleftrightarrow{ij}}\right)^{-\epsilon-1}} > 0$$

The same can be shown for the import value fall between the models:

$$\frac{\partial X_{ij}^{Exo}/\partial\tau_{ij}}{\partial X_{ij}^{R}/\partial\tau_{ij}} = \frac{\left(w_i\tau_{ij}+c_{ij}\right)^{-\epsilon}}{\left(\frac{1}{1+A_{ij}}\right)^{1-\epsilon}\left(w_i\tau_{ij}+w_j\tau_{ji}+c_{\overleftrightarrow{ij}}\right)^{-\epsilon}} > 0$$

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 (equation (A.3)): $\frac{\partial T_{ji}^{R}}{\partial\tau_{ij}} = \frac{1}{1+A_{ij}^{-1}}w_i > 0$. 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 (equation (A.4)): $\frac{\partial p_{ji}^{R}}{\partial\tau_{ij}} = \frac{1}{1+A_{ij}^{-1}}w_i > 0$. 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 (equation (A.4)): $\frac{\partial q_{ji}^{R}}{\partial\tau_{ij}} = -\epsilon w_i\left(\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ji}}(\frac{1}{1+A_{ij}^{-1}}\right)^{-\epsilon}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)^{-\epsilon-1} < 0$. The derivative of j's export value to i with respect to j's preference for i's good is negative (equation (A.4)): $\frac{\partial X_{ji}^{R}}{\partial\tau_{ij}} = -\left(\epsilon-1\right)w_i\left(\frac{1}{1+A_{ij}^{-1}}\right)^{1-\epsilon}\left[\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ji}}\left(w_j\tau_{ji}+w_i\tau_{ij}+c_{\overleftrightarrow{ij}}\right)\right]^{-\epsilon} < 0$.

Proof of Lemma 2 This lemma can be proven via direct calculation following lemma 1's proof.

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 (A.2)): $\frac{\partial q_{ij}^{Exo}}{\partial a_{ij}} = \epsilon a_{ij}^{\epsilon-1}\left[\frac{\epsilon}{\epsilon-1}\left(w_i\tau_{ij} + c_{ij}\right)\right]^{-\epsilon} > 0$. The derivative of j's import value from i with respect to j's preference for i's good is also positive (equation (A.2)): $\frac{\partial X_{ij}^{Exo}}{\partial a_{ij}} = \epsilon a_{ij}^{\epsilon-1}\left(\frac{\epsilon}{\epsilon-1}\right)^{-\epsilon}\left(w_i\tau_{ij} + c_{ij}\right)^{1-\epsilon} > 0$. Country j's import price from i does not change with its preference for i's good (equation (A.1)): $\frac{\partial p_{ij}^{Exo}}{\partial a_{ij}} = 0$.

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 (7)): $\frac{\partial T_{ij}^{R}}{\partial a_{ij}} = \frac{1}{a_{ij}}\frac{1}{1+A_{ij}}\frac{1}{1+A_{ij}^{-1}}\left[w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right] > 0$.

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 (8)) 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: $\frac{\partial p_{ij}^{R}}{\partial a_{ij}} = \frac{1}{a_{ij}}\frac{1}{1+A_{ij}}\frac{1}{1+A_{ij}^{-1}}\left[w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right] > 0$.

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 (9), the derivative of the trade quantity from i to j with respect to j's preference for i's good is positive: $\frac{\partial q_{ij}^{R}}{\partial a_{ij}} = \epsilon\left(\frac{1}{a_{ij}}\right)^{1-\epsilon}\left(\frac{1}{1+A_{ij}}\right)^{1-\epsilon}\left[\frac{\epsilon}{\epsilon-1}\left(w_j\tau_{ji} + w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right)\right]^{-\epsilon} > 0$. From equation (9), the derivative of the trade value from i to j with respect to j's preference for i's good is positive: $\frac{\partial X_{ij}^{R}}{\partial a_{ij}} = \left(\epsilon + A_{ij}\right)\left(\frac{1}{a_{ij}}\right)^{1-\epsilon}\left(\frac{1}{1+A_{ij}}\right)^{2-\epsilon}\left[\frac{\epsilon}{\epsilon-1}\right]^{-\epsilon}\left(w_j\tau_{ji} + w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right)^{1-\epsilon} > 0$.

The mitigating effects from the endogenous transport cost and round trip effect model is clear when comparing the import trade changes between the two models. The import quantity increase in the exogenous transport cost model is larger than the endogenous model:

$$\frac{\partial q_{ij}^{Exo}/\partial a_{ij}}{\partial q_{ij}^{R}/\partial a_{ij}} = \frac{\left(w_i\tau_{ij} + c_{ij}\right)^{-\epsilon}}{\left(\frac{1}{1+A_{ij}}\right)^{1-\epsilon}\left(w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right)^{-\epsilon}} > 0$$

The same can be shown for the import value increase between the models:

$$\frac{\partial X_{ij}^{Exo}/\partial a_{ij}}{\partial X_{ij}^{R}/\partial a_{ij}} = \frac{\epsilon\left(w_i\tau_{ij} + c_{ij}\right)^{1-\epsilon}}{\left(\epsilon + A_{ij}\right)\left(\frac{1}{1+A_{ij}}\right)^{2-\epsilon}\left(w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right)^{1-\epsilon}} > 0$$

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 (equation (A.3)): $\frac{\partial T_{ji}^{R}}{\partial a_{ij}} = -\frac{1}{a_{ij}}\frac{1}{1+A_{ij}}\frac{1}{1+A_{ij}^{-1}}\left[w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right] < 0$. 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 (equation (A.4)): $\frac{\partial p_{ji}^{R}}{\partial a_{ij}} = -\frac{1}{a_{ij}}\frac{1}{1+A_{ij}}\frac{1}{1+A_{ij}^{-1}}\left[w_i\tau_{ij} + w_j\tau_{ji} + c_{\overleftrightarrow{ij}}\right] < 0$. 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 (equation (A.4)): $\frac{\partial q_{ji}^{R}}{\partial a_{ij}} = \epsilon\frac{1}{a_{ij}}\frac{1}{1+A_{ij}}\left(\frac{1}{1+A_{ij}^{-1}}\right)^{-\epsilon}\left[\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ji}}\left(w_j\tau_{ji} + w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right)\right]^{-\epsilon} > 0$. The derivative of j's export value to i with respect to j's preference for i's good is positive (equation (A.4)): $\frac{\partial X_{ji}^{R}}{\partial a_{ij}} = (\epsilon - 1)\frac{1}{a_{ij}}\frac{1}{1+A_{ij}}\left(\frac{1}{1+A_{ij}^{-1}}\right)^{1-\epsilon}\left[\frac{\epsilon}{\epsilon-1}\frac{1}{a_{ji}}\right]^{-\epsilon}\left(w_j\tau_{ji} + w_i\tau_{ij} + c_{\overleftrightarrow{ij}}\right)^{1-\epsilon} > 0$.

E. The Round Trip Effect and Search Model

One of the main implications from the round trip effect is that trade shocks that affect a country's trade with a partner, like preference changes or tariffs, will generate spillovers onto the country's opposite direction trade with the same partner. This result relies on the assumption the quantity of goods transported between these countries are the same.[6] Specifically, trade shocks are restricted such that transport prices remains strictly positive and so are always able to clear the market. Since the carriers service a round trip journey, this means that its capacity is equal in both directions and therefore the quantity of traded goods transported in both directions is also equal.[7]

This section investigates the robustness of result by relaxing this main assumption. I start with the same Armington trade model in the main theory model with a transportation industry constrained to service a round trip. The difference in this model is this: in order to export, manufacturing firms will need to successfully find a transport firm and negotiate a transport price. This operation matches the fact that there are long term contracts in container shipping which are negotiated. These contracts can provide more favorable terms to an exporter who can commit to moving a steady stream of goods over time—a larger or more productive exporter. A more productive manufacturing firm will be able to negotiate for a lower transport price and thus export at a lower cost than a less productive firm. This search process smooths the relationship between price and quantity relative to the trade shocks which renders the balanced quantity assumption unnecessary.

This paper shows that the main spillover predictions hold without the balanced trade assumption. An increase in a country's tariffs on its trading partner's good will result in an increase in the country's export transport costs to the same partner. This is because the decrease in the country's imports due to its tariff rise will result in less incoming transport firms. From the round trip effect, the number of outgoing transport firms will decrease as well. However, since the partner's demand for the country's exports have not changed, the fall in transport supply will result in a relative rise in export transport costs which

[6] This assumption is ultimately relaxed in the counterfactual section such that the quantity of transport services between countries, like the number of containers, are the same. The transported quantities are then allowed to differ with a container loading factor.

[7] There is a second possible equilibrium outcome where there is excess capacity in one direction while the other is at capacity. However the transport price on the excess capacity direction, from that equilibrium, will be zero while the transport price on the full capacity direction will be equal to the carrier's marginal cost of servicing the round trip. Since the observed container freight rates are nonzero, the balanced quantity equilibrium is chosen to be the focus.

decreases its equilibrium export quantity and value to the partner it was imposing protectionist policies on. On the flip side, an increase in a country's preferences for its trading partner's good will result in a decrease in the country's export transport cost to the same partner and an increase in its export quantity and value to the same. This result provides evidence for the robust relationship between the round trip effect and the spillover of shocks between a country's two-way trade with one particular trading partner via transport costs.

MODEL SETUP. — The trade model is the same augmented partial equilibrium Armington model with multiple countries as the baseline model from Hummels, Lugovskyy and Skiba (2009) with three types of agents: consumers, manufacturing firms, and transport firms. Consumers in each country maximize utility by consuming two types of goods—a differentiated good that can be produced locally or abroad as well as a homogeneous local good. Countries are heterogeneous and each has one manufacturing firm which produces a unique manufacturing variety and prices like a monopolistically competitive firm. These firms choose production to just meet local demand or to export as well. If they export, they require a transport firm to ship their goods to the destination country. The firm will need to successfully find a transportation firm and negotiate a transport price in order to export. This operation is modeled as a search and bargaining process between the exporting manufacturing firm and the transport firm.

The transport firms are homogeneous and perfectly competitive. The round trip effect applies to these firms in that they have to commit to a round trip service if they enter the market. This is due to the fact that the vessels, trucks, and airplanes utilized by transport firms are re-used and so have to return to the origin so that they can continue to provide transportation services. In the model, this translates into their joint profits in both direction being non-negative.

There are five stages in this model:

1) Entry decision of the transport firms (carriers). Since carriers commit to servicing a

round trip route upon entry, they will enter the market only if their expected joint profits in both directions are non-negative.

2) Export decision of the manufacturing firms (exporters). Upon receiving their productivity draw, a manufacturing firm will choose to export or not based on their expected profits from selling the variety as well as going through the search process.

3) Export production decision of the firms. An exporter whose productivity is above the export threshold from the previous stage will produce to maximize its export profits.

4) Search and bargaining process between exporters and carriers. An exporter needs to successfully search for a carrier and bargain with them for their services in order to export. Exporters who are unsuccessful will not be able to sell their goods but will still have to pay for production costs.

5) Consumers maximize utility by consuming a mixture of locally produced and imported differentiated goods as well as a homogeneous good subject to a budget constraint.

Hummels, Lugovskyy and Skiba (2009) is the basis for manufacturing firms and consumers while Miao (2006) is the basis for the search and bargaining model between exporters and carriers. This model is solved by backward induction and each stage of the model is introduced below.

CONSUMER DEMAND. — I assume that the world consists of M potentially heterogeneous countries where each country produces a different variety (ω) of a tradeable good.[8] Consumers consume varieties of the tradeable good from this set of countries as well as a

[8]There is one exporter per country and so the good variety ω translates into the productivity draw of the exporter firm φ.

homogeneous numeraire good. The quasilinear utility function of a representative consumer in country j is

$$U_j = q_{j0} + \int^M a_{ij} q_{ij}(\omega)^{(\sigma-1)/\sigma} d\omega, \ \sigma > 1 \tag{B.6}$$

where q_{j0} is the quantity of the numeraire good consumed by country j, a_{ij} is j's preference for the variety from country i,[9] q_{ij} the quantity of variety consumed on route ij, while σ is the price elasticity of demand.[10] The numeraire good, interpreted as services here, is costlessly traded and its price is normalized to one.

TRANSPORT COST DETERMINATION. — In order for exporters in i to export q_{ij} amount of its goods to country j, they need to engage the transport services of the carrier. This is modeled as a process of search, matching, and bargaining in a decentralized market. Once a match occurs, the exporter and carrier will bargain over the price of the transport service, t_{ij}.

The object of bargain here–transportation services–deserve some explanation. It is not one container since most exporters ship more than one container. It is also not an entire ship since an average exporter does not ship 4000 containers–the average capacity of a containership. The reality is somewhere in between. As such, this model adopts the same interpretation as the baseline model—the object of bargain is a shipment of goods that includes all the products that an exporter exports to one particular country. For example if there is a exporter who wants to export 5 containers worth of goods from i to j, she will search for a carrier who is going from i to j. They negotiate for the price of the 5 container shipment and the export takes place if the negotiation is successful. A carrier picks its round trip capacity to be larger of its shipments within a round trip.

Exporters are heterogeneous, monopolistically competitive, and each produces one va-

[9]Preference parameter a_{ij} can also be interpreted as the attractiveness of country i's product to country j (Head and Mayer, 2014).

[10]Similar to Hummels, Lugovskyy and Skiba (2009), σ is the price elasticity of demand: $\frac{\partial q_{ij}}{\partial p_{ij}} \frac{q_{ij}}{p_{ij}} = -\sigma$ (equation (B.6)).

riety.[11] Carrier are homogeneous and incur cost ψ_{ij} of transporting a shipment which is independent of quantity. Examples of this cost include the loading and unloading cost, the cost of hiring a captain and crew, as well as the capital cost of deploying a ship. There are $M_{Ex,ij}$ number of exporters and $M_{C,ij}$ number of carriers which are endogenously determined in equilibrium.

There are two frictions in the search process for a trader, who can be an exporter or carrier. First, there is a positive discount rate of $r \in (0,1]$. Second, search incurs an explicit cost $\rho > 0$. Following Miao (2006), it is assumed that a trader contacts another trader according to a Poisson process with intensity ρ. A trader is a carrier with probability $\zeta_{ij}(\tilde{\varphi}_{ij}) = \frac{M_{C,ij}}{M_{C,ij}+M_{Ex,ij}}$ where $\tilde{\varphi}_{ij}$ is the exporter's productivity threshold for search. An exporter whose productivity is $\tilde{\varphi}_{ij}$ will be indifferent between exporting—which necessitates searching for a carrier—and not.

At any time, an exporter with productivity φ meets a carrier with probability $\rho\zeta(\tilde{\varphi}_{ij})$. If she can negotiate and agree on a price with the carrier, she can export her goods and obtain her producer surplus in the form of export revenue minus transport cost (t_{ij}), $\left[\left(p_{ij}(\varphi) - t_{ij}(\varphi)\right) q_{ij}(\varphi))\right]$.[12] If not, the goods expire and are not sold.[13] A carrier meets an exporter with probability $\rho(1 - \zeta_{ij}(\tilde{\varphi}_{ij}))$. If his negotiations with the exporter is successful, he sells his services for $t_{ij}(\varphi)$ and receives a profit of $\left(t_{ij}(\varphi)q_{ij}(\varphi) - \psi_{ij}\right)$. The carrier's revenue increases with the amount of goods he transports in one shipment. If the bargaining is unsuccessful, he gets zero profit.

When a exporter meets a carrier, they negotiate a transport price where one of the two randomly announces a take-it-or-leave-it price offer. If the offer is accepted, the trade occurs and they leave the market. If the offer is rejected, the exporter continues searching. Let $V_{Ex,ij}(\varphi)$ be the expected payoff of an exporter with productivity φ and $V_{C,ij}$ be the

[11]Following Chaney (2008) and Melitz (2003), exporters are heterogeneous in their productivity (assume Pareto distribution $G(\varphi) = P(\varphi^* < \varphi)$ of productivity φ with shape parameter $\gamma \sim [1, +\infty)$.

[12]Note that including tariffs in the producer surplus would be straightforward. It would involve adding another term after transport cost and since tariffs are exogenous here its comparative statics would be the same as assuming exogenous transport cost. If tariffs from i to j are τ_{ij}, the producer surplus is $\left(p_{ij}(\varphi) - t_{ij}(\varphi) - \tau_{ij}\right) q_{ij}(\varphi))$.

[13]The inability of exporters to sell their goods if the search is unsuccessful is a simplification. An earlier version of this model allows for unsuccessful exporters to sell their goods locally. The end result between the earlier model and the present version is qualitatively similar. This version is chosen for simplicity.

expected payoff of a carrier. The bargaining problem between exporter and carrier is as follows:

$$\max_{t_{ij}} \left[\Big(p_{ij}(\varphi) - t_{ij}(\varphi) \Big) q_{ij}(\varphi) - V_{Ex,ij}(\varphi) \right]^{\eta} \left[t_{ij}(\varphi) q_{ij}(\varphi) - \psi_{ij} - V_{C,ij} \right]^{1-\eta}$$

where p_{ij} is the per unit price of the export goods, t_{ij} is the per unit transport price, q_{ij} is the quantity of exports, ψ_{ij} is the cost to transport the goods,[14] and $\eta \in (0,1)$ is the relative bargaining power of the exporter.

This bargaining problem is subject to the fact that exporters and carriers are risk-neutral and enter the market if their expected payoff is positive and only if their expected payoff is non-negative, $\Big(p_{ij}(\varphi) - t_{ij}(\varphi) \Big) q_{ij}(\varphi) \geq V_{Ex,ij}(\varphi)$ and $t_{ij}(\varphi) q_{ij}(\varphi) - \psi_{ij} \geq V_{C,ij}$. As such, the transport price for one unit of good is as follows:

$$t_{ij}(\varphi) = \frac{1}{q_{ij}(\varphi)} \left[\eta \Big(\psi_{ij} + V_{C,ij} \Big) + (1-\eta) \Big(p_{ij}(\varphi) q_{ij}(\varphi) - V_{Ex,ij}(\varphi) \Big) \right] \tag{B.7}$$

where the transport price is increasing in the cost of providing transport services (ψ_{ij}), the exporter's relative bargaining power (η), as well as the expected payoff of the carriers ($V_{C,i}$). It is decreasing in the relative bargaining power of the carriers ($1-\eta$) and the expected payoff of the exporters ($V_{Ex,i}$). The effect of export quantity $q_{ij}(\varphi)$ on transport price depends on the bargaining parameters, cost of shipping, and magnitudes of the value functions.[15]

The value function of the exporter's search process ($V_{Ex,ij}$) conditional on its productivity φ being above the search threshold $\varphi \geq \tilde{\varphi}_{ij}$, is:

$$rV_{Ex,i}(\varphi, \tilde{\varphi}_{ij}) = \rho \zeta_{ij}(\tilde{\varphi}_{ij}) \max \left\{ \left[\Big(p_{ij}(\varphi) - t_{ij}(\varphi) \Big) q_{ij}(\varphi) - V_{Ex,ij}(\varphi) \right], 0 \right\} \tag{B.8}$$

[14] As mentioned earlier, this cost is independent of quantity. It is possible to include a marginal cost of transporting the goods that also depends on quantity and the results would not change.

[15] $\frac{\partial t_{ij}(\varphi)}{\partial q_{ij}(\varphi)} = \frac{(1-\eta)V_{Ex,ij}(\varphi) - \eta(\psi_{ij} + V_{C,ij})}{q_{ij}(\varphi)^2}$.

where the probability of meeting a carrier is $\rho\zeta(\tilde{\varphi}_{ij})$ and the exporter's total profit from exporting is the difference between its export revenue and transport cost, $\Big(p_{ij}(\varphi) - t_{ij}(\varphi)\Big) q_{ij}(\varphi)$.[16]

The value function of the carrier $V_{C,ij}$ is as follows:

$$rV_{C,ij}(\tilde{\varphi}_{ij}) = \rho(1 - \zeta_{ij}(\tilde{\varphi}_{ij}))E_F\left[\max\left\{\left[t_{ij}(\varphi)q_{ij}(\varphi) - \psi_{ij} - V_{C,i}\right], 0\right\}\right] \tag{B.9}$$

where $\rho(1 - \zeta_{ij}(\tilde{\varphi}_{ij}))$ is the probability of a carrier meeting an exporter, and the carrier's expected profits is the difference between its revenue and its cost from providing transport.

Incorporating the bargaining outcome of the transport price in (B.7), the exporter value function from (B.8) as well as the the carrier's value function from (B.9) can be re-written as

(B.10)

$$rV_{Ex,ij}(\varphi, \tilde{\varphi}_{ij}) = \rho\zeta_{ij}(\tilde{\varphi}_{ij})\eta \max\left\{\left[p_{ij}(\varphi)q_{ij}(\varphi) - V_{Ex,ij}(\varphi) - \psi_{ij} - V_{C,ij}\right], 0\right\}$$

$$rV_{C,ij}(\tilde{\varphi}_{ij}) = \rho(1 - \zeta_{ij}(\tilde{\varphi}_{ij}))(1 - \eta)E_G\left[\max\left\{\left[p_{ij}(\varphi)q_{ij}(\varphi) - V_{Ex,ij}(\varphi) - \psi_{ij} - V_{C,ij}\right], 0\right\}\right]$$

The exporter's value function $V_{Ex,i}(\varphi, \tilde{\varphi}_{ij})$ is increasing in its productivity φ since more productive exporters have a higher willingness to pay for transport services. So exporters from i to j, there exists a cutoff value $\tilde{\varphi}_{ij} > 0$ such that only exporters with $\varphi \geq \tilde{\varphi}_{ij}$ have non-negative gains from trade. This cutoff value is the search threshold $\tilde{\varphi}_{ij}$:

$$p(\tilde{\varphi}_{ij})q(\tilde{\varphi}_{ij}) - V_{Ex,ij}(\tilde{\varphi}_{ij}, \tilde{\varphi}_{ij}) - \psi_{ij} - V_{C,ij}(\tilde{\varphi}_{ij}) = 0 \tag{B.11}$$

An exporter with productivity $\tilde{\varphi}_{ij}$ will be indifferent between searching or not, $V_{Ex,ij}(\tilde{\varphi}_{ij}, \tilde{\varphi}_{ij}) = 0$. Any exporter whose productivity is lower than the search threshold $\varphi < \tilde{\varphi}_{ij}$ will have

[16]Since exporters have already produced their goods before searching for a carrier, their search value function does not include production costs of their goods.

negative gains from searching and exporting $V_{Ex,ij}(\varphi, \tilde{\varphi}_{ij}) < 0$. As such, only exporters with productivity above this threshold $\varphi \geq \tilde{\varphi}_{ij}$ will enter the search.

Since the exporter's expected payoff at the threshold is zero ($V_{Ex,ij}(\tilde{\varphi}_{ij}, \tilde{\varphi}_{ij}) = 0$), equation (B.11) also determines the carrier's value function for one direction of a round trip from i to j:

$$V_{C,ij}(\tilde{\varphi}_{ij}) = p(\tilde{\varphi}_{ij})q(\tilde{\varphi}_{ij}) - \psi_{ij} \equiv R_{ij} \tag{B.12}$$

A carrier's expected payoff is equal to the marginal participating exporter's export revenue minus the cost of providing transport. When a carrier meets the marginal participating exporter, the transport price is a function of the exporter's productivity which in this case is the search threshold ($t_{ij}(\tilde{\varphi}_{ij})$). Since all the carriers are homogeneous, R_{ij} is the common reservation value for all carriers.

In steady state, the number of exporters $M_{Ex,ij}$ should equal the number of firms whose productivity is above the search threshold. Since exporters and carriers exit the market in pairs once a trade is made, the condition below holds:[17]

$$\zeta_{ij}(\tilde{\varphi}_{ij})\rho M_{Ex,ij} = \rho(1 - \zeta_{ij}(\tilde{\varphi}_{ij}))M_{C,ij} \tag{B.13}$$

Export production. — In Chaney (2008) and Melitz (2003), there are two trade barriers from the perspective of an exporter: (1) a fixed cost to export defined in terms of the numeraire, and (2) a variable transport cost, or transport price as introduced in the previous section, $t_{ij}(\varphi)$ that exporters in country i with productivity φ have to pay to ship their goods to destination j. In this model, transport cost is modeled as the only trade barrier.[18] Each exporter draws a random unit of productivity φ. This draw determines their willingness to pay for transport services and hence the transport price $t_{ij}(\varphi)$. In addition, an

[17] This follows from the matching probability which is the probability of meeting a carrier: $\zeta_{ij}(\tilde{\varphi}_{ij}) = \frac{M_{C,ij}}{M_{C,ij}+M_{Ex,ij}}$.

[18] The endogenous transport cost generates the fixed cost to export since it has a fixed cost to provide transport ψ_{ij}.

exporter has to search for its carrier in order to export. From the previous section, the probability of meeting a carrier is $\rho\zeta_{ij}(\tilde{\varphi}_{ij})$ which is a function of the share of carriers in i, $\zeta_{ij}(\tilde{\varphi}_{ij}) = \frac{M_{C,ij}}{M_{C,ij}+M_{Ex,ij}}$.

An exporter with productivity φ chooses its export price to maximize domestic and export profits. An exporter who is productive enough to export will also produce for domestic consumption. However, it can only export if its goods can be transported abroad by a carrier. Otherwise, the exporter will not be able to export. In both cases it will still have to pay for production costs since the production decision has already been made. It is assumed that there are no domestic transport costs ($t_{ii} = 0$). The export profit maximization problem for an exporter with productivity φ in country i selling to country j is as follows:

$$\max_{p_{ij}(\varphi)} \pi_{ij}(\varphi) = \underbrace{V_{Ex,ij}(\varphi, \tilde{\varphi}_{ij})}_{\substack{\text{Surplus from exporting} \\ \text{if search is successful}}} - \underbrace{c_{ij}(\varphi)q_{ij}(\varphi)}_{\substack{\text{Production cost regardless} \\ \text{of search outcome}}} \tag{B.14}$$

where it is made up of two terms. The first term is the surplus from exporting if the exporter successfully finds a carrier. The second term is the marginal cost of production that the exporter has to pay in order to produce $q_{ij}(\varphi)$ units of its good. The marginal cost term is made up of the price of the sole input, labor (wages w_i), and the exporter's productivity:

$$c_{ij}(\varphi) \equiv \frac{w_i}{\varphi} \tag{B.15}$$

EXPORTER ENTRY DECISION. — The entry condition in equation (B.11) determines the search threshold $\tilde{\varphi}_{ij}$, where exporters are indifferent between searching or not. Here exporters with productivity $\bar{\varphi}_{ij}$ will earn zero profit from exporting and so are indifferent between exporting or not:

$$\pi(\bar{\varphi}_{ij}) = 0 \rightarrow V_{Ex,ij}(\bar{\varphi}_{ij}, \tilde{\varphi}_{ij}) = c_{ij}(\bar{\varphi}_{ij})q_{ij}(\bar{\varphi}_{ij}) = \frac{w_i}{\bar{\varphi}_{ij}}q_{ij}(\bar{\varphi}_{ij}) \tag{B.16}$$

In equilibrium, the search threshold and the exporting threshold should be the same $\bar{\varphi}_{ij} = \tilde{\varphi}_{ij}$.

CARRIER ENTRY DECISION. — In order for the carriers to enter the market, their expected profits from their round trip service has to be non-negative. This means that for any round trip between i and j, $V_{C,ij}$ and $V_{C,ji}$ has to be non-negative:

$$V_{C,ij}(\tilde{\varphi}_{ij}) + V_{C,ji}(\tilde{\varphi}_{ij}) \geq 0 \tag{B.17}$$

This means that a carrier could still serve a round trip journey when one direction generates negative profits if the other direction makes up for the loss.

Since carriers who enter the market commit to a round trip route, there has to be the same number of carriers going from i to j and back

$$M_{C,ij} = M_{C,ji} \tag{B.18}$$

SOLVING FOR THE EQUILIBRIUM. — For the tradeable good, the solution to the consumer's problem in (B.6) takes the CES form:

$$q_{ij} = \left[\frac{\sigma}{\sigma - 1}\frac{1}{a_{ij}}p_{ij}\right]^{-\sigma} \tag{B.19}$$

An increase in j's preference for i's good (a_{ij}) will increase its demanded quantity while an increase in the export price (p_{ij}) will decrease the quantity.

The exporter's value function in (B.10), conditional on its productivity being above the search threshold $\tilde{\varphi}_{ij}$, can be rewritten as:

$$V_{B,i}(\varphi,\tilde{\varphi}_{ij}) = \frac{\rho\eta\zeta_{ij}(\tilde{\varphi}_{ij})}{r+\rho\eta\zeta_{ij}(\tilde{\varphi}_{ij})}\left[p_{ij}(\varphi)q_{ij}(\varphi)-\psi_{ij}-R_{ij}\right], \text{ for } \varphi \geq \tilde{\varphi}_{ij} \tag{B.20}$$

By inserting the rewritten exporter's value function from (B.20) into the transport price bargaining outcome in (B.7), the following can be shown:

(B.21)

$$t_{ij}(\varphi) = \frac{1}{q_{ij}(\varphi)}\left[\psi_{ij}+R_{ij}+\frac{r(1-\eta)}{r+\rho\zeta_{ij}(\tilde{\varphi}_{ij})\eta}\left[\left(p_{ij}(\varphi)q_{ij}(\varphi)-\psi_{ij}-R_{ij}\right)\right]\right], \text{ for } \varphi \geq \tilde{\varphi}_{ij}$$

Holding the search cost ρ and the productivity threshold $\tilde{\varphi}_{ij}$ constant, the transport price is decreasing in the match probability ($\frac{\partial t_{ij}}{\partial \zeta_{ij}} \leq 0$) and in the cost for the carrier to provide transport ($\frac{\partial t_{ij}}{\partial \psi_{ij}} \leq 0$). Since exporter revenue $p(\varphi)q(\varphi)$ is increasing in productivity φ ($\frac{\partial p(\varphi)q(\varphi)}{\partial \varphi} \geq 0$) and total transport price is increasing in exporter revenue ($\frac{\partial t_{ij}(\varphi)q(\varphi)}{\partial p(\varphi)q(\varphi)} \geq 0$), total transport cost is increasing in productivity–more productive exporters pay higher total transport costs. However, the per unit transport prices these exporters pay are decreasing in the volume of goods their export. As such, per unit transport price is decreasing in productivity—all else equal, more productive exporters pay less for transport.

The equilibrium matching probability ζ_{ij} is solved for by substituting the new exporter value function in (B.20) into the carrier's value function in (B.10)

$$\zeta_{ij}(\tilde{\varphi}_{ij}) = \frac{\rho(1-\eta)E_G\left[p_{ij}(\varphi)q_{ij}(\varphi)-\psi_{ij}-R_{ij}\right]-r(R_{ij})}{\rho\left[\eta R_{ij}+(1-\eta)E_G\left[p_{ij}(\varphi)q_{ij}(\varphi)-\psi_{ij}-R_{ij}\right]\right]} \tag{B.22}$$

where $E_G\left[p_{ij}(\varphi)q_{ij}(\varphi)-\psi_{ij}-R_{ij}\right] = \int_{\tilde{\varphi}_{ij}}^{\infty} p_{ij}(\varphi)q_{ij}(\varphi)-\psi_{ij}-R_{ij}\, dG(\varphi)$.

Given equilibrium matching probability $\zeta_{ij} = \frac{M_{C,ij}}{M_{C,ij}+M_{Ex,ij}}$ and the carrier's non-negative round trip profits in (B.17), the number of carriers will match the number of exporters who choose to enter from condition (B.11). The optimal export profit-maximizing price

$p_{ij}(\varphi)$ from (B.14) is a constant mark-up over unit cost of production plus a transport cost of the iceberg form T_{ij}:

$$\begin{aligned} p_{ij}(\varphi) &= \frac{\sigma}{\sigma-1}\frac{w_i}{\varphi}\frac{r+\rho\zeta_{ij}(\tilde{\varphi}_{ij})\eta}{\rho\zeta_{ij}(\tilde{\varphi}_{ij})\eta\left(r+\rho\zeta_{ij}(\tilde{\varphi}_{ij})\right)} \\ &\equiv \frac{\sigma}{\sigma-1}\frac{w_i}{\varphi}T_{ij}(\tilde{\varphi}_{ij}) \end{aligned} \tag{B.23}$$

Since ρ, ζ_{ij}, η, and r are all fractions respectively, $T_{ij}(\tilde{\varphi}_{ij}) > 1$.[19]

The export price for goods from country i to j is increasing in local wages w_i, decreasing in the exporter's productivity φ, and increasing in the cost of transport T_{ij}. The cost of shipping increases with the decrease in the probability of successful search $\rho\zeta_{ij}$. Intuitively, the exporter's bargaining power η relative to the carrier decreases $\eta \to 0$, the transport price increases $T_{ij} \to \infty$ as does the export price $p_{ij} \to \infty$.

The export profits of an exporter with productivity $\varphi > \tilde{\varphi}_{ij}$ from i to j is

$$\begin{aligned} \pi_{ij}(\varphi) &= \frac{\rho\zeta_{ij}(\tilde{\varphi}_{ij})\eta\left(r+\rho\zeta_{ij}(\tilde{\varphi}_{ij})\right)}{r+\rho\zeta_{ij}(\tilde{\varphi}_{ij})\eta}\left[p_{ij}(\varphi)q_{ij}(\varphi) - R_{ij} - \psi_{ij}\right] - \frac{w_i}{\varphi}q_{ij}(\varphi) \\ &= \frac{1}{T_{ij}(\tilde{\varphi}_{ij})}\left[p_{ij}(\varphi)q_{ij}(\varphi) - R_{ij} - \psi_{ij}\right] - \frac{w_i}{\varphi}q_{ij}(\varphi) \end{aligned} \tag{B.24}$$

Here a decrease in the transport price (T_{ij}), wages (w_i), carrier's reservation value (R_{ij}), and the cost of providing transport services (ψ_{ij}) will increase exporter profits. An increase in the export revenue ($p_{ij}(\varphi)q_{ij}(\varphi)$) will also increase profits.

In equilibrium, an exporter's search threshold is equal to its export threshold: $\bar{\varphi}_{ij} = \tilde{\varphi}_{ij}$. Hence the export productivity threshold of the exporters ($\bar{\varphi}_{ij}$) can be pinned down by equating their value function from search (equation (B.20)) to the cost of production that they pay for regardless of the search outcome. This means that the exporter earns zero

[19]Since $\eta < 1$, $r > \eta r \to r + \rho\zeta_{ij}\eta > \eta r + \rho\zeta_{ij}\eta \to \frac{r+\rho\zeta_{ij}\eta}{\eta\rho\zeta_{ij}\eta} > 1$.

profit in equation (B.14):[20]

$$\pi_{ij}(\bar{\varphi}_{ij}) = 0 \rightarrow V_{Ex,ij}(\bar{\varphi}_{ij}, \bar{\varphi}_{ij} = \tilde{\varphi}_{ij}) = c_{ij}(\bar{\varphi}_{ij})q_{ij}(\bar{\varphi}_{ij})$$

$$\bar{\varphi}_{ij} = \lambda_1 \left[\frac{R_{ij} + \psi_{ij}}{a_{ij}^{\sigma}}\right]^{\frac{1}{\sigma-1}} w_i T_{ij}(\bar{\varphi}_{ij}) \tag{B.25}$$

Note that this export threshold is not solved in its entirety yet since the transport cost still takes the threshold as a function due to matching probability $\zeta_{ij}(\bar{\varphi}_{ij})$. Any manufacturing firms who draw a productivity lower than this threshold will choose to only produce domestically. All else equal, an increase in the reservation value of the carrier (R_{ij}), the cost of providing transport (ψ_{ij}), the cost of production (w_i), and the transport price ($T_{ij}(\bar{\varphi}_{ij})$) raises the export threshold which lowers the number of exporters. An increase in j's preference for i's product (a_{ij}) will decrease the export threshold which increases the number of exporters.

Between two countries k and l, the equilibrium in this model can be described by the following (for $k,l = i,j$ and $k \neq l$): the utility-maximizing quantity of goods traded back and forth (q_{kl}), value functions of exporters and carriers ($V_{Ex,kl}$ and $V_{C,kl}$), negotiated transport prices ($t_{kl}(\varphi)$), profit-maximizing prices of goods traded back and forth ($p_{kl}(\varphi)$), marginal exporters ($\bar{\varphi}_{kl}$), and the stock of exporters and carriers ($M_{Ex,kl}$ and $M_{C,kl}$) such that

(i) Quantity q_{kl} satisfies the consumer utility function in (B.6),

(ii) Value functions $V_{Ex,kl}$ and $V_{C,kl}$ satisfy (B.10),

(iii) Transport price $t_{kl}(\varphi)$ satisfies the bargaining outcome in (B.7),

(iv) Price of traded goods $p_{kl}(\varphi)$ satisfies the exporter's profit function in (B.14),

(v) The productivity of the marginal exporters $\bar{\varphi}_{kl}$ is given by (B.25),

(vi) The stock of carriers between k and l are the same ($M_{C,kl} = M_{C,lk}$ from (B.18)), and

[20]Constant $\lambda_1 \equiv \left[\frac{\sigma}{\sigma-1}^{-2\sigma}\frac{1}{\sigma-1}\right]^{\frac{1}{\sigma-1}}$

(vii) The flow of carriers and exporters satisfies the market clearing condition in (B.13)

Aggregate trade flows from i to j is a share of the total expenditure on goods in country j, which is as follows:[21]

$$X_{ij}(\bar{\varphi}_{ij}) = \int_{\bar{\varphi_{kj}}}^{\infty} p_{ij}(\varphi) q_{ij}(\varphi) dG(\varphi) \tag{B.26}$$
$$= \lambda a_{ij}^{\frac{\sigma\gamma}{\sigma-1}} \left(R_{ij} + \psi_{ij}\right)^{1-\frac{\gamma}{\sigma-1}} \left(w_i T_{ij}(\bar{\varphi}_{ij})\right)^{-\gamma}$$

where all else equal, an increase in j's preference for i (a_{ij}) will increase aggregate trade flows. On the other hand, increasing the wages (w_i), transport cost (T_{ij}), and the cost of providing transport (ψ_{ij}) will decrease aggregate flows.

COMPARATIVE STATICS. — One of the main theoretical results in Proposition 1 is that the round trip effect generates spillovers of trade shocks on the origin country's imports from its trading partner 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. These results are based on the assumption that the trade shocks are restricted such that transport prices in both directions can clear the market resulting in the same quantity of traded goods between countries. The model in this paper emphasizes the robustness of the baseline results by providing the same spillover outcome without relying on the same assumption. This shows that the balanced quantity assumption is not crucial for the round trip effect to generate spillovers between a country's two-way trade with a partner.

Specifically, Lemma 1 shows that an increase in the origin country's tariffs on its trading partner decreases both its imports from and exports to the same partner. The inverse applies for an increase in its preferences for its trading partner (Lemma 2). Similarly, this model shows that an increase in the origin country's tariff will decrease its exports to the same partner. Inversely, an increase in its preference for goods from its partner will also

[21] Constant $\lambda \equiv \frac{\sigma}{\sigma-1}^{1+\frac{2\sigma\gamma}{1-\sigma}} \frac{1}{\sigma-1}^{\frac{\gamma}{\sigma-1}-1} \frac{\gamma}{\gamma-(\sigma-1)}$.

increase its exports to the same partner.[22]

I first focus on country j's preference for j, a_{ij}. When country j's preference for goods from country i increases, it is intuitive that j's import quantity q_{ij} should increase (equation (B.19)). Since this also increases the revenue from exporting to country j which increases aggregate trade value X_{ij} (equation (B.26)), the number of exporters from i to j will also increase (lowering the export threshold $\bar{\varphi}_{ij}$). This increases the demand for transport services from i to j which increases the number of carriers along the same route. Due to the round trip effect, carriers who go from i to j have to return (equation (B.18)). As such, while trade conditions from j to i remain unchanged (including i's preferences for goods from j a_{ji}), there are now more carriers available to bring goods from j to i. From (B.13), this increases the matching probability between exporters and carriers from j to i: $\frac{\partial \zeta_{ji}}{M_{C,ji}} > 0$.[23] As a result, the transport price from j to i decreases ($\frac{\partial T_{ji}}{\zeta_{ji}} < 0$, equation (B.23)).[24] In turn, the export quantity and value from j to i increases while the export price falls.[25] The following lemma can be shown:[26]

Lemma 5. *When transport cost is determined on a round trip basis and through a search and bargaining process, an increase in origin country j's preference for its trading partner i's goods will affect both the origin country's imports and exports to its partner. 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.*

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

In order to establish these results for tariffs, I first incorporate tariffs into this model. Tariffs are paid by the exporters and so they are incorporated into their profit functions in

[22] The comparative statics for the mitigating effects on the imports side is not shown here for two reasons. First, the spillover results are novel and thus are the focus here. Second, this model does not yield a close-formed solution and so the mitigating effects would have to be shown analytically.

[23] $\frac{\partial \zeta_{ji}}{M_{C,ji}} = \frac{1}{M_{Ex,ji}} > 0$

[24] $\frac{\partial T_{ji}}{\zeta_{ji}} = -\frac{\rho^2 \zeta_{ji}^2 \eta + \left(r^2 + 2\rho\zeta_{ji}\right)}{\zeta_{ji}\left(r + \rho\zeta_{ji}\right)} < 0$

[25] $\frac{\partial p_{ji}}{T_{ji}} > 0$, $\frac{\partial q_{ji}}{T_{ji}} < 0$, and $\frac{\partial X_{ji}}{T_{ji}} < 0$.

[26] See Section B.E for proof.

(B.14) as such:

$$\max_{p_{ij}(\varphi)} \pi_{ij}(\varphi) = \rho\zeta_{ij}(\varphi, \tilde{\varphi}_{ij}) \Big(p_{ij}(\varphi) - t_{ij}(\varphi) \Big) q_{ij}(\varphi) - \tau_{ij} c_{ij}(\varphi) q_{ij}(\varphi) \tag{B.27}$$

where the first two terms are the surplus from being able to export if the exporter successfully finds a carrier. The second term is the marginal cost of production that the exporter has to pay in order to produce $q_{ij}(\varphi)$ units of its good which includes the tariff on these goods $\tau_{ij} > 1$.[27] The marginal cost term is made up of the price of the sole input, labor (w_i), and the exporter's productivity. The equilibrium for this model with tariffs is very similar to the equilibrium defined previously where tariffs enter the same way as wages w_i.

When country j increases its tariffs on goods from country i, it is again intuitive that its import price p_{ij} should increase which will lead to a fall in quantity q_{ij} (equation (B.19)).[28] Since this then decreases the revenue from exporting to country j (X_{ij}, equation (B.26)), the number of exporters will also fall which increases the export threshold $\bar{\varphi}_{ij}$. This decreases the demand for transport services from i to j which decreases the number of carriers along the same route. Due to the round trip effect, there are now less carriers available to bring goods from j to i all else equal (equation (B.18)). From (B.13), this decreases the matching probability between exporters and carriers from j to i: $\frac{\partial \zeta_{ji}}{M_{C,ji}} > 0$. As a result, the transport price from j to i increases ($\frac{\partial T_{ji}}{\zeta_{ji}} < 0$, equation (B.23)). The export quantity and value from j to i falls while price increases. The following lemma can be shown:[29]

Lemma 6. *When transport cost is determined on a round trip basis and through a search and bargaining process, an increase in the origin country j's import tariffs on its trading partner i's goods will affect both the origin country's imports and exports to its partner. On the export side, the origin country's export freight rate and price to its partner will increase while its export quantity*

[27] This method of modeling is chosen for simplicity. Another way to model tariffs here is for the firms to only pay for it if it successfully exports. This alternative method would not change the results but would complicate the solution.

[28] Since $p_{ij}(\varphi) = \frac{\sigma}{\sigma-1} \frac{w_i \tau_{ij}}{\varphi} \frac{r+\rho\zeta_{ij}(\tilde{\varphi}_{ij})\eta}{\rho\zeta_{ij}(\tilde{\varphi}_{ij})\eta\left(r+\rho\zeta_{ij}(\tilde{\varphi}_{ij})\right)} \equiv \frac{\sigma}{\sigma-1} \frac{w_i \tau_{ij}}{\varphi} T_{ij}(\tilde{\varphi}_{ij})$, $\frac{\partial p_{ji}}{\tau_{ij} < 0}$.

[29] Section B.E for proof.

and value decreases.

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

From the results from these two lemmas, the following proposition can be established:

Proposition 3. *A model with the round trip effect predicts a spillover effect of trade shocks on the origin country's imports from its trading partner 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. This result is robust under a balanced trade quantity assumption as well as a search and bargaining process between exporter and carrier without the balanced assumption. With the search and bargaining model, the traded quantities between countries are no longer constrained to be the same.*

An increase in the origin country's tariffs on its trading partner decreases its exports to the same partner. The same applies inversely for a positive preference shock.

PROOFS. — **Proof of Lemma 5** When country j's preference for goods from country i (a_{ij}) increases, it is intuitive that j's import quantity q_{ij} should also increase (equation (B.19)). Since in turn increases the export revenue from country i to j which increases the route's aggregate trade value X_{ij} (equation (B.26)). The number of exporters from i to j will also increase from the fall in export threshold $\bar{\varphi}_{ij}$).

Since there are more goods being shipped from i to j, the demand for transport services from i to j also goes up which increases the number of carriers along the same route. Due to the round trip effect, carriers who go from i to j have to return (equation (B.18)). As such, while trade conditions from j to i remain unchanged (including i's preferences for goods from j a_{ji}), there are now more carriers available to bring goods from j to i.

From (B.13), the matching probability between exporters and carriers from j to i now increases:

$$\frac{\partial \zeta_{ji}}{M_{C,ji}} = \frac{1}{M_{Ex,ji}} > 0 \tag{B.28}$$

Since there are more carriers, the match probability between carriers and exporters from j to i is now higher.

From the higher matching probability, the transport price from j to i decreases:

$$\frac{\partial T_{ji}}{\zeta_{ji}} = -\frac{\rho^2 \zeta_{ji}^2 \eta + \left(r^2 + 2\rho\zeta_{ji}\right)}{\zeta_{ji}\left(r + \rho\zeta_{ji}\right)} < 0 \tag{B.29}$$

This is due to the fact that an exporter now has a relatively better chance of finding a carrier to match with and also more outside options during its bargaining process.

In turn, cheaper transport price means that it's now cheaper to export. As such, the export quantity and value from j to i increases while the export price falls.

Proof of Lemma 6 When country j increases its tariffs on goods from country i (τ_{ij}), it is intuitive that its import price p_{ij} should increase which will lead to a fall in quantity q_{ij} (equation (B.19)). Since an export price increase will decreases the overall export revenue from country i to j (X_{ij}, equation (B.26)), the number of exporters will also fall. Similarly, this can be described as an increase in the export threshold $\bar{\varphi}_{ij}$.

Since the amount of goods being shipped from i to j has decreased, the demand for transport services from i to j decreases as well which lowers the number of carriers along the same route. Due to the round trip effect, there are now less carriers available to bring goods from j to i all else equal (equation (B.18)).

From (B.13), this decreases the matching probability between exporters and carriers from j to i:

$$\frac{\partial \zeta_{ji}}{M_{C,ji}} = \frac{1}{M_{Ex,ji}} > 0 \tag{B.30}$$

With less carriers, there is a lower probability of matching between exporters and carriers.

As a result, the transport price from j to i increases since exporters now have less outside options in the form of other carriers as well as less chances of meeting a carrier:

$$\frac{\partial T_{ji}}{\zeta_{ji}} = -\frac{\rho^2 \zeta_{ji}^2 \eta + \left(r^2 + 2\rho\zeta_{ji} \right)}{\zeta_{ji} \left(r + \rho\zeta_{ji} \right)} < 0 \tag{B.31}$$

All this result in the export quantity and value from j to i falling while the export price increases.