Endogenous Transport Costs in International Trade

Joern Kleinert[a,] , Julia Spies[b]

[a]University of Graz, Universitaetsstrasse 15/F4, A-8010 Graz, Austria, joern.kleinert@uni-graz.at
[b]Institute for Applied Economic Research (IAW), Ob dem Himmelreich 1, D-72074 Tuebingen, Germany, julia.spies@iaw.edu

---

Abstract

In this paper we claim that distance alone is a poor proxy for international transport costs in empirical studies. We model a manufacturing and a transport sector and let the level of manufacturing exports determine the demand for transport services. Above a particular trade level, transport service suppliers find it profit-maximizing to invest in an advanced transport technology, which lowers their marginal costs and as a consequence, equilibrium transport prices. Transport costs thus vary with two characteristics: with the distance between two locations and with the endogenous decision to invest in a more efficient technology which is driven, in turn, by the bilateral export level. A simulation exercise reveals that ignoring the effect of the investment decision on transport costs biases empirical results. The empirical estimations rely on newly collected transport price data from United Parcel Service (UPS). We apply an instrumental variable (IV) estimator to account for the endogeneity of the investment decision. Our results confirm that transport prices are influenced by both the distance and the level of exports between two countries. We find that trade partners with 10% more exports enjoy 0.8% lower transport prices.

Keywords: Distance, endogenous transport costs
JEL: F12, F15, R41

Corresponding author. Phone: +43 316 380 3443, Fax: +43 316 380 9520

Preprint submitted to Elsevier July 21, 2011

1. Introduction

Falling cross-border transaction costs have stimulated an unprecedented increase in cross-border transactions of all kinds. This rise in international activities has been impressive enough to label the past two decades nothing short of an era of globalization. The falling costs of cross-border transactions are thereby at the same time the source of the globalization process and its result. Increased cross-border transactions do not only stem from transport cost reductions, they also boost investments in the infrastructure of international trade, which induce further cost cuts. In the light of the importance of this phenomenon, the scarcity of economic studies that address the role of infrastructure investments in lowering transport costs and in stimulating trade, is surprising. In this paper, we put the infrastructure of international trade and the transport sector where the investment decisions are taken in the focus of the analysis.

We start with the observation that the costs of transporting goods between two countries seem to vary not only with respect to the distance between them. While most Asian economies, first and foremost, China, trade high volumes at moderate transport prices with the United States and the European Union (EU), many African economies trade rather moderate volumes at high transport prices despite of their more favorable geographic location. Hence, there must be more than just distance affecting transport costs. The recent literature has stressed that transport costs differ systematically with the market structure of the transport sector (Hummels et al., 2009), with bilateral trade imbalances (Behrens and Picard, 2011 and Jonkeren et al., 2011), and with port efficiencies (Clark et al., 2004 and Blonigen and Wilson, 2008). Complementing these findings, we argue that bilateral trade levels are an important, yet largely neglected driver of the differences.

To back the argument, we develop a theoretical framework that explicitly models a manufacturing and a transport sector and focuses on the investment decision of transport service suppliers. Transport service suppliers can choose between two route-specific technologies: (i) a low fixed costs / high variable costs technology and (ii) a high fixed costs / low variable costs technology. This choice is motivated by the fact that increasing

in the trade imbalance. Firms in the net exporting country face higher, firms in the net importing country face lower transport costs if transport firms optimally set prices for the return journey. This price wedge works against the agglomeration forces. Thus, endogenous transport prices mitigate the separation of countries in an industrial core and an agricultural periphery which is so prominent in the models using iceberg transport costs.

Starting with Clark et al. (2004), a number of empirical studies have identified economies of scale as a determinant of transport costs (see e.g. Wilmsmeier et al., 2006, Martínez-Zarzoso and Wilmsmeier, 2010 and Pomfret and Sourdin, 2010). Clark et al. (2004) find higher transport costs on routes with lower trade volumes. Assuming that any effect of country size on transport costs goes through trade volumes, they use GDP as an instrumental variable (IV) for trade volumes. The negative effect of trade volumes on transport prices becomes more pronounced when exports are instrumented, suggesting that failing to account for the endogeneity of exports understates their impact. Using the gap between c.i.f and f.o.b values of Australian imports as a measure of transport costs, Pomfret and Sourdin (2010) show that country size explains some of the variation in transport costs along with distance, the weight of the product, and the institutional quality of the exporting and/or the importing country. Once imports are used as a regressor instead of GDP to approximate country size, the significantly negative effect on trade costs becomes larger and more robust. Clark et al. (2004) and Blonigen and Wilson (2008) make a reference to technology. They argue that differing port efficiencies explain the country-specific part of transport cost variations whereas variables such as distance, trade imbalances and product weight are introduced to capture the bilateral transport cost determinants.

transport sector. The decision to supply transport services thereby involves a decision about an investment in a particular transport technology.

Although we focus on the determinants of transport prices, the analysis naturally relates also to the literature that deals with the correct specification of the gravity equation. Endogeneity problems in gravity equations have provoked lengthy discussions in the trade literature of the past decade. Nearly all of the typically employed variables have been surmised to simultaneously influence trade, and, be influenced by trade. The usual suspects include national incomes (Frankel and Romer, 1999) and Free Trade Agreements (FTAs) (see e.g. Baier and Bergstrand, 2004 and Egger et al., 2010). Mostly approximated by time-invariant distance, transport costs have, by contrast, been perceived as exogenous and even served as an instrumental variable for trade assuming their orthogonality to other gravity variables (Frankel and Romer, 1999).

A notable exception is Rudolph (2009) who argues that scale economies leading to falling average costs arise in the presence of fixed costs in the transport sector. Not accounting for the endogenous impact of trade on transport costs biases the coefficients of traditionally estimated gravity equations. Rudolph (2010) applies a simultaneous equation model to jointly estimate trade and transport costs, the latter being approximated by the trade volume within the respective economies relative to the trade volume between them. He presents two findings: first, trade levels and transport costs are simultaneously determined. Second, ignoring the simultaneity results in overestimating the impact of transport cost proxies on trade. In order to provide a more reliable estimate sector. We account for the evidence they present by modeling an oligopolistic sector which invests in route-specific instead of country-specific infrastructure. For clarity, we abstract from Hummels et al. (2009)'s finding of different degrees of competition and focus instead on the technology choice.

3. Theoretical Framework

In this section, we develop a two-sector model that formalizes the argument that bilateral trade levels and bilateral transport prices are jointly determined. The model consists of an oligopolistic transport sector, T, (with a fixed number of firms) which produces a homogenous transport service for each route and of a monopolistically competitive manufacturing sector, M, where exporting firms face per-unit transport costs. Prices are determined in equilibrium where the units of offered transport services equal the units of goods from the manufacturing sector that need transportation to a foreign country. To fit the structure of the transport sector, we model the manufacturing sector based on a Melitz and Ottaviano (2008)-framework with a quasi-linear demand structure and additive transport costs. We choose the simplest possible set-up with labor as the only factor of production. There are L_j individuals in economy j, each offering one unit of (homogenous) labor.

3.1. The Manufacturing Sector

The manufacturing sector, M, comprises N heterogenous firms that engage in monopolistic competition. Firms set prices depending on their marginal costs and decide about their export participation. Marginal costs depend on the firm-specific productivity level that is drawn independently at market entry from a common distribution. This firm-specific productivity is the only primary source of firm heterogeneity. The other, secondary source of heterogeneity, is the firm's export status which directly results from the heterogeneity with respect to productivity. In this static framework, consumers spend their complete income on the consumption of the goods produced in the manufacturing sector.

Consumers

Following Melitz and Ottaviano (2008), preferences of a representative individual from country j are described by a quadratic utility function,

$$U_j = q^c_{ij}(0) + \int_{m \in _j} q^c_{ij}(m)\,dm \quad \frac{1}{2} \int_{m \in _j} (q^c_{ij}(m))^2 dm \quad \frac{1}{2} \left(\int_{m \in _j} q^c_{ij}(m)\,dm \right)^2 ; \tag{1}$$

where $q^c_{ij}(0)$ and $q^c_{ij}(m)$ refer to the individual consumption of the numeraire and the differentiated good, m. The first index, i, refers to the country where the production of the differentiated good, m, takes place. The second index, j, refers to the home country of the consumer. and indicate the degree of substitutability between the differentiated varieties and the numeraire, governs the degree of differentiation between the varieties. The inverse demand function is given by

$$p_{ij}(m) = \quad q^c_{ij}(m) \quad Q^c_{ij} ; \tag{2}$$

where $Q^c_{ij} = \int_{m \in _j} q^c_{ij}(m)\,dm$. With $q_{ij} = L_j q^c_{ij}$ and $q^c_{ij} > 0$, we obtain the subset of produced varieties which satisfies

$$p_{ij}(m) \quad \frac{1}{N_j +} (\quad + N_j p_j) ; \tag{3}$$

where N denotes the number of firms and p_j the average price in country j with $p_j = 1/N \sum_m p_{ij}(m)$. The consumer price, $p_{ij}(m)$, includes the per-unit transport costs, $p_{ij}(m) = p_i(m) + t_{ij}$, if the good is imported ($j \neq i$).

Producers

We assume that product differentiation is costless which guarantees that each good m is produced by only one firm. Firms maximize profits,

$$_{ij}(m) = q_{ij}(m)(p_{ij}(m) \quad c_i(m) \quad t_{ij}) \tag{4}$$

for the foreign market ($i \neq j$) and for the domestic market ($i = j$ and $t_{ii} = 0$) separately. While products enter symmetrically in the consumption bundle, we keep the firm index m because firms differ with respect to their productivity level. Firm-specific productivity levels translate into firm-specific marginal costs $c_i(m)$, firm-specific prices $p_{ij}(m)$ and firm-specific output levels $q_{ij}(m)$. Using the residual demand from (2), firms obtain their output function as

$$q_{ij}(m) = \frac{L_j}{} \left(p_{ij}(m) - c_i(m) - t_{ij}\right): \qquad (5)$$

A firm stays in the domestic and enters a foreign market if its price at least equals its marginal costs, $p_{ij}(m) = c_i(m) + t_{ij}$. We denote the maximum marginal costs for firms from country i to be active in market j as of the maximum costs in country j, $\hat{c}_j$, and the number of firms from country i, N_i. The number of firms from country i that are active in country j can be expressed as the product of the share of exporters in the number of firms in i, $N_{ij} = \frac{G(\hat{c}_{ij})}{G(\hat{c}_i)} N_i = \frac{\hat{c}_j \quad t_{ij}}{\hat{c}_i} \quad N_i$.

In Appendix A.1, we show that the transport costs affect the trade level negatively, i.e. that the partial derivative $\frac{\partial Q_{ij}}{\partial t_{ij}} < 0$. Considering that exports are declared net of transport costs, we next obtain the total bilateral export value by aggregating each firm's export sales, $r_{ij}^{fob}(m) = p_{ij}^{fob}(m) q_{ij}(m)$, over all exporters from i to j,

$$\begin{aligned} EX_{ij} &= N_i \frac{L_j}{4} \int_0^{\hat{c}_{ij}} \hat{c}_j^2 \quad c_i^2(m) + 4t_{ij}^2 \quad 4\hat{c}_j t_{ij} \quad g(c_i(m))\, dc_i(m) \\ &= \frac{1}{4} N_i L_j \hat{c}_i \quad \underbrace{\frac{2}{2+} (\hat{c}_j \quad t_{ij})^{2+} + 3t_{ij}^2 \quad 2\hat{c}_j t_{ij} \quad (\hat{c}_j \quad t_{ij})}_{(\ t)} \quad : \end{aligned} \tag{8}$$

Equation (8) shows that the aggregate bilateral export values are characterized by a gravity-type relation where the two country sizes, N_i and L_j, affect exports positively, while the transport costs, t_{ij}, affect them negatively (since $\hat{c}_j \quad 2t_{ij}$). Furthermore, exports rise in the minimum (and therefore average) productivity of the home country f $(1/\hat{c}_i)$ and fall in the productivity of the partner country f $(1/\hat{c}_j)$. As a result of the additive transport costs, the partner country's productivity, $(1/\hat{c}_j)$, is strongly interlinked with the transport costs between the two countries, t_{ij}.

3.2. The Transport Sector

As the transport sector typically consists of a few, large companies, we impose an oligopolistic market structure. We assume that transport is a homogenous service. Consequently, exporting firms will base their decision for a particular transport service supplier entirely on cost considerations. To keep the model simple and to focus on differences in the aggregate pattern of transport costs between two countries, we model the transport sector as consisting of n^T symmetric firms.[2] In a world with I exporting and J importing countries, $I \quad J$ transport routes exist. We assume that each transport firm

---

[2] Imposing symmetry does not affect our main argument while it simplifies the analysis considerably.

serves each route. The total number of transport firms, n^T, is exogenously given.[3]

Transport firms choose their transport technology when starting to service a particular route. Like Yeaple (2005) and Bustos (2011), we simplify this choice by assuming that there are just two possible cost structures to choose from: technology L with low variable costs, a^L, and high fixed costs, f^L, and technology H with high variable costs, a^H, and low fixed costs, f^H, i.e. $a^L < a^H$ and $f^L > f^H$

with $\varepsilon = -\frac{\partial Q_{ij}}{\partial t_{ij}}\frac{t_{ij}}{Q_{ij}}$ as the price elasticity of demand. Output, i.e. the supply of transport services, increases in the transport price, t_{ij}, and the export quantity, Q_{ij}, of the manufacturing sector. With demand (as given in (7)) strictly falling and supply (as given in (11)) strictly rising in the transport price, t_{ij}, there exists exactly one transport price level that clears the market for transport services. Equation (11) also shows that the output of a transport service supplier is negatively affected by the variable costs of supplying the service, a_{ij}.

The second equation in (11) uses the fact that transport firms are symmetric by assumption and that the transport service market must be cleared in equilibrium, hence $Q_{ij}(t) = \sum_1^{n^T} q_{ij}(t_{ij}) = n^T q_{ij}$. Solving the supply equation (11) for the transport price, t_{ij}, yields the price as a function of the firms' costs, a_{ij}, the number of firms, n^T, and the demand elasticity, ε,

$$t_{ij} = \frac{\varepsilon n^T}{\varepsilon n^T - 1} a_{ij}. \tag{12}$$

Knowing that in a symmetric equilibrium every firm serves Q_{ij}/n^T of the demand, we can rewrite the profits from (10) as

$$\pi_{ij} = (t_{ij} - a_{ij})q_{ij} - f = \underbrace{(t_{ij} - a_{ij})}_{\mu_{ij}}\frac{Q_{ij}}{n^T} - f, \tag{13}$$

where we define the mark-up μ_{ij} as $t_{ij} - a_{ij}$. With this outline, we can now study the incentive to invest in a variable costs saving transport technology for the route between country i and j. Equation (14) uses (12) to show that the variable profits, π_{ij}^{var}, generated on route ij increase as the marginal costs of shipping between these two countries fall,

$$\begin{aligned} \frac{d\pi_{ij}^{var}}{da_{ij}} &= \frac{\partial \mu_{ij}}{\partial a_{ij}}\frac{Q_{ij}}{n^T} + \frac{\partial Q_{ij}}{\partial a_{ij}}\frac{\mu_{ij}}{n^T} \\ &= B\frac{Q_{ij}}{n^T}\frac{1}{\varepsilon n^T - 1} < 0, \end{aligned} \tag{14}$$

where $B \equiv 1 - \frac{(1+\ )[2\hat{c}_j - (2+\ )t_{ij}]}{(\hat{c}_j - t_{ij})[\hat{c}_j - (2+\ )t_{ij}]}\frac{\varepsilon n^T}{\varepsilon n^T - 1} = 1 - \frac{\varepsilon}{a_{ij}} < 0$ if the price elasticity of demand ε is not to low, i.e. if $\varepsilon > a_{ij}$. This holds if the transport costs are not too low, since the price elasticity of demand rises with transport costs.[6] In the following, we assume that the price elasticity of demand for shipping is sufficiently high to ensure the negative relationship. Note, that there is a trade-off between lower mark-ups and larger demand following the cost reduction. Since the second effect outweighs the first, profits increase with falling costs. For our argument most important, equation (14) states that the profit-rising effect of investing in advanced technologies increases in the export volume, Q_{ij}, from the manufacturing sector of country i. Thus, routes on which large volumes of goods are traded generate more additional profits if the variable costs of transportation, a_{ij}, fall.

The comparison of profits guides the firm's decision of investing in one of the two available technologies. Transport suppliers decide to invest in the advanced technology if the lower marginal costs generate sufficiently high variable profits to make up for the higher fixed costs. The discussion above reveals that this is more likely for transport routes with high trade volumes, Q_{ij},

$$d\pi_{ij} > 0 \rightarrow \frac{1}{n^T}\left[(t^L_{ij} - a^L_{ij})Q^L_{ij} - (t^H_{ij} - a^H_{ij})Q^H_{ij}\right] > f^L - f^H : \qquad (15)$$

Routes that generate more additional variable profits are more likely to jump the additional fixed costs hurdle $f^L - f^H$. As argued above, the large trade volume routes create the largest additional variable profits. Hence, on these routes the introduction of the low variable costs technology is more likely. Since the technology choice depends on the trade volume, we expect lower transport prices on routes with large trade volumes. In turn, the technology choice affects the marginal costs and therefore the transport prices,

$$t^l_{ij} = \begin{cases} \dfrac{n^T a^L_{ij}}{n^T - 1/\varepsilon^L} & \text{for a high trade volume} \\ \dfrac{n^T a^H_{ij}}{n^T - 1/\varepsilon^H} & \text{for a low trade volume:} \end{cases} \qquad (16)$$

Equation (16) shows that the transport costs for firms from the manufacturing sector

---

[6] See Appendix A.2 for the derivation of this result.

differ for routes of similar distance and similar other characteristics if the chosen technology differs. This implies that transport prices which are set in the transport sector eventually depend on export volumes decided on in the manufacturing sector, which, in turn, depend on transport prices. The mutual dependance of exports as given by equation (8) and transport prices as given by equation (16) reveals that both variables are, in fact, jointly determined.

4. Estimating Transport Costs: An Illustrative Example

porting and 61 importing countries[7], from which we calculate a distance matrix between any two of these countries.[8] We draw an arbitrary size ($GDP_i > 0; GDP_j > 0$) for each of these countries from a uniform distribution with mean 500 and a country-specific marginal cost threshold which corresponds to $\hat{c}_i$

country i to country j

above imply that investments into the advanced technology take place on about 15% of all trade routes. In the continuous version of the investment decision, we assume $I_{ij} = 2(EX_{ij} = 10)^{0:15}$. The parameters are chosen to match the maxima and minima of

Table 1: Addressing the Omitted Variable Bias in the Transport Cost Estimation: the Discrete Case

	Omitting	Proxy	Proxy	Proxy	IV	IV
	I_{ij}	top 150	top 250	top 350	I_{ij}	EX_{ij}
Dependent variable: Bilateral transport costs t_{ij}						
$dist_{ij}$	0.275	0.209	0.206	0.214	0.200	0.229
	(0.0148)	(0.0101)	(0.00813)	(0.00898)	(0.00453)	(0.0116)
gdp_i	1.000	1.000	1.000	1.000	1.000	1.000
	(0.0105)	(0.00707)	(0.00571)	(0.00633)	(0.00312)	(0.00817)
top 150		-1.054				
		(0.0232)				
top 250			-0.961			
			(0.0150)			
top 350				-0.788		
				(0.0145)		
I_{ij}					-1.000	
					(0.0176)	
EX_{ij}						-0.165
						(0.00474)
R^2	0.84	0.92	0.95	0.94	0.99	0.90

Table 2: Addressing the Omitted Variable Bias in the Transport Cost Estimation: the Continuous Case

	Omitting	Proxy	Proxy	Proxy	IV	IV
	I_{ij}	top 150	top 250	top 350	I_{ij}	EX_{ij}
Dependent variable: Bilateral transport costs t_{ij}						
$dist_{ij}$	0.230	0.209	0.208	0.207	0.200	0.198
	(0.00906)	(0.00852)	(0.00821)	(0.00793)	(0.00435)	(0.00434)
gdp_i	1.000	1.000	1.000	1.000	1.000	1.000
	(0.00640)	(0.00597)	(0.00577)	(0.00558)	(0.00309)	(0.00308)
top 150		-0.328				
		(0.0196)				
top 250			-0.315			
			(0.0151)			
top 350				-0.309		
				(0.0128)		
I_{ij}					-1.000	
					(0.0141)	
EX_{ij}						-0.138
						(0.00182)
R^2	0.93	0.94	0.94	0.95	0.98	0.98

Note: Standard errors in parentheses.

Source: Own calculations.

350 export routes come close to the coefficients of the true model. In the continuous case, using the instrumented export level, however, works better. The overidentification test

rejects the validity of the instruments in less than 10% of the repetitions with the continuous investment indicator, while it rejects the validity of the instruments for nearly 50% of the repetitions with the discrete investment indicator. Because the instruments are exogenous by construction, this result demonstrates how sensitive the overidentification test reacts to the nature of the omitted investment variable, i.e. whether it is aisare working with real data and (ii) because poisson regressions allow for a correct treatment of zero trade flows. Even though the number of zeros is very low in this OECD countries-centered sample, the poisson estimations provide an important robustness check.

5.1. Data

Bilateral transport costs are difficult to measure.[11] We have built a new data set by collecting information from UPS on the costs of shipping a10kg package per express delivery between two countries. Transport prices for 2010 are available for 61 countries. In cases where different prices apply to different regions of one country, we take the prices of the region to which the most populated city belongs.

We analyze the transport prices charged on different routes together with bilateral trade data. The OECD ICTS database provides bilateral trade data in US$ for 30 OECD countries (all member states as of 2009) with partner countries worldwide. The latest available year for which the data is complete, is currently 2009. We select the 61 trade partners for which we were also able to gather information on transport prices. If we had full information, we would have a data set containing 30

Figure 1: UPS Transport Prices and Exports

5.2. Main Results

We start with estimating transport prices by using a single equation approach. In order to make our results match the predominant number of empirical studies, we primarily report OLS estimates. Table 3 shows the estimation of transport prices as a function of distance and GDP per capita in Column 1. The results indicate that firms set higher prices on more distant routes. The impact of distance on transport prices is, however, moderate. Transporting goods between countries which are 10% farther away from each other is 1.43% more expensive, on average. This result is in line with Clark et al. (2004) and other empirical estimations of transport cost equations that do not control for route-specific investments. Other marginal costs, captured by per capita GDP, have a similar effect.

Table 3: OLS Estimation of Transport Prices

	Omitting I_{ij}	Proxy top 150	Proxy top 250	Proxy top 350	IV EX_{ij}
Dependent variable: t_{ij}					
$dist_{ij}$	0.143***	0.121***	0.117***	0.112***	0.083***
	(0.018)	(0.017)	(0.016)	(0.017)	(0.017)
gdp_i	0.132***	0.145***	0.150***	0.148***	0.163***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
top 150		-0.383***			
		(0.049)			
top 250			-0.345***		
			(0.037)		
top 350				-0.293***	
				(0.030)	
EX_{ij}					-0.076***
					(0.008)
N	1,740	1,740	1,740	1,740	1,739
R^2	0.151	0.205	0.220	0.214	0.232
Endog. test					12.585
p-val.					0.000
Hansen J					1.241
p-val.					0.265
Underid. test					57.35
p-val.					0.000
Weak id. test					1730.70
p-val.					0.000

Note: Cluster-robust standard errors in parentheses with significance at the *** p<0.01, ** p<0.05, * p<0.1 level.
Source: Own calculations.

Since we cannot observe investments in the transport sector, we follow the strategy outlined in Section 4 and let the R^2s guide our decision about the most appropriate specification. In Columnslet to0

Table 4: Poisson Estimation of Transport Prices

	Omitting I_{ij}	Proxy top 150	Proxy top 250	Proxy top 350	IV EX_{ij}
Dependent variable: t_{ij}					
$dist_{ij}$	0.131***	0.113***	0.109***	0.104***	0.088***
	(0.018)	(0.017)	(0.016)	(0.017)	(0.018)
gdp	0.132***	0.142***	0.146***	0.145***	0.152***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
top 150		-0.391***			
		(0.046)			
top 250			-0.347***		
			(0.037)		
top 350				-0.289***	
				(0.030)	
EX_{ij}					-0.054***
					(0.007)
N	1,740	1,740	1,740	1,740	1,739
R^2	0.126	0.171	0.185	0.181	0.198

Note: the single equation estimations are reported with cluster-robust standard errors in parentheses with significance at the *** p<0.01, ** p<0.05, * p<0.1 level.

Source: Own calculations.

strong predictor of transport prices, even though there is no exclusive relationship as suggested by the gravity literature which often relies entirely on distance to approximate transport costs. Instead, the infrastructure investments, which we approximate by dummy variables for the most frequented export routes and by the bilateral export level are important transport price determinants as well. Including the investment proxies increases the R^2 also in the poisson regressions. Again, it is highest in Column 5, where we include and instrument the bilateral export level. Moreover, the distance coefficient falls which we, based on the theoretical considerations and the simulation, interpret as bias correction.

5.3. Robustness Checks

Transport service suppliers like the UPS do not offer transport for all kinds of goods. Certain raw materials, for example, need a very specific infrastructure, like pipelines, on which cross-border transport crucially hinges. To account for the fact that the collected UPS transport prices may not apply to all goods, we repeat the estimations in Table

6. Transport Sector Investments and Globalization

The empirical results reveal that distance affects transport prices positively. Yet, geography is not a destiny although it poses a challenge to policy-makers. Our results point to a strong price reducing effect of bilateral trade values, which we interpret as stemming from investments in the transport sector. These investments in new, often large-scale trade-enhancing transport technologies result in important cost savings. Falling transport costs, i.e. falling costs of trade are the drivers of globalization. Even though the debate on the distance puzzle or the missing globalization puzzle (Coe et al., 2007) mentions that new technologies in transport bring down the costs of trade, in empirical applications such technology changes do not play a role. Instead, transport costs are modeled as iceberg costs which increase in distance. Consequently, globalization is searched for in the distance coefficient.

We argue that finding the source of falling trade costs requires augmenting international trade models by a transport sector, where the transport prices are actually set. When setting up the transport sector, we explicitly model firms that face a technology choice. Firms choose route-specific technologies to maximize profits on each route. Modeling both the manufacturing goods sector and the transport sector enables us to show that specifying transport costs as a mere function of distance and distance-related variables misses an important point and creates an omitted variable problem in empirical applications. Since actual investments are often unobservable, the regressions require a proxy variable as a regressor.

From a policy perspective, there are at least three arguments that support the inclusion of transport sector investments in the analysis of international trade: it helps understanding (i) the driving force of globalization, (ii) the distance puzzle, and (iii) trade and development.

First, our model has the nice reinforcing feature of increasing trade leading to falling

---

dummies. We obtain qualitatively the same results with a slightly higher distance and per capita GDP coefficient. These additional results are not reported here but will be made available upon request.

transport prices which again stimulate trade. We think that the globalization process is well explained by such an investment-induced fall in transport prices. Seen like this the driving force of globalization is endogenous and the outcome of a profit-maximizing behavior in the transport sector. The empirical results support this view. Transport prices are driven down by trade levels. Unfortunately, we do not have time series data and take all variation from the cross-section but if the production function of the transport sector did not miss anything important, infrastructure investments are a main source of differences in transport prices on routes with similar distances. And, they are easily included as a regressor in the transport price equation.

Second, the study relates to the distance puzzle in two rather different ways. On the one hand, we observe that the omitted variable biases the distance coefficient in the transport price equation upwards which might contribute to the biased distance coefficient in gravity equations. On the other hand, we argue that if estimated correctly, the distance coefficient should be unaffected anyway by technological changes that do not influence the distance elasticity of transport costs. If this elasticity is systematically reduced, we are probably confronted with an investment function which is not only affected by the trade level but also by distance. That might be the case if the technology choice includes the decision about different modes (air, sea, land, rail, pipeline) of transport which we have abstracted from in this study.

Third, the circular causality of transport prices and trade levels is very important for developing countries. Any change that leads to increasing trade has the potential to reduce transport prices and any transport price reduction increases trade levels. A regional trade agreement for instance might induce more trade and therefore lower transport prices which reinforce trade integration even more. Better investment conditions in the transport sector might induce investments in modern technologies and lower transport prices, thereby increasing the level of trade. One can think of many other policy measures that could help relatively closed economies to start a virtuous circle of lower transport costs and larger trade.

7. Conclusions

Unlike most of the literature that assumes exogenously set, iceberg-type transport costs, this paper proposes marginal costs and prices in the transport sector to be endogenous and affected by the bilateral export levels between two countries. By setting up a theoretical framework which comprises a manufacturing and a transport sector, we show that optimizing transport service suppliers invest in modern transport technology on highly frequented trade routes. The technology choice affects transport prices via the marginal costs of supplying transport services between two locations. If this description of investment in the transport sector is correct, it is not sufficient to approximate transport costs by distance and distance-related variables as done in the vast majority of empirical trade applications.

Using a constructed data set, we illustrate that the bias stemming from the omission of the investment decision in the transport sector, and its endogeneity to bilateral trade levels can be cured by using proxy variables and IV techniques. Employing a new data set which contains information on UPS transport prices, we detect an effect from exports on transport prices. We find that two countries with exports 10% above the average for all trade pairs enjoy 0.8% lower transport prices. This result adds to the discussion of the drivers of globalization, the distance puzzle and the development of economies which are currently lagging behind in terms of trade openness.

Acknowledgements

This project has benefited from the joint support of the French and German science foundations ANR and the DFG. Special thanks go to Maria Fenger Jensen, Lena Tonzer and Christoph Schroeder, who provided most valuable research assistance.

References

Baier, S. L., Bergstrand, J. H., 2004. Economic Determinants of Free Trade Agreements. Journal of International Economics 64 (1), 29 63.

Behrens, K., Picard, P. M., 2011. Transportation, Freight Rates, and Economic Geography. Journal of International Economics In Press, Accepted Manuscript.

Blonigen, B. A., Wilson, W. W., 2008. Port Efficiency and Trade Flows. Review of International Economics 16 (1), 21 36.

Bustos, P., 2011. Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms. American Economic Review 101 (1), 304 40.

Clark, X., Dollar, D., Micco, A., December 2004. Port Efficiency, Maritime Transport Costs, and Bilateral Trade. Journal of Development Economics 75 (2), 417 450.

Coe, D. T., Subramanian, A., Tamirisa, N. T., 2007. The Missing Globalization Puzzle: Evidence of the Declining Importance of Distance. IMF Staff Papers 54, 34 58.

Egger, P., Larch, M., Staub, K. E., Winkelmann, R., 2010. The Trade Effects of Endogenous Preferential Trade Agreements. CESifo Working Paper Series 3253, CESifo Group Munich.

Frankel, J., Romer, D., 1999. Does Trade Cause Growth? American Economic Review 89 (3), 379 399.

Hummels, D., 2007. Transportation Costs and International Trade in the Second Era of Globalization. Journal of Economic Perspectives 21 (3), 131 154.

Hummels, D., Lugovskyy, V., Skiba, A., 2009. The Trade Reducing Effects of Market

Rudolph, S., 2009. The Gravity Equation with Micro-founded Trade Costs. Dresden Discussion Paper Series in Economics 11/09.

Rudolph, S., 2010. Estimating Gravity Equations with Endogeneous Trade Costs. Dresden Discussion Paper Series in Economics 01/10.

Silva, J. M. C. S., Tenreyro, S., 2006. The Log of Gravity. The Review of Economics and Statistics 88 (4), 641 658.

Skiba, A., 2007. Regional Economies of Scale in Transportation and Regional Welfare. Working Paper Series in Theoretical and Applied Economics 200705, University of Kansas, Department of Economics.

Wilmsmeier, G., Hoffmann, J., Sanchez, R. J., 2006. The Impact of Port Characteristics on International Maritime Transport Costs. Research in Transportation Economics 16 (1), 117 140.

Wooldridge, J. M., 2002. Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge MA.

Yeaple, S. R., 2005. A Simple Model of Firm Heterogeneity, International Trade, and Wages. Journal of International Economics 65 (1), 1 20.

Appendix B. Country List

Table B.1: List of Exporting Countries

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Iceland
Ireland
Italy
Japan
Luxembourg
Mexico
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
South Korea
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

Table B.2: List of Importing Countries

Algeria
Argentina
Australia
Austria
Belgium
Brazil
Bulgaria
Canada
Croatia
Czech Republic
Côte d'Ivoire
Denmark
Egypt
Estonia
Finland
Iceland
India
Indonesia
Ireland
Israel
Italy
Japan
Netherlands
New Zealand
Nigeria
Norway
Panama
Peru
Philippines
Slovenia
South Africa
South Korea
Spain
Sweden
Switzerland
Thailand

Table C.2: Descriptive Statistics: Real Data Set

Variable	Mean	Std. Dev.	Min	Max
t_{ij}	426.4566	180.4115	65.35735	989.058
$dist_{ij}$	6444.817	5042.864	59.61723	19629.5
gdp_i	38277.33	18457.15	8720	84640
top 150	.0833333	.2764622	0	1
top 250	.1388889	.3459266	0	1
top 350	.1944444	.3958824	0	1
EX_{ij} (in Tsd. US$)	3760000	13200000	0.439	237000000
GDP_i (in Mrd. US$)	1360	2620	12.1	14100
GDP_j (in Mrd. US$)	879	1990	12.1	14100

Source: Own calculations.

Appendix D. Additional Empirical Results

Table D.1: Robustness: Restricted Samples

	Large Sample				Small Sample			
	Proxy top 150	Proxy top 250	Proxy top 350	IV EX_{ij}	Proxy top 150	Proxy top 250	Proxy top 350	IV EX_{ij}
Dependent variable: t_{ij}								
$dist_{ij}$	0.121***	0.117***	0.112***	0.084***	0.118***	0.116***	0.109***	0.079***
	(0.016)	(0.016)	(0.017)	(0.018)	(0.016)	(0.016)	(0.017)	(0.018)
gdp_j	0.144***	0.147***	0.145***	0.161***	0.145***	0.145***	0.144***	0.160***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
top 150	-0.397***				-0.428***			
	(0.046)				(0.047)			
top 250		-0.340***				-0.348***		
		(0.037)				(0.035)		
top 350			-0.292***				-0.312***	
			(0.032)				(0.032)	
EX_{ij}				-0.076***				-0.075***
				(0.008)				(0.008)
N	1,740	1,740	1,740	1,739	1,740	1,740	1,740	1,739
R^2	0.210	0.218	0.213	0.231	0.219	0.221	0.222	0.245
Endog. test				13.635				6.330
p-val.				0.000				0.012
Hansen J				1.273				1.618
p-val.				0.256				0.203
Underid. test				57.437				56.979
p-val.				0.000				0.000
Weak id. test				1753.73				1420.70
p-val.				0.000				0.000

Note: Cluster-robust standard errors in parentheses with significance at the *** $p<0.01$, ** $p<0.05$, * $p<0.1$ level.

Source: Own calculations.

Table D.2: Robustness: Maritime Transport Costs

	Omitting I_{ij}	Proxy top 20%	Proxy top 25%	Proxy top 30%	IV EX_{ij}
Dependent variable: $martc_{ijk}$					
$dist_{ij}$	0.361***	0.309***	0.287***	0.308***	0.252***
	(0.033)	(0.033)	(0.033)	(0.031)	(0.034)
gdp_i	-0.046*	0.024	0.035	0.021	0.037
	(0.026)	(0.027)	(0.027)	(0.027)	(0.029)
top 20%		-0.344***			
		(0.067)			
top 25%			-0.385***		
			(0.065)		
top 30%				-0.313***	
				(0.059)	
EX_{ij}					-0.062***
					(0.013)
N	6,754	6,754	6,754	6,754	6,754
R^2	0.039	0.055	0.062	0.056	0.069
Endog. test					3.900
p-val.					0.048
Hansen J					1.605
p-val.					0.205
Underid. test					89.77
p-val.					0.000
Weak id. test					2598.91
p-val.					0.000

Note: Cluster-robust standard errors in parentheses with significance at the *** $p<0.01$, ** $p<0.05$, * $p<0.1$ level.

Source: Own calculations.

Table D.3: Robustness: Trade Imbalances

	Omitting I_{ij}	Proxy top 150	Proxy top 250	Proxy top 350	IV EX_{ij}
Dependent variable: t_{ij}					
$dist_{ij}$	0.115***	0.108***	0.107***	0.105***	0.086***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.019)
gdp_i	0.138***	0.144***	0.147***	0.145***	0.162***
	(0.01)	(0.009)	(0.009)	(0.009)	(0.01)
top 150		-0.213***			
		(0.048)			
top 250			-0.198***		
			(0.037)		
top 350				-0.152***	
				(0.032)	
EX_{ij}					-0.068***
					(0.015)
trade imbalance	-0.063***	-0.051***	-0.047***	-0.049***	-0.01
	(0.006)	(0.006)	(0.007)	(0.007)	(0.012)
N	1,737	1,737	1,737	1,737	1,737
R^2	0.241	0.255	0.258	0.254	0.238
Endog. test					8.703
p-val.					0.003
Hansen J					1.181
p-val.					0.277
Underid. test					42.726
p-val.					0.000
Weak id. test					125.89
p-val.					0.000

Note: Cluster-robust standard errors in parentheses with significance at the *** $p<0.01$, ** $p<0.05$, * $p<0.1$ level.

Source: Own calculations.