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The Trade Reducing Effects of Market Power in International Shipping

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Abstract

Developing countries pay substantially higher transportation costs than developed nations, which leads to less trade and perhaps lower incomes. This paper investigates price discrimination in the shipping industry and the role it plays in determining transportation costs. In the presence of market power, shipping prices depend on the demand characteristics of goods being traded. We show theoretically and estimate empirically that shipping firms charge higher prices when transporting goods with higher product prices, lower import demand elasticities, and higher tariffs, and when facing fewer competitors on a trade route. These characteristics explain more variation in shipping prices than do conventional proxies such as distance, and significantly contribute to the higher shipping prices facing the developing world. Markups increase shipping prices by at least 83 percent for the mean shipment in Latin American imports. Our findings are also important for evaluating the impact of tariff liberalization. Shipping firms decrease prices by 1-2 percent for every 1 percent reduction in tariffs.

I. Introduction

Trade and development economists have become increasingly focused on trade barriers and the costs of remoteness. Geographically remote countries trade less, and this appears to reduce both the level (Redding and Venables, 2004) and growth rate (Frankel and Romer, 1999) of income. While we do not know precisely why remoteness matters, an obvious possibility is that isolated countries face significantly higher transportation costs.

Table 1 provides data on transportation costs for imports into the US and a number of Latin American countries, and makes clear several basic facts about costs of trade. One, ad valorem transport costs are negatively correlated with per capita income – they are 1.5-2.5 times higher for Latin American importers than for the United States, and systematically higher for low income exporters into a given import market.

Two, transport costs are comparable in size to, or larger than, tariffs. For the median good in US imports transportation represents 85 percent of the total costs (transport plus tariffs) faced by an exporter. For Latin American importers, transportation costs represent from 31 to 63 percent of total costs faced by exporters in the median good.

Three, despite the fact that international transportation technology and the use of containerized liner shipping is common across goods and exporters, transportation costs vary enormously. For US imports, the coefficient of variation (across exporters and goods) in ad-valorem transportation costs is 1.4, meaning that shipments with costs that are one-standard deviation above the mean have costs 140 percent greater than the mean. Even if we hold constant the product in question there is tremendous variation in transport costs across exporters to a given market. For US imports, the exporter one standard deviation above the mean pays shipping prices 89 percent higher than the mean. Variability in Latin America is comparable to or higher than the US. Given their size and variability, transportation costs are likely to play an especially important role in changing relative prices – lowering trade volumes in the aggregate and altering patterns of trade across goods and partners.

In this paper we investigate the hypothesis that the exercise of market power by shipping companies can help explain the level of shipping costs, their variability across goods and exporters, and critically, can provide insights into why costs are higher for developing countries. If correct, transportation costs should not be viewed as some exogenously set friction that limits trade, as is

most commonly assumed when adopting the "iceberg" formulation. Rather, transportation costs are a barrier to trade that, like tariffs, are amenable to reduction through concerted policy action.

There are two reasons to suspect the exercise of market power might be especially important in international shipping. First, minimum efficient scale in shipping is significant. The capacity of a modern container ship is large relative to the export volumes produced by smaller countries, and there are substantial economies of scope in offering transport services over a network of ports. One way to see this effect is to calculate the number of liner shipping firms operating on a particular trade route. In the fourth quarter 2006 one in six importer-exporter pairs world-wide was served by a single liner "service", meaning that only one ship was operating on that route. Over half of importer-exporter pairs were served by three or fewer ships, and in many cases all of the ships on a route were owned by a single shipping firm.[1] Figure 1 plots the number of shipping firms operating between a given exporter and the US, graphed against the GDP of the exporter. Trade routes involving larger countries have higher trade volumes, more ships and more liner companies operating on them.

Second, even on trade routes with multiple firms operating, the ferocity of competition is in question. Shipping companies on densely traded routes are organized into cartels known as liner conferences that discuss shipping prices and market shares. The role of market power in shipping has been a long standing concern in policy circles (see Fink et al 2000 for a recent review). More recently, the European Union Competitiveness Council concluded that cartelization had led to a less competitive shipping market and higher shipping prices, and repealed a block exemption to its competition laws for liner conferences.[2] Beginning in 2008 liner firms serving the EU will no longer be able to meet in conferences or to collude in setting prices and market share.

But are these concerns valid? The existence of liner conferences does not prove that they collude successfully nor indicate how much lower shipping prices would be in their absence. A theoretical literature on contestability argues that a small number of shipping lines serving a particular route is not prima facie evidence of market power, so long as entrants stand ready to

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[1] Data extracted by the Port2Port evaluation tool, www.compairdata.com, December 2006.
[2] Commissioner Charlie McCreevy, who handled the proposal, said "The European shipping industry will benefit from the more competitive market that will result from the repeal of the block exemption and the EU economy as a whole stands to benefit from lower transport prices and more competitive exports." EU Press Release IP/05/1249.

compete away monopoly profits (Davies, 1986). For example, tramp shipping services may act as a kind of competitive fringe disciplining the pricing behavior of liner companies.[3]

The direct evidence linking shipping prices to market power is mixed. Clyde and Reitzes (1995) find no statistically significant relationship between shipping prices and the market share of conferences serving on a route. Fink et al (2000) find that shipping prices are higher in the presence of price-fixing agreements by conferences. Both papers rely on US imports data and, given the large volumes of cargo and many competitors operating on US trade routes, the results may not be representative of the shipping industry worldwide. In addition, the test of market power in both papers relies on variation in liner conference activity across trade routes, and this poses significant identification problems. That is, liner conferences may drive up shipping prices through collusive behavior, or liner conferences may be especially active on routes where shipping prices are likely to be high for other reasons.

In this paper we provide a test of market power in the shipping industry that links shipping price variation to characteristics of products. This test enables us to identify how much variation in shipping prices across goods and across markets is due to market power. In addition, we are able to show how market power leads to systematically higher shipping prices in the developing world and to calculate their impact on trade flows.

We model the shipping industry as a Cournot oligopoly with a fixed number of firms, and determine optimal shipping markups as a function of the number of firms and the elasticity of transportation demand faced by firms. A key insight of the model is that transportation is not consumed directly; instead shipping firms face transportation demand derived indirectly from import demand. This implies that the impact of an increased shipping markup on the demand for transportation depends on the share of transportation costs in the delivered price of the good, and elasticity of import demand. Both vary considerably across goods, and we can use this variation to identify whether shipping firms exercise market power.

To make plain the intuition behind the model, suppose the marginal cost of shipping either of two goods equals $10, and shippers are considering adding a $5 markup. The first good has a factory price of $10, so the markup will increase the delivered price by 25%. The second good has a factory price of $90, so the markup increases the delivered price by 5%. The same shipping markup has a much larger effect on the delivered price of the $10 good because shipping costs

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[3] Tramp shipping represented 17 percent of US waterborne import cargoes by value (and 5 percent of containerized value) in 2002, author's calculations from US Waterborne Imports database, 2002.

represent a larger share of the delivered price. Holding fixed marginal costs of transportation, the optimal markup charged by a shipping firm is then increasing in product prices.

Several previous papers have used this intuition as a simple test of market power in shipping.[4] If the marginal cost of transport is independent of the price of the good shipped, and markets are competitive, then the prices charged by shipping firms should also be independent of goods prices. Since shipping prices *are* positively correlated with goods prices in the data, previous authors have concluded that market power is being exercised. The problem with this logic is that marginal costs of transportation are likely not independent of goods prices. There is a wide range of transport service quality available to exporters. Faster ships, direct routing, and more careful handling are all available at a premium, and are more likely to be demanded for the transport of higher quality goods.[5] Shipping prices also include insurance charges that are surely increasing in the value of the goods shipped. That is, one would expect to see a positive correlation between goods prices and shipping prices even if shipping markets were highly competitive.

Happily our model delivers two more testable implications that do not suffer this identification problem. First, when considering the impact of shipping prices on the delivered price of goods, it is necessary to examine product prices inclusive of tariffs. Raising the tariff on a good raises its price, lowers the percentage impact of a given transportation charge on the delivered price, and therefore increases the optimal shipping markup. The impact on the markup operates through precisely the same channel as an increase in prices due to product quality, except that increasing tariffs does not affect the demand for higher quality transportation. If we find a positive relationship between tariffs and shipping prices we can attribute this to market power, and not to variation in the marginal cost of shipping. This channel also suggests a particularly deleterious role for tariffs in limiting trade. Tariffs raise foreign goods prices directly by taxing them, and indirectly by inducing higher shipping prices, and both reduce trade flows.

Our second testable implication relates to the responsiveness of trade to increased prices. Returning to our example above, now suppose we have two traded goods with a factory gate price of $90 and marginal costs of shipping equal to $10, so that a markup of $5 will yield an equal 5% increase in the delivered price of each good. The first good is a differentiated product and faces an import demand elasticity equal to 1.1. Here, a markup that yields a 5% increase in delivered price

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[4] Sjostrom (1992) reviews and critiques this literature.
[5] Hummels (2007) provides evidence for this claim in an instance, the use of air versus ocean transportation, where service quality differences can be directly observed.

reduces traded quantities, and therefore demand for transportation services, by only 5.5% The second good is a highly substitutable commodity and faces an import demand elasticity of 10. Here, the markup raises prices by 5% but lowers quantities traded and demand for transportation services by 50%! In the latter case the identical markup reduces import (and therefore transportation) demand to a much greater degree, limiting the optimal markup for the shipping firm.

Our model uses these simple insights to show how, conditional on the number of firms, optimal markups will be increasing in product price and tariffs, and decreasing in the absolute value of the import demand elasticity.   However, the impact of these factors is each lessened as the number of firms rises. This provides us with the alternative hypothesis: if shipping markets are sufficiently competitive then shipping firms are unable to exploit their market power to raise prices even in cases where the derived demand for transportation services is relatively inelastic.

Our empirical work uses data on shipping prices derived from detailed imports data for the US and Latin America. We relate shipping prices to variation across exporters and products in: cost shifters, product prices, tariffs, the elasticity of import demand, and the number of shippers. Our data confirm the theoretical predictions. Price discriminating shippers charge higher markups on goods with high prices, high tariffs, and a low (absolute) import demand elasticity.   Particularly relevant from a policy perspective, a 1 percent increase in tariffs leads to an increase in transportation prices of 1-2 percent. Having more shippers on a route directly lowers transportation prices, and reduces the effect of the import demand elasticity on prices. This confirms that price discrimination is substantially weakened in the presence of more competition.

We show that the exercise of market power is responsible for a large portion of the observed variation in shipping costs across goods and exporters. In the US sample, goods with an import demand elasticity of 3.2 face shipping prices that are, ceteris paribus, 43 percent higher than goods with an import demand elasticity of 16.5. In the Latin American sample, goods subject to a 23 percent ad-valorem tariff face shipping prices that are 36 percent higher than those goods subject to no tariff. Exporters served by only two shipping firms face shipping prices that are 22 percent larger than exporters in which there are 8 firms competing.

Market power helps explain higher ad-valorem shipping prices faced by developing countries.   On average, non-OECD exporters pay 48 percent more than OECD exporters when shipping into the US, and 39 percent more when shipping into Latin America. More than half of this effect is explained by differences in product prices with a relatively minor role played by

simple measures of market access like distance. Shipping prices on Latin American imports are, on average, 25.7 percent higher than shipping prices on US imports. One-third of this difference is explained by the small number of shippers serving Latin American importers. Another half of the difference is due to much higher tariffs on Latin American imports that allow shipping firms room to charge higher markups.

Finally, we provide a back of the envelope calculation of what shipping prices and trade volumes would be if markups on all traded goods were equal to the smallest markups observed in the data. For the US, the mean (across goods and exporters) response would be a 34.6 percent reduction in shipping prices and 12.4 percent increase in trade volumes. In the aggregate freight expenditures as a percentage of import value would drop from 4.9 to 3.1 percent, and trade volumes would increase by 4.96 percent. For Latin America, the mean response (across goods and exporters) would be a 45.4 percent reduction in shipping prices and 17 percent more trade. In the aggregate, freight expenditures as a percentage of import value would drop from 5.9 to 2.8 percent, resulting in 21.1 percent more trade.

II. The Model

In this section we develop a simple model of trade in which shippers have market power and set an optimal shipping price as a function of market and product characteristics. We assume a fixed number of shippers which compete in quantities (à la Cournot), and relate optimal markups to the number of firms, the price elasticity of import demand, and the cost share of transportation services in the delivered price of the traded good.

This approach abstracts from a potentially important real world complication. The international shipping industry has numerous components including inland freight services, ports, and ocean shipping lines. In some markets port services are highly competitive while in others monopoly power reigns. A trade route may exhibit very little market power in the pricing of the shipping lines or freight forwarders, yet substantial market power can be found at the port level. Without knowing the details of market microstructure for every market and every product it is exceptionally difficult to sort out precisely where market power, if any, is exerted. Accordingly, we examine shipping as an integrated value chain, examine shipping prices paid over the entire chain and relate these to product characteristics. While this loses some of the institutional richness of the

transportation industry it allows us to focus on an object – total transportation charges – that is of most interest from the perspective of a firm deciding to engage in international trade.

Assumptions

The world consists of $i=1,2,...,$ M symmetric countries each of which consists of one representative consumer. Consumers have quasi-linear preferences defined over a homogenous numeraire good and varieties of a good that consumers regard as Armington differentiated by national origin, with a price elasticity of demand σ. A representative consumer in country i has a utility function

$$(1) \qquad U_i = q_{i0} + \sum_{j=1}^{M} q_{ij}^{(\sigma-1)/\sigma} \qquad\qquad\qquad \sigma > 1,$$

where q_{i0} – is country i's consumption of the numeraire;

q_{ij} – is country i's consumption of a variety purchased from source country j.

The price of the numeraire is normalized to one and it can be traded at no cost. Goods from country j are sold at price p_j which shipping firms take as given.[6] The delivered price of traded varieties includes a per-unit transportation price, f_{ij}, and the ad-valorem tariff rate, $\tau_{ij} \geq 1$:

$$(2) \qquad p_{ij} = p_j \tau_{ij} + f_{ij}.$$

Transportation prices are set by shipping firms and are taken as given by consumers. The exclusive rights on shipping from country i to j belong to n_{ij} symmetric firms. Each firm's technology is defined by the fixed cost C_{ij} and marginal cost c_{ij}.

Shipping prices in trade equilibrium

We begin by solving for import demand for good k imported from country j. Consumers purchase quantities of each good that set the ratio of marginal utilities equal to the ratio of delivered

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[6] This is equivalent to assuming that the Armington good is produced by a perfectly competitive, constant returns to scale sector requiring p_j units of labor to produce one unit of the good. Alternatively, it is as if the shipping firm is buying an intermediate input at price p_j from country-producer, adds shipping services, and sells it as a final product to a country consumer.

prices. Relative to the numeraire, consumption of a variety from exporter j satisfies:

$$\frac{\sigma}{\sigma-1} q_{ij}^{\frac{1}{\sigma}} = \frac{p_{i0}}{p_{ij}}, \text{ which gives us the demand for } j\text{'s variety:}[7]$$

$$(3) \qquad q_{ij} = \left[\frac{\sigma}{\sigma-1} \left(p_j \tau_{ij} + f_{ij} \right) \right]^{-\sigma}.$$

Using this we can calculate the price elasticity of demand for shipping services in the industry as a whole. It is just the elasticity of import demand with respect to the shipping price f_{ij},

$$(4) \qquad \frac{\partial q_{ij}}{\partial f_{ij}} \frac{f_{ij}}{q_{ij}} = -\sigma s_{ij}.$$

The key point is that transportation services are not valued for their own sake, and are only consumed indirectly as a function of import demand. The price elasticity of demand for shipping services equals the elasticity of import demand with respect to a change in import prices, σ, multiplied by the share of the shipping charge in the delivered price $s_{ij} = \dfrac{f_{ij}}{p_j \tau_{ij} + f_{ij}}$.

A 1% increase in the shipping price f_{ij} raises the delivered price of the good by s_{ij} percent. An s_{ij} percent change in delivered prices then yields a $-\sigma s_{ij}$ reduction in import (and therefore transport) demand. When s_{ij} is small, shippers can raise shipping prices at the margin without having a large effect on demand for their services. This is true even if σ is very high and trade itself is highly sensitive to changes in delivered prices. For example, take an import demand elasticity near the upper bound of our estimated elasticities from the next section, $\sigma = 25$, meaning that a 1% increase in import prices reduces import quantities by 25%. If $s_{ij} = .10$, a 1% increase in the shipping price lowers shipping demand by only 2.5%. In other words, even goods that face highly elastic import demands might still face significant markups by the shippers.

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[7] This differs from a standard CES demand because we are calculating demands for each good relative to the numeraire rather than relative to a basket of other varieties. In the case without a numeraire, this expression would include a CES price index that is specific to an importer. Our empirical estimates control for importer specific effects, which can be read as the price of the numeraire for our function, or as the level of the CES price index for the more standard case without a numeraire.

We can now calculate the optimal shipping prices for our n oligopolists. The profit functions of shipper l delivering from country j to country i is:

$$\pi_{ij}^l = Q_{ij}^l \left(f_{ij} - c_{ij} \right) - C_{ij} \qquad \forall\ l = 1, 2, ..., n_{ij},$$

where Q_{ij}^l denotes the quantity of a differentiated variety transported by shipping firms l from j to i, and n_{ij} is the number of shipping firms on the route from j to i. The $n_{ij} \times 1$ vector of the first order condition can be represented as

(5) $\qquad \dfrac{\partial \pi_{ij}^l}{\partial Q_{ij}^l} = f_{ij} + Q_{ij}^l \dfrac{\partial f_{ij}}{\partial Q_{ij}^l} - c_{ij} = 0 \qquad \forall\ l = 1, 2, ..., n_{ij}.$

The total amount shipped from i to j equals the aggregate demand of country i for variety produced by j:

(6) $\qquad Q_{ij}^1 + Q_{ij}^2 + ... Q_{ij}^{n_{ij}} = q_{ij}.$

From (3) - (6) we obtain the optimal quantity per shipping firm and the profit-maximizing shipping price:

(7) $\qquad Q_{ij}^l = \dfrac{1}{n_{ij}} \left[\left(\dfrac{\sigma}{\sigma - 1} \right) \left(\dfrac{c_{ij} + p_j \tau_{ij}}{1 - 1/\left(\sigma n_{ij}\right)} \right) \right]^{-\sigma}.$

(8) $\qquad f_{ij} = c_{ij} + \dfrac{c_{ij} + p_j \tau_{ij}}{n_{ij} \sigma - 1}.$

The second summand is a marginal profit of shipping, which is independent of the fixed cost of shipping. To obtain the shippers markup we divide the freight rate by the marginal cost, $\mu = f / c$, or

(9) $\qquad \mu_{ij} = \dfrac{\sigma s_{ij} n_{ij}}{\sigma s_{ij} n_{ij} - 1}.$

The term $\sigma s_{ij} n_{ij}$ measures the elasticity of demand facing each of the n firms. For the case of a monopolist, it is precisely equal to the elasticity facing the shipping industry as a whole, σs_{ij}. Rewriting the markup as a function of exogenous variables we have

(10) $\qquad \mu_{ij} = 1 + \dfrac{1 + p_j \tau_{ij} / c_{ij}}{n_{ij} \sigma - 1}.$

The markup depends on route-specific and product-specific determinants. Markups are decreasing in the number of shippers on a route n_{ij}, the final product's price elasticity of demand σ, and the marginal costs of shipping relative to product prices inclusive of tariffs, $c_{ij}/p_j\tau_{ij}$. We discuss the intuition for each in turn.

There are large differences across trade routes in the number of shipping firms competing for cargo – see Figure 1. When comparing shipping prices across routes, equation (10) indicates that the number of shipping firms has a potentially large effect on the markup rule and shipping prices. Consider a good with median elastic import demand ($\sigma = 5$) and suppose that the marginal costs of shipping relative to product prices inclusive of tariffs, $c_{ij}/p_j\tau_{ij} = .05$. With a monopoly shipper, the optimal markup would be $\mu_{ij} = 1 + \dfrac{1 + 1/.05}{5 - 1} = 6.25$ times the marginal costs of shipping, resulting in a 31% ad-valorem trade barrier. Having just one more firm cuts the markup almost in half to $\mu_{ij} = 1 + \dfrac{1 + 1/.05}{10 - 1} = 3.33$, resulting in a 16.7% ad-valorem trade barrier.

Even fixing n along a particular route, markups will vary considerably since $c_{ij}/p_j\tau_{ij}$ and σ might vary across goods. Shipping firms markups depend on how elastic is import demand with respect to a change in shipping prices. As $c_{ij}/p_j\tau_{ij}$ rises, a given shipping markup has a larger effect on delivered goods prices and reduces import and transport demand to a greater degree. Similarly, high values of σ mean that a given increase in delivered goods prices reduces import and transport demand more rapidly, limiting the optimal markups that can be charged.

To formalize our test of market power in the shipping industry we need to assume a particular functional form for the marginal cost of transportation so we can relate the markup rule to observable characteristics. Let the marginal cost of shipping depend on the distance between countries i and j, and on the price of the shipped good, according to

(11) $\quad c_{ij} = \exp(\beta_0)(p_j)^{\beta_1}(dist_{ij})^{\beta_2}.$

The effect of distance on costs is obvious, but prices are a bit more subtle. While we have ignored the quality of shipping services to this point, when confronting the data it is important to realize that there is a wide range of transport service quality available to exporters. Faster ships, direct routing, and more careful handling are all available at a premium, and are more likely to be demanded for the transport of higher quality goods. In addition, our data on shipping costs include insurance

charges which surely depend on the value of the good being transported. Plugging this into the markup equation we have

$$(12) \quad \mu_{ij} = \left(1 + \frac{1 + \left(p_j \right)^{1-\beta_1} \tau_{ij} \big/ \exp\left(\beta_0 \right) \left(dist_{ij} \right)^{\beta_2}}{n_{ij}\sigma - 1} \right).$$

Equations (11) and (12) make clear the difficulty with an approach used in the literature to test for shipping market power. Several papers simply regress shipping prices on goods prices and conclude that a positive coefficient indicates the presence of market power. If $\beta_1 = 1$, marginal shipping costs depend on goods prices but the markup does not. If $\beta_1 = 0$, the markup depends on goods prices, but marginal costs do not. For values between 0 and 1, both marginal costs and the markup are affected by goods prices.

Unlike goods prices, tariffs τ_{ij} and the elasticity of import demand σ appear only in the markup equation. These variables should only affect shipping prices if firms are able to exercise market power. Moreover, the elasticity of shipping prices with respect to τ_{ij} and σ depends on the number of firms, and approaches zero as n grows large. On the limit the markup converges to one and shipping prices equal marginal costs. The alternative hypothesis for our empirical tests is that n_{ij} is sufficiently large that shipping prices are independent of τ_{ij} and σ.

We can now summarize the relationship between the components of shipping prices (marginal cost and markups) and observable characteristics, holding the number of firms fixed. These comparative statics can be thought of as a short run response of shipping prices to changes in exogenous variables before entry / exit of shipping firms occurs in the long run. Alternatively, one can think of the comparative statics as describing variation in shipping prices across different kinds of goods along the same shipping route. That is, the number of firms shipping goods between Brazil and the United States is fixed at a point in time, but there is still variation across goods on the Brazil-US route in goods prices, tariffs, and the elasticity of substitution.

The signs of the model's comparative statics are reported in the first two columns of Table 2, with the contrasting case of marginal cost pricing reported in the final two columns. Marginal costs are increasing functions of goods prices and distance as given by equation (11). The markup

is increasing in the factory price and tariff, and decreasing in distance[8], number of firms, and price elasticity of demand. In the empirical work we examine the elasticity of shipping prices with respect to the changes in the observed variables, and given the functional form of (10) there are important interactions between the variables. In particular, the elasticity of the shipping price with respect to σ_k is decreasing in n_{ij} and decreasing in $c_{ij} / p_j \tau_{ij}$.

III. Empirics

In this section we relate shipping prices to product characteristics to test for the existence of market power in shipping. The precise functional form implied by our model is difficult to capture empirically as it involves nonlinear interactions between the levels of variables we are unable to measure exactly. In particular, we know some correlates of marginal costs (product price, distance), but not the intercept or other factors like product bulkiness or special handling requirements. Accordingly, we use a simple log linear expression and interactions meant to capture the sign of the comparative statics summarized in Table 2. We use two data samples, and exploit somewhat different sources of variation in the two cases.

The first data sample comes from the US Census Imports of Merchandise, years 1991-2004. We employ data on US imports in each year t, disaggregated by exporter j, product k (HS 6 digit data which includes roughly 5,000 product categories) and transport mode m (air, ocean). We observe value, weight, duties paid, and shipment charges for each j-k-m-t observation. We only employ ocean shipping data, and hereafter drop the mode m subscript.

We run several specifications. The first is

$$(13) \qquad \ln f_{jkt} = \alpha_{jt} + \beta_1 \ln p_{jkt} + \beta_2 \ln \tau_{jkt} + \beta_3 \sigma_k + e_{jkt}$$

where f_{jkt} is the freight price per kg shipped, p_{jkt} is the value/kg price of the good, τ_{jkt} is the ad-valorem tariff, σ_k is the elasticity of import demand, and α_{jt} is a vector of exporter-time fixed effects. This is equivalent to holding fixed the number of shipping firms between the US and exporter j and exploiting only variation across product characteristics. It also holds fixed many

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[8] Distance is an interesting variable since it directly raises marginal costs but indirectly lowers the markup. As distance increases the share of shipping charge in the delivered price goes up, shippers pricing behavior has a stronger effect on total demand and this limits their market power. The magnitude of the direct effect outweighs the indirect effect.

difficult to capture features of the shipping industry that are exporter specific, including cargo reservation policies (Fink et al 2000), the strength of liner conference activity (Fink et al 2000, Clyde and Reitzes 1995), and port efficiency (Wilmsmeier et al 2006, Blonigen and Wilson, 2006, Clark et al 2004).

In the second specification, we omit exporter fixed effects and include data on the number of shippers operating on a route, both in levels and interacted with the price elasticity of demand.

$$(14) \quad \ln f_{jkt} = \alpha + \beta_1 \ln p_{jkt} + \beta_2 \ln \tau_{jkt} + \beta_3 \sigma_k + \beta_4 DIST_j + \beta_5 n_j + \beta_6 n_j \sigma_k + e_{jkt}$$

All variables except the number of shippers and the elasticity of import demand are taken directly from the US import data. The number of shippers is calculated using the Port2Port Evaluation Tool from www.compairdata.com. This database reports shipping schedules for each vessel carrying cargo between each port-port pair worldwide, including the liner company or consortium operating each vessel. From this we calculate the number of distinct companies operating on each route. The data were collected for the 4th quarter of 2006, and cover shipping schedules in that period. We do not have time series data for the number of shippers and so treat it as constant for a given exporter to the US over the sample period. For reference, Figure 1 displays a scatterplot of (log) number of firms against (log) exporter GDP.

Not all exporters have direct connections to US seaports and so do not appear in the schedule data. In these cases we impute the number of firms using information on indirect routings. For example, there is a service between Singapore and the US but no direct shipments between Kenya or Tanzania and the US. These exporters must first ship goods to ports in Singapore where they are aggregated into larger ships and sent along to the US. For exporters with no direct service to the US we use the number of shippers between the origin ports and the hub ports from which they are subsequently shipped to the US. In our sample there are 52 exporters for which we have direct observations on numbers of firms, to which we add 36 more exporters in which we can reasonably impute values. We drop the remaining exporters from our set of US data. Our tables report results that include the imputed data, but we have experimented and our results are very similar when we use only those exporters with direct service to the US.

The elasticity of import demand is a critical variable for our study, so we experiment with values taken from two sources. First, we use estimates of σ_k at the 3 digit level of Standard

International Trade Classification revision 3 (SITC) taken from Broda-Weinstein (2006). Their σ_k elasticities are estimated using a procedure developed by Feenstra (1994) that exploits time series variation in the quantity shares of exporter j selling product k to the US market as a function of time series variation in the price of j-k. Second, we directly estimate σ_k, using trade costs to trace out price variation across source countries j quantity shares. The details on our estimation method are contained in the appendix, along with a discussion of the advantages and disadvantages of our approach relative to Broda-Weinstein, and some summary statistics on the estimated values. Briefly, our estimates are more disaggregated, and estimated specifically for the transportation mode, country sample, and time period employed in the shipping price regressions. If substitutability varies by level of aggregation, mode, countries or time, the elasticities we estimate would be preferred. When using the BW elasticities we still employ shipping data at the HS 6 level so as to avoid aggregating away interesting variation in the f_{jkt}, p_{jkt}, and τ_{jkt} data. In this case each SITC 3 digit estimate of σ_k is used in multiple HS 6 products.

Our second data sample comes from the BTI trade database for 2000.[9] In this case we have multiple Latin American importers (Argentina, Brazil, Chile, Ecuador, Peru, Uruguay) and therefore many importer-exporter pairs, but lack time series variation. The specifications are similar to equations (13) and (14), except that all time "t" subscripts are replaced with importer "i" subscripts. The corresponding equations are

(15) $\quad \ln f_{ijk} = \alpha_j + \beta_1 \ln p_{ijk} + \beta_2 \ln \tau_{ijk} + \beta_3 \sigma_k + e_{ijk}$

(16) $\quad \ln f_{ijk} = \alpha + \beta_1 \ln p_{ijk} + \beta_2 \ln \tau_{ijk} + \beta_3 \sigma_k + \beta_4 DIST_{ij} + \beta_5 n_{ij} + \beta_6 n_{ij} \sigma_k + e_{ijk}$

In the first specification we control for the number of shippers using a vector of exporter fixed effects α_j. In the second we omit the fixed effects but include data on the number of shippers and an interaction with σ_k.

All variables except n_{ij} and σ_k come from the BTI data. As with the US data, n_{ij} comes from the Port2Port evaluation tool at www.compairdata.com. Compared to the US case there are

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[9] We are grateful to Jan Hoffman at UN ECLAC for providing these data.

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far fewer exporters for which we either have schedule data directly or can infer reasonable substitute exporters to impute values, and this substantially reduces our sample. We have compared estimated elasticities in the fixed effect regressions that omit n_{ij} for the larger and the reduced samples, and coefficients are all very similar except distance, where truncating the sample significantly reduces the estimated coefficient. Since the main variables of interest are robust to the two sample types and we wish to maintain comparability of samples across columns we employ the smaller samples for all Latin American regressions.

Because the elasticity of import demand σ_k may be different in the Latin American and US import markets, we estimate values of σ_k that are specific to this dataset (details in the appendix). We also use our estimates of σ_k from the US data, and Broda-Weinstein estimates of σ_k from the US data, and results are qualitatively similar in each case.

Results

Table 3 reports estimates of equations (13) and (14) using US imports data. The first three columns use our elasticities estimated at the HS6 level. All signs match our theory. Shipping prices are increasing in distance, and in product prices. As we note above, the positive correlation between shipping prices and product prices has been shown elsewhere in the literature and could reflect market power if marginal costs of shipping are independent of goods prices. A much stronger test of market power is found in the other variables. Shipping prices are higher for goods with lower import demand elasticities (elasticity -.22 to -.25). That is, shipping firms are best able to take advantage of their position between producer and consumer to increase markups when consumption decisions are less sensitive to changes in delivered prices. Shipping prices are increasing in tariffs with an elasticity close to 1, meaning that a 1 percent tariff increase calls forth an additional 1 percent increase in shipping costs. The results on product prices, import demand elasticities and tariffs go through whether we use exporter-time fixed effects (and omit distance and number of shippers) or omit the fixed effects and enter distance and number of shippers directly. Finally, the coefficient on number of shippers operating on a route is negative and the interaction between number of shippers and demand elasticity is positive. This means that that adding more shippers to a route directly lowers shipping prices and weakens the ability of firms to charge higher markups on goods facing a less elastic import demand.

The last three columns of Table 3 employ SITC 3 digit demand elasticities from Broda-Weinstein (2006). The coefficients on the demand elasticity are roughly half the size as those estimated with our HS 6 values for σ_k, but still negative and highly significant, and all other variables have a similar affect on shipping prices. A likely explanation for the difference in the σ_k coefficients is that the Broda-Weinstein elasticities are estimated on more aggregated data and using samples which do not exactly match the data in question. In this case their estimates are noisy indicators of the true elasticity of import demand facing shippers, and so the coefficients are subject to attenuation bias toward zero.

Table 4 reports estimates of equations (15) and (16) using Latin American data. As with the US data shipping prices are increasing in distance, product prices, and tariffs, and decreasing in the import demand elasticity, and the number of shippers. The coefficients on the import demand elasticity are comparable in magnitude to those estimated on the US data in Table 3, while the coefficients on tariffs and the number of shippers are larger (in absolute magnitudes). When using the BW elasticities the interaction between the import demand elasticity and number of shippers is positive, meaning that adding more shippers to a route weakens the ability of firms to charge higher markups on goods facing a less elastic import demand. The interaction term is insignificant in the regressions using HS 6 σ_k data, but the net effect of both the number of shippers and the import demand elasticity is negative when evaluated at both variables means.

The differences between the US and Latin American samples in the tariff and number of shippers effects are particularly interesting. In the US, where tariffs are relatively small, a 1 percent increase in tariffs leads to a 1 percent increase in shipping prices. In Latin America, where tariffs are larger and exhibit much greater variation across products, a 1 percent increase in tariffs yields a 1.3 to 2.1 percent increase in shipping prices. This suggests that tariff reductions in and of themselves could be a useful tool for lowering shipping prices facing Latin American importers. US trading routes have higher volumes and more shippers competing than on Latin American trade routes. In this case, doubling the number of shippers reduces shipping costs by 6 to 9 percent. In Latin America, doubling the number of shippers reduces shipping costs by 11 to 15 percent.

The Strength of Market Power

Tables 3 and 4 provide strong support for the idea that market power allows shipping firms to price discriminate across cargoes, charging higher prices when shipping is a smaller portion of

the delivered price, and when increases in the delivered price will result in a smaller reduction in import (and therefore transport) demand. Next we examine how important market power is relative to other factors in explaining variation across goods and exporters in shipping prices.

In many trade applications distance is used to proxy for transportation costs. In the US sample, Table 3, we see that a 10% increase in distance shipped raises US transportation prices by 1.5%. Whether distance explains a large or small portion of total variation in shipping prices depends on how much distance varies in the sample. We can show this by calculating the predicted value of shipping prices for exporters at various distances from the US, holding other variables at their means. For example, exporters at 5th, 50th and 95th percentile values of distance are 3233 km, 8830 km and 13,326 km away from the US, respectively. The model predicts that, ceteris paribus, the exporter at 13,326 km distance faces shipping prices to the US that are 24 percent higher than an exporter at 3233 km, $\frac{f_{DIST95}}{f_{DIST5}} = \left(\frac{DIST95}{DIST5}\right)^{.15} = \left(\frac{13326}{3233}\right)^{.15} = 1.24$, while an exporter at median distance of 8830 km faces prices 17 percent higher than an exporter at 4880 km.

How does this variation compare to that induced by the variables that capture market power? Table 5 reports the estimated coefficient for each variable taken from the fifth columns of Table 3 (for the US) and Table 4 (for Latin America) along with the 95th/5th percentile comparisons and 50th/5th percentile comparisons for each explanatory variable.   Values of each variable at 5th, 50th and 95th percentiles – hereafter referred to as "low", "median" and "high" – are reported in the Table notes.

There is enormous variation across goods in factory prices measured in units of dollars per kg (compare microchips to cement), and this results in considerable variation across goods in shipping prices. Goods with high factory prices have shipping prices 18 (Latin America) to 21 (US) times greater than goods with low factory prices. As we argue above, some of the difference in shipping prices may reflect differences in the marginal cost of providing shipping services of variable quality, but this may also reflect market power effects.

The elasticity of shipping prices with respect to the import demand elasticity is estimated to be -0.10 (for SITC 3 digit σ_k values) to -0.22 (for HS 6 σ_k values). In the US data, goods with a low elasticity of import demand have shipping prices that are 33 percent (SITC3) to 43 percent higher (HS6) than goods with a high elasticity of import demand. Note that when comparing the effect for HS v. SITC, the elasticity of shipping prices with respect to σ_k is half as big for SITC 3

digit, but the range of SITC 3 digit σ_k values is larger. This means that the range of variation in shipping prices due to σ_k variation is comparable whether we use our estimated σ_k or Broda-Weinstein's. The range of variation in shipping prices explained is similarly comparable for Latin America.

Tariffs exhibit less variation over goods than we see with product prices or import demand elasticities. However, the elasticity of shipping prices with respect to tariffs is much larger. In the US, high tariff goods face shipping prices that are 17 percent greater than low tariff goods. In Latin America, where tariff variation is greater, high tariff goods face shipping prices 36 percent greater than low tariff goods.

Finally, the elasticity of shipping prices with respect to the number of shippers is much greater in Latin America than in the US, but there is less variation in the number of shippers. As a result, number of shippers explains a comparable amount of variation in shipping prices in both samples. Exporters with a small number of shippers (1 for the US, 2 for Latin America) face shipping prices that are 22-23 percent higher than exporter with a high number of shippers (32 for the US, 8 for Latin America).

Using distance as a proxy for transportation costs has become commonplace, but it explains relatively little of the variation in shipping prices. Each of our variables that clearly indicate market power (import demand elasticity, tariffs, number of shippers) has an effect comparable to or larger than distance. Product prices, which likely capture a combination of marginal costs of shipping and market power, explain variation in shipping prices an order of magnitude larger than that explained by distance variation.

Market Power and Shipping Prices in Developing Countries

Table 1 shows that Latin American importers face higher shipping prices than do US importers, and developing country exporters face higher shipping prices into most import markets. We next use our estimates to identify how much of this effect is due to the exercise of market power in the shipping industry.

First we compare non-OECD to OECD exporters shipping into each import market. We re-estimate the model from equations (14) and (16) for the US and Latin American samples, with two

differences. First, the dependent variable is the ad-valorem (rather than per kg) shipping price.[10] This makes it easier to think in terms of the effect of shipping on the delivered price of the product, and also helps us to explain the observed differences in freight expenditures relative to import values reported in Table 1. Second, we include separate intercepts for OECD and non-OECD exporters to capture differences in the level of costs that we cannot attribute to explicitly measured variables. This yields

US Imports

$$\ln\left(\frac{\widehat{f_{jkt}}}{p_{jkt}}\right) = \alpha_t - 3.66 - .18OECD_j - .11\ln\sigma_k - .47\ln p_{jkt} + 1.14\ln\tau_{jkt} + .18\ln DIST_j - .01\ln n_j$$

Latin America:

$$\ln\left(\frac{\widehat{f_{ijk}}}{p_{ijk}}\right) = -1.99 - .11OECD_j - .10\sigma_k - .48\ln p_{ijk} + 1.38\ln\tau_{ijk} + .02DIST_{ij} - .15n_{ij}$$

We can now attribute differences between OECD and non-OECD exporters to differences in the intercepts plus difference in shipment characteristics, that is, differences in the average product price, demand elasticity, tariff, distance, and number of shippers for the two groups. Table 6 reports for each variable the mean differences between non-OECD and OECD exporters in the explanatory variables. In the US sample, non-OECD prices are lower, $\overline{P}_{non-oecd} / \overline{P}_{oecd} = .61$. To get the difference between shipping prices from OECD and non-OECD exporters attributable to differences in product prices, we calculate, $-.47\left(\ln p^{non-OECD} - \ln p^{OECD}\right) = .224$ and similarly for each explanatory variable. Summing over all the differences in explanatory variables, plus the difference in the intercept, yields the total difference in mean shipping prices facing OECD and non-OECD exporters.

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[10] Coefficients on all variables except product prices are the same whether shipping prices are expressed on a per kg, or on an ad-valorem basis. Since we have effectively subtracted ln(p) from both sides, the coefficient on product prices in the ad-valorem regression is -1 smaller than in the per kg regressions. That is, higher product prices result in higher per kg shipping prices with an elasticity of roughly 0.5, and lower ad-valorem shipping prices with an elasticity of roughly -0.5.

For the US, ad valorem shipping prices from non-OECD exporters are 1.48 times shipping prices from OECD exporters (log difference equal to .393). Of this, 57 percent comes from OECD exporters having higher prices, 7 percent comes from OECD exporters being served by more shippers and 5 percent comes from OECD exporters being closer to the US.[11] Most of the remaining difference, or 34 percent, represents higher non-OECD shipping prices conditional on the other variables. The import demand elasticity plays very little role here because the average values for the elasticity are quite similar for the OECD and non-OECD.

For the Latin American import sample, non-OECD exporters have shipping prices 1.39 times larger than OECD exporters (log difference of .327). Of this, two-thirds come from OECD exporters shipping higher priced goods, and the remaining third comes form the OECD intercept.

Next we decompose the difference in shipping prices into the US import market compared to the Latin American import markets. To decompose the sources of this difference we first estimate equation (14) on a pooled sample for the US and Latin America in 2000,

$$\ln\left(\frac{\widehat{f_{ijk}}}{p_{ijk}}\right) = 3.10 - .10 \ln \sigma_k - .47 \ln p_{ijk} + 1.14 \ln \tau_{ijkt} + .12 \ln DIST_{ij} - .076 \ln n_{ij}$$

Latin American importers face shipping prices that are, on average, 1.257 times that of the US as importer (log difference .228). Half of this difference is due to Latin American importers imposing higher tariffs on goods, one-third is due to the smaller number of shipping firms operating on Latin American routes, 13 percent is due to Latin American countries being further from their export sources, and 4 percent is due to the US buying higher priced products.

Trade Volumes: A Back of the Envelope Calculation

As a final exercise we calculate the reduction in trade volumes that results from shipping firms pricing above marginal cost. Starting from the import demand equation (3), express the actual volume of trade relative to a counterfactual quantity of trade that would taken place had shipping firms priced at marginal cost

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[11] China is a large outlier in the number of shippers serving the market. If we drop China from the calculation, the number of shippers serving non-OECD/OECD markets = 0.41 and number of shippers explains 10 percent of the difference in shipping costs.

$$\frac{q_s}{q_s^*} = \left(\frac{p_s \tau_s + f_s}{p_s \tau_s + c_s}\right)^{-\sigma_s}$$

where q_s^* is the counterfactual quantity of trade with marginal cost shipping prices, and the subscript s denotes shipment. The dimensionality of this variable depends on the data in question. For our Latin American data, s represents importer i, exporter j, commodity k. For the US data, s represents exporter j, commodity k, time t.

We do not observe the marginal cost of shipping, but we can approximate it by manipulating our empirical specification for shipping prices. The shipping price for shipment s is empirically specified in equations (14) and (16). Ignoring the interaction term the equation can be rewritten as

(17) $f_s = e^\alpha p_s^{\beta_1} DIST_s^{\beta_4} \tau_s^{\beta_2} \sigma_s^{\beta_3} n_s^{\beta_5} e^{\varepsilon_s}$

Three variables, the elasticity of import demand, tariff, and the number of shippers affect only the markup. That is to say, theoretically the shipping price equals marginal cost only if the elasticity and the number of shippers are infinitely large and tariff is equal to one. We approximate this by choosing very large (99th percentile) values for the import demand elasticity and the number of shippers and very small values (1st percentile) for tariffs. Our approximation of marginal cost is then

(18) $c_s = \left[e^\alpha p_s^{\beta_1} DIST_s^{\beta_4}\right]\left[\tau_{1\%}^{\beta_2} \sigma_{99\%}^{\beta_3} n_{99\%}^{\beta_5}\right] e^{\varepsilon_s}$

The error term from the estimation is equal to the actual shipping price relative to the fitted shipping price from the empirical model, or

$$e^{\varepsilon_s} = \frac{f_s}{e^\alpha p_s^{\beta_1} \tau_s^{\beta_2} \sigma_s^{\beta_3} DIST_s^{\beta_4} n_s^{\beta_5}}$$

Substituting the error term into the cost equation and simplifying gives us

(19) $f_s = c_s \left(\frac{\tau_s^{\beta_2} \sigma_s^{\beta_3} n_s^{\beta_5}}{\tau_{1\%}^{\beta_2} \sigma_{99\%}^{\beta_3} n_{99\%}^{\beta_5}}\right).$

Strictly speaking the term in brackets is not precisely the shipping markup over marginal cost. Rather it is the ratio of the observed values $\tau_s^{\beta_2} \sigma_s^{\beta_3} n_s^{\beta_5}$ that affect markups for a particular shipment s

and the values for the smallest markup we can see in our data $\tau_{1\%}^{\beta_2}\sigma_{99\%}^{\beta_3}n_{99\%}^{\beta_5}$. The true markup over marginal cost for shipment s must be at least this large.

We can now construct a counterfactual volume of trade for each shipment s:[12]

$$\frac{q_s}{q_s^*} = \left(\frac{p_s\tau_s + f_s}{p_s\tau_s + f_s \dfrac{\tau_{1\%}^{\beta_2}\sigma_{99\%}^{\beta_3}n_{99\%}^{\beta_5}}{\tau_s^{\beta_2}\sigma_s^{\beta_3}n_s^{\beta_5}}} \right)^{-\sigma_s}$$

This calculation provides a conservative estimate of the size of the markup and the corresponding effect on trade volumes. First, we attribute all of the effect of higher product prices on higher shipping prices to marginal cost differences and none to markup differences. Second, we choose values for σ, n that are at the high end of those observed in the data, rather than choosing some infinite value. The counterfactual is then equivalent to the following: suppose all shipments were charged the same markup as the smallest observed markup in the data. How much lower would shipping prices be, and how much higher would be the resulting trade volumes?

The summary of estimated markups and counterfactual trade volumes amounts of trade are as follows. For US imports, shipping prices for the mean shipment are 1.53 times higher than prices for the lowest markup shipment (standard deviation of 0.23). In ad-valorem terms shipping markups result in delivered prices that are 1.024 times higher for the mean shipment (stdev = .03), resulting in trade volumes that are 12.4 percent lower. These calculations weight all observations equally, and the aggregate results are somewhat smaller. Aggregate freight expenditures as a percentage of imports would drop by 1.8 percentage points, from 4.9 to 3.1 percent ad-valorem, if shipping prices for each shipment were lowered to reflect the smallest observed markup. This would lead to a 4.96 percent increase in trade.[13]

For Latin American imports, shipping prices for the mean shipment are 1.83 times higher than prices for the lowest markup shipment, with a standard deviation of .28. In ad-valorem terms

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[12] Our trade volume calculation employs a useful property of the quasi-linear utility function we initially assumed. Lowering delivered prices by 1 percent yields a σ percentage increase in trade volumes even if all exporters have similar price declines. That is, expenditures on the imported goods grow while expenditures on the numeraire shrink. In a standard model with CES utility over the imported goods and no numeraire, changes in delivered prices would shift expenditures from one exporting source relative to another, or relative to the domestic versions of the imported good.
[13] The "before" aggregate ad-valorem numbers do not match those from Table 1 for two reasons. One, we focus here only on waterborne shipments. Two, due to data availability constraints we have reduced the sample of countries and goods on which this calculation can be performed.

shipping markups result in delivered prices that are 1.038 times higher for the mean shipment (stdev =.06), resulting in trade volumes that are 17 percent lower. Aggregate results are somewhat larger. Aggregate freight expenditures as a percentage of imports would drop by 3.1 percentage points, from 5.9% to 2.8%, if shipping prices for each shipment were lowered to reflect the smallest observed markup. This would lead to a 21.1% percent increase in trade.

Shipping prices inclusive of markups are much larger (53 percent for US imports, 83 percent for Latin America) than would be observed for the shipment with the smallest markup, which implies that the total markup is larger still. Is this plausible? Recall from the modeling section (p.9-10) that, for a monopoly shipper, markups 6 times marginal cost can be generated under plausible parameter values.

IV. Conclusion

Many recent papers have focused on the importance of transportation costs, or more simply distance, in shaping trade flows. A common feature of these papers is the assumption of Samuelson iceberg shipping cost in which ad-valorem shipping costs are treated as an exogenous constant, and most typically captured solely by the distance between markets. We get inside the black box of the transportation industry to show how the exercise of market power drives much of the variation in shipping prices.

Our test of market power in the shipping industry focuses on the ability of shipping firms to price discriminate across products. The elasticity of demand facing a shipping firm is a function of the elasticity of import demand and the degree to which changes in shipping prices affect the final delivery price of a product. Shippers can charge especially large markups on goods whose import demand is relatively inelastic, and on those goods where the marginal cost of shipping represents a small percentage of delivered prices. That is, increases in factory gate product prices and increases in tariffs give shippers more room to price discriminate. Further, a larger number of shipping firms competing on a route lowers both the level of shipping prices and the ability of firms to price discriminate across products.

These theoretical predictions are strongly supported by shipping data taken from US and Latin American imports. Shipping prices are increasing in product prices and tariffs, and decreasing in the elasticity of import demand the number of shippers on a route. Each of these

market power variables has an impact on shipping prices equal to or greater than the effect of shipping cargoes greater distances.

Our findings suggest that high transportation costs in the developing world are not an unfortunate technological fact of life, and provide two important policy implications. First, because the demand facing the shipping industry as whole can be highly inelastic even a little entry can go a long way in reducing market power and markups in shipping. The recent decision by the EU Competitiveness Council to bar shipping firms from participating in liner conferences and from colluding on price and market share agreements is worth watching in this regard. Second, high tariffs are especially harmful to trade. They directly increase the delivered price of traded goods and indirectly lead to increased shipping markups. We estimate that a 1% increase in tariffs leads to a 1-2% increase in transportation costs. This effect is especially pronounced in Latin America where tariffs are much larger and more variable to begin with. Cutting these tariffs would yield a double dose of trade growth for liberalizing countries.

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Appendix: Estimating the Price Elasticity of Demand for Imports

A key parameter for our study is the import elasticity of demand σ_k and its variance over products. This parameter can be thought of either as the own-price elasticity of demand for a particular good from a particular exporter, or as the degree of substitutability between varieties of good k being exported from two or more distinct exporters.

Identifying σ_k requires us to estimate the slope of a demand curve using some variation in prices. Broda-Weinstein (2006) estimate values for σ_k using a procedure developed by Feenstra (1994) to analyze a simultaneous system of export supply and import demand. The procedure exploits time series variation in the quantity shares of exporter j selling product k to the US market as a function of time series variation in the price of j-k. This approach has advantages and disadvantages. One advantage is that it allows for slope in the export supply curve rather than assuming that exporters have a constant marginal cost. A disadvantage is that the parameters of interest are only identified if there are no simultaneous shocks to the error terms in the supply and demand equations. The necessary identifying assumption would be violated if, for example, the quality of a given product k varies over time for an exporter. Nevertheless, the Broda-Weinstein estimates seem sensible, and are becoming something of an industry standard for studies that require an estimate of the price elasticity of import demand.

We employ BW values while also estimating σ_k values of our own using a different identification method. Our method follows Hummels (2001) and identifies the slope of the import demand curve using variation in trade costs. It allows us to better match our estimates of σ_k to the level of aggregation, transportation mode, country sample, and time period that we employ in our shipping price regressions. If σ_k varies across level of aggregation, mode, country or period, our estimates will provide better information about the elasticity of import demand facing a shipping firm as it makes pricing decisions.

Our identification technique works as follows. Equation (3) in the text captures quantity demanded by a single representative consumer in importer j for a single variety from exporter j. Rewrite this to reflect variation across products k in prices, trade costs and the elasticity of import demand

$$(20) \qquad q_{ijk} = \left[\frac{\sigma}{\sigma - 1} p_{jk} \phi_{ijk} \right]^{-\sigma_k}$$

where the last term in the brackets $\phi_{ijk} = \tau_{ijk} + \dfrac{f_{ijk}}{p_{jk}}$ is total ad-valorem trade costs. In the case where product quality varies across exporting sources, this can be further augmented to include a price-equivalent quality shifter of the form.

$$(21) \qquad q_{ijk} = \left[\frac{\sigma}{\sigma - 1} p_{jk} \phi_{ijk} \right]^{-\sigma_k} \left(\lambda_{jk} \right)^{\sigma_k}$$

Trade flows between individual consumers and firms are not observable in our data, so to get something observable (total imports in product k between exporter j and importer i) we multiply

both sides by the number of varieties produced by an exporter and the total expenditures of an importer and take logs

$$(22) \quad \ln Q_{ijk} = a + \ln Y_i + \ln n_{jk} + \sigma_k \ln \lambda_{jk} - \sigma_k \ln p_{jk} - \sigma_k \ln(\phi_{ijk})$$

where $Q_{ijk} = n_{jk}q_{ijk}$ are total quantities traded. In our Latin American data we have many importer i-exporter j pairs for each product k. This allows us to run a separate regression for each k (an HS 6 good) of the form

$$(23) \quad \ln Q_{ijk} = a_k + \alpha_{ik} + \alpha_{jk} - \sigma \ln(\phi_{ijk}) + e_{ijk}$$

In this case, the value of σ_k is identified off the bilateral variation in trade costs. The exporter fixed effects eliminate exporter j-product k specific variation in product prices, and unobserved variation in the number of varieties and product quality. The importer fixed effects eliminate importer i-product k variation in real expenditures. In our simple model with quasi-linear utility this is just real incomes since all prices are written relative to a numeraire. In the more common model with CES preferences there would be an additional CES price index that is i-k specific, but such a term would be differenced out of the estimation of (23) in any case.

A key difference between BW and our technique is that BW is identified off price variation in the time series, assuming that there are no simultaneous shocks to the supply and demand equations as would be caused by changing quality over time. If quality is changing over time then we have the classical simultaneity problem in estimating a demand curve off of prices – there is an unobserved term (quality) that is positively correlated with both supply prices and demand quantity. This biases estimates of σ_k toward zero.

Because we have multiple importers for each exporter, we can control for exporter-specific quality variation using a fixed effect. In this case, we eliminate prices from the equation, but we can still identify σ_k through the variation in trade costs.

This approach assumes that, for a given HS 6 good k, exporters send identical quality levels to each importer. Suppose instead that quality is i-j-k specific. In this case we must rewrite equation (22) as

$$\ln Q_{ijk} = a + \ln Y_i + \ln n_{jk} + \sigma_k \ln \lambda_{ijk} - \sigma_k \ln p_{ijk} - \sigma_k \ln(\phi_{ijk})$$

Our estimating equation becomes

$$(24) \quad \ln Q_{ijk} = a_k + \alpha_{ik} + \alpha_{jk} + \beta_{1k} \ln p_{ijk} - \sigma \ln(\phi_{ijk}) + e_{ijk}$$

and the coefficient on prices is biased due to unobserved (ijk specific) quality variation that shifts out demand and is correlated with prices. However, our measure of trade costs still cleanly identifies σ_k. We use equation (24) to estimate σ_k for each HS 6 product in the Latin American imports data.

For the US imports we do not have multiple importers but we do have a time series and we have multiple (HS 10) observations per HS6 product. Rewriting (22) to reflect this we have

$$\ln q_{jt,g\in k} = a + \ln Y_t + \ln n_{jtk} + \sigma_k \ln \lambda_{jtk} - \sigma_k \ln p_{jt,g\in k} - \sigma_k \ln(\phi_{jt,g\in k})$$

Where $g \in k$ means that we pool over all HS 10 products g within a given HS 6 classification, and we assume that exporter quality and number of varieties are symmetric within an HS 6. We can then estimate this separately for each HS6 and use exporter fixed effects to yield

(25) $\qquad \ln q_{jt,g \in k} = a_t + \alpha_{jk} + \beta_{1k} \ln p_{jt,g \in k} - \sigma_k \ln\left(\phi_{jt,g \in k}\right)$

Using an exporter fixed effect eliminates the time-invariant components of quality, prices, and number of varieties. If we believed that quality was time invariant, as in Broda-Weinstein, we could read the coefficient directly off the price term to get σ_k. If we do not believe this, we can still read the coefficient in front of trade costs to get σ_k.

We can either use quantities on the left hand side of equations (24) and (25), or we can multiply by both sides of the equation and use values. This increases the predicted coefficient on prices by 1, but does not otherwise change the estimating equation. We use import values since they tend to be measured with less noise than import quantities.

In the US imports data, after we restricted our attention to the HS 6-digit categories with at least 50 observations we were left with 4756 separate estimates of elasticity. Out of these, we are able to estimate elasticities in the theoretically sensible range (smaller than -1) and statistically significant in 3750 cases. Using quantities as a dependent variable instead yields only 2321 usable estimates, but the correlation coefficient of 0.88 between these and the elasticities estimated using values as a dependent variable. Similarly for Latin America, we start with 4585 goods for which we have at least 50 observations, and estimate statistically significant elasticities smaller than -1 in 2877 cases.

Figure 1

Number of Shippers on the Route to the US (logs)

$$\ln\left(n_j\right) = \underset{(.743)}{-4.96} + \underset{(.031)}{.25} \ln\left(GDP_j\right)$$

$$N = 95 \quad R^2 = .42$$

Table 1 The Importance of Transportation Costs.

	US	Argentina	Bolivia	Brazil	Chile	Ecuador	Paraguay	Peru	Uruguay
Aggregate freight expenditures (% of imports value)									
All exporters	3.5%	5.9%	8.4%	5.7%	8.1%	9.2%	9.7%	8.5%	5.8%
OECD exporters	2.6%	5.7%	8.6%	5.2%	6.8%	8.4%	9.9%	8.3%	6.7%
Non-OECD exporters	4.5%	6.2%	8.1%	6.2%	9.6%	10.1%	9.4%	8.6%	5.5%
Freight bill as a % of total trade costs (1)	85%	31.3%	45.7%	31.0%	42.4%	45.5%	63.0%	39.5%	31.5%
Coefficient of variation in ad-valorem transportation costs across goods (2)	1.4	5.24	1.83	1.34	1.70	1.68	1.64	1.28	1.59
Coefficient of variation in ad-valorem transportation costs across exporters (3)	.89	.82	.71	.95	.81	.86	.72	.82	.59

Notes:

(1) For each importer, calculate ad-valorem transportation expenditures for each exporter j-HS6 product k as $g_{jk} = f_{jk} / p_{jk} = F_{jk} / PQ_{jk}$. Ad-valorem tariff is τ_{jk}. $g_{jk} / (g_{jk} + \tau_{jk})$ is freight bill as a percentage of total trade costs for each exporter j-HS6 product k. Table entry reports median values of this statistic (over all j-k) for each importer.

(2) The Coefficient of variation is $c.o.v.(g_{jk}) = stdev(g_{jk}) / mean(g_{jk})$. Table reports median value of $c.o.v.(g_{jk})$ over all jk for each importer.

(3) For each importer, calculate ad-valorem transportation expenditures for each exporter j-HS6 product k, relative to product k means as $h_{jk} = (g_{jk}) / (\overline{g}_k)$. The coefficient of variation is $c.o.v.(h_{jk}) = stdev(h_{jk}) / mean(h_{jk})$. The table reports median values of $c.o.v.(h_{jk})$ over all jk for each importer.

Table 2. Model Comparative Statics

Key variables	Oligopoly with fixed number of firms		Marginal cost pricing	
	Marginal Cost	Markup	Marginal Cost	Markup
Import Demand Elasticity σ	0	-	0	0
Distance, d_{ij}	+	-	+	0
Factory price, p_j	+	+	+	0
Tariff, $1+\tau_{ij}$	0	+	0	0
Number of shipping firms, n_{ij}	0	-	0	0
Interaction Term, $\sigma \times n_{ij}$	0	+	0	0

Table 3. Ocean Cargo Prices and Market Power, US Imports

	HS 6 demand elasticities (our estimates)			SITC 3 digit demand elasticities (Broda-Weinstein)		
Dependent variable: Ocean Shipping Costs per Kilogram $\ln f_{jtk}$						
Product Price $\ln p_{jtk}$	.59 (.001)	.58 (.001)	.58 (.001)	.55 (.001)	.54 (.006)	.54 (.001)
Import Demand Elasticity $\ln(\sigma_k)$	-.22 (.002)	-.22 (.002)	-.25 (.004)	-.10 (.002)	-.10 (.002)	-.16 (.004)
Tariff $\ln(1+\tau_{jtk})$	.98 (.019)	1.07 (.018)	1.08 (.018)	1.09 (.019)	1.17 (.019)	1.18 (.019)
Number of Shippers $\ln(n_j)$		-.06 (.001)	-.09 (.003)		-.06 (.001)	-.08 (.002)
Interaction $\ln(n_j)\times\ln(\sigma_k)$			.02 (.002)			.03 (.002)
Distance $\ln(dist_j)$		.17 (.002)	.17 (.002)		.15 (.002)	.15 (.002)
Exporter-year fixed effects	Yes	No	No	Yes	No	No
Adj-R^2	.47	.48	.48	.48	.48	.48
n-obs	725,030			799,215		

Notes:
1. Table contains estimates of equations (13) and (14), data from US Imports of Merchandise, ocean-borne imports only. See appendix for estimation procedure for import demand elasticities.
2. Standard errors in parentheses.
3. Sample includes only those exporters for which data on "n" are available.

Table 4. Ocean Cargo Prices and Market Power, Latin American Imports

Dependent variable: Ocean Shipping Costs per Kilogram $\ln f_{ijk}$						
	HS 6 demand elasticities (our estimates)			SITC 3 digit demand elasticities (Broda-Weinstein)		
Product Price $\ln p_{ijk}$	.55 (.002)	.54 (.002)	.54 (.002)	.53 (.002)	.52 (.002)	.52 (.002)
Import Demand Elasticity $\ln(\sigma_k)$	-.181 (.004)	-.195 (.006)	-.187 (.009)	-.097 (.004)	-.104 (.004)	-.117 (.008)
Tariff $\ln(1+\tau_{ijk})$	2.00 (.057)	1.27 (.055)	1.26 (.055)	2.10 (.051)	1.40 (.050)	1.40 (.050)
Number of Shippers $\ln(n_{ij})$		-.13 (.004)	-.11 (.015)		-.14 (.004)	-.15 (.007)
Interaction $\ln(n_{ij})\times\ln(\sigma_k)$			-.008 (.007)			.012 (.006)
Distance $\ln(dist_{ij})$		.034 (.005)	.034 (.005)		.028 (.005)	.029 (.005)
Bilateral pair Fixed Effects	Yes	No	No	Yes	No	No
adj-R^2	.59	.58	.58	.58	.57	.57
n-obs	61,053	61,053	61,053	75,532	75,532	75,532

Notes:
1. Table contains estimates of equations (15) and (16), data from BTI database, ocean-borne imports only. See appendix for estimation procedure for import demand elasticities.
2. Standard errors in parentheses.
3. Sample includes only those exporters for which data on "n" are available.

Table 5 Explaining Variation in Shipping Costs per kg
Contribution of Explanatory Variables

US Imports						
	Product Price	Import Demand Elasticity (SITC 3digit)	Import Demand Elasticity (HS 6)	Tariff	Number of shippers	Distance
Estimated Elasticity	.54	-.10	-.22	1.17	-.06	.15
$f(X_{50\,pctile})/f(X_{5\,pctile})$	8.50	.92	.80	1.03	.85	1.17
$f(X_{95\,pctile})/f(X_{5\,pctile})$	20.91	.75	.70	1.17	.81	1.24

Latin American Imports						
	Product Price	Import Demand Elasticity (SITC 3digit)	Import Demand Elasticity (HS 6)	Tariff	Number of shippers	Distance
Estimated Elasticity	.51	-0.104	-0.195	1.48	-.14	.028
$f(X_{50\,pctile})/f(X_{5\,pctile})$	5.75	.92	.85	1.19	.88	1.03
$f(X_{95\,pctile})/f(X_{5\,pctile})$	18.36	.79	.70	1.36	.82	1.06

Notes:
1. Estimated elasticities taken from 5th columns of Tables 3,4
2. For each column calculate the predicted freight rate for 5th, 50th, and 95th percentile values of the explanatory variable weighted by value of trade, holding other variables at means. $f(X_{50\,pctile})/f(X_{5\,pctile})$ then reports the ratio of freight rates at the 50th and 5th percentiles.
3. The values of each variable at (5th,50th, and 95th) percentiles are: Import demand elasticity (SITC 3digit) – US (1.23, 2.69, 22.15), LA (1.22, 2.69, 11.37); Import demand elasticity (HS 6) – US (3.23, 9.10, 16.50), LA(3.53,8.09,21.85); Tariff – US (1,1.02,1.17), LA (1,1.12,1.23); Product price – US (0.14, 7.66, 40.66), LA (0.13, 4.06, 39.56); Distance – US (3233, 8830, 13326), LA (2344, 7915, 18372); Number of shippers – US (1, 15, 32), LA (2,5,8).
4. 99th percentile elasticity of substitution (estimated at SITC 3digit) for Latin America and for US is 25.03.

Table 6. Decomposing Differences in Shipping Costs by Income Level

	Ad-valorem Shipping Costs	Explanatory variable					
		OECD intercept	Product Price	Import Demand Elasticity	Tariff	Number of shippers	Distance
		US Imports Shipment Characteristics: non-OECD exporter means / OECD exporter means					
$\overline{X}_{non-OECD} / \overline{X}_{OECD}$	1.48		0.61	1.02	0.995	0.52	1.16
Contribution to fitted values $\ln \hat{f}_{noecd} - \ln \hat{f}_{oecd}$	0.393 (100%)	0.132 (34%)	0.224 (57%)	-0.002 (-.5%)	-0.007 (-2%)	0.027 (7%)	0.019 (5%)
		Latin American Imports Shipment Characteristics: non-OECD exporter means/OECD exporter means					
$\overline{X}_{non-OECD} / \overline{X}_{OECD}$	1.39		0.63	0.94	1.01	1.14	1.17
Contribution to fitted values $\ln \hat{f}_{noecd} - \ln \hat{f}_{oecd}$	0.327 (100%)	.11 (33%)	0.222 (67.8%)	0.006 (1.8%)	0.007 (2%)	-0.019 (-5.8%)	0.003 (1%)
		Shipment Characteristics: Latin America Imports Mean/ US Imports Mean					
$\overline{X}_{LA} / \overline{X}_{US}$	1.257		.98	.97	1.10	.38	1.28
Contribution to fitted values $\ln \hat{f}_{LA} - \ln \hat{f}_{US}$	0.228 (100%)		0.009 (3.9%)	0.003 (1.3%)	0.112 (49%)	0.074 (32.5%)	0.030 (13.2%)

Notes:

1. Difference in predicted non-OECD freight rate attributable to product price is calculated as $\beta_p \left(\ln p^{non-OECD} - \ln p^{OECD} \right)$.

2. Calculations based on these regressions (all coefficients significant at 1%, SITC 3 elasticities

US imports: $\ln(f/p) = \alpha_t - 3.66 - .18\,OECD - .11\ln\sigma - .47\ln p + 1.14\ln\tau + .18\ln DIST - .04\ln n$.

Latin American: $\ln(f/p) = -1.99 - .11\,OECD - .10\ln\sigma - .48\ln p + 1.38\ln\tau + .02\ln DIST - .15\ln n$

US v. Latin America imports: $\ln(f/p) = 3.10 - .10\ln\sigma - .47\ln p + 1.14\ln\tau + .12\ln DIST - .076\ln n$