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Transport Costs**

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# Markups, Quality and Transport Costs. \*

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## Abstract

This paper investigates the impact of transport costs on firm pricing policy. The empirical part provides new evidence on trade prices based on firm level data from France. We find that for a given product, a typical exporting firm sets higher (net of transport costs) prices toward more distant countries. This empirical regularity suggests that firms charge higher markups and/or sell more expensive quality up-graded versions of their product when facing higher transport costs. None of these two mechanisms is present in models of international trade. Even models with firm heterogeneity in terms of quality fail in explaining the firm pricing policy observed in the data. We demonstrate that, in existing models of trade, for firms to set higher markups or to upgrade the quality of their product toward more distant countries it is necessary to relax the mill pricing assumption and to use *per unit* rather than *iceberg* transport costs. This finding is critical since, in trade models, the structure of transport costs affects the microeconomic behavior of exporting firms but also the composition of export flows and the size of gains from trade.

Keywords: Firm-Level Data, Per Unit Transport Costs, Quality Upgrading, Markups.

JEL Classification: F10, F14, L11.

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# 1 Introduction

The exploration of firm level data on trade has conducted to extend Krugman' (1980) seminal model of trade by relaxing the firm homogeneity assumption. In "new new trade models", firms differ in their productivity (Melitz 2003) or in the quality they produce (Baldwin & Harrigan 2007). This new generation of models allows explaining many stylized facts concerning firm heterogeneity, firm selection on export markets, and spatial variations of *average* trade prices.

Nonetheless, these models fail to explain one striking stylized fact: a typical French firm sets higher prices toward more distant countries. This stylized fact holds true when controlling for the wealth, size or level of competition of the destination country.<sup>1</sup> Interestingly, in parallel works, Bastos & Silva (2008), Manova & Zhang (2009) and Görg, Halpern & Muraközy (2010) find similar patterns using bilateral firm level data on Portuguese, Chinese and Hungarian exports respectively. As emphasized in section 2, this empirical regularity on firm pricing policy is not explained by existing models of trade.<sup>2</sup> This fact can be interpreted in two ways: firms charge higher markups toward more distant countries and/or they sell more expensive quality upgraded versions of their products in remote markets. We demonstrate that a simple way to obtain a positive impact of distance on prices through markups or through quality upgrading in CES models of trade is to relax the assumptions of mill pricing and iceberg trade cost and introduce instead a per unit transport cost. Furthermore, it is shown that standard models with quasi linear demand cannot reproduce the positive impact of distance on prices even when allowing for quality upgrading, whatever the structure of transport costs.

These theoretical results coupled with empirical evidence that firms set higher prices in remote countries militates in favor of relaxing the mill pricing and iceberg transport costs assumptions. The use of per unit rather than iceberg costs to model the distance-related barrier to trade has important implications at the microeconomic and macroeconomic levels. First, in

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<sup>1</sup>This finding, detailed in section 3, relies on the use of firm level data describing bilateral trade of French exporters in 2003.

<sup>2</sup>Models with exogenous (Baldwin & Harrigan 2007, Hummels & Skiba 2004) or endogenous (Verhoogen 2008, Antoniadis 2008, Hallak & Sivadasan 2009, Johnson 2008) quality heterogeneity explain price differential between firms and the impact of distance on average prices but they do not explain why prices, within firm, increase with distance.

CES models under monopolistic competition such as Melitz (2003) or Krugman (1980), per unit transport costs induce variable markups.<sup>3</sup> Second, per unit transport costs distort the relative price of goods which induces a composition effect along the intensive margin in addition to the composition through selection effects of new new trade models.<sup>4</sup> Last, the price distortion implied by per unit costs affects the nature of gains from trade due to a reduction of transport costs (Irrazabal, Moxnes & Oromolla 2009).<sup>5</sup>

Section 4 theoretically investigates how firms' export prices vary with distance to the destination market depending on the nature of the demand and the structure of transport costs. In the entire analysis, the assumption of monopolistic competition is maintained.<sup>6</sup> Transport costs are supposed to have a more general form than usual, with per unit and iceberg transport costs as particular cases. The pricing policy of exporting firms is examined under two alternative assumptions concerning demand: a CES demand like in Krugman (1980) or Melitz (2003) and a quasi linear demand like in Ottaviano, Tabuchi & Thisse (2002) or Melitz & Ottaviano (2008). Under both forms of demand, it is first supposed that a firm sells the same quality whatever the distance to the destination market. Then, this assumption is relaxed and the firm is allowed to set a different quality depending on destination market characteristics. Among these different variants, a firm is expected to set higher prices toward distant countries *only* in a CES model, in presence of per unit transport costs. In that context, the firm charges higher markups if quality is fixed. If not, it charges higher markups and upgrades the quality of the products exported in distant markets. More generally, we show that the reaction of markup and quality to a change in transport costs is driven by the relationship between the elasticity of demand to the *cif* and *fob* prices.

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<sup>3</sup>This device to get non constant markup in CES model has already been used to generate incomplete pass through via the presence of distribution costs which enter additively in firm costs (Corsetti & Dedola 2005, Berman, Martin & Mayer 2009).

<sup>4</sup>The Alchian & Allen (1964) effect is a well known example of composition effect due to per unit transport costs.

<sup>5</sup>Arkolakis, Costinot & Rodríguez-Clare (2009) show that recent trade models developed to explain stylized fact of micro data do not change the gains from trade. By contrast, the modification we propose to explain the micro fact presented in this paper does affect the nature of gains from trade as shown by Irarrazabal et al. (2009).

<sup>6</sup>We do not consider Eaton & Kortum (2002) and Bernard, Eaton, Jensen & Kortum (2003) models in this paper. In the first model, perfect competition implies prices are set at marginal costs. In the second model, Bertrand competition induces positive markups, heterogeneous across firms but identical within firm across destinations.

This paper aims to point out the implications of the structure of transport costs on firm pricing policy. The highly stylized framework used here does not allow us to match other facts concerning export prices. However, the mechanism linking markups, quality and transport costs can be embedded in standard models of international trade allowing to reproduce other facts on trade prices.

The main drawback of the empirical analysis is the use of unit values as a proxy for prices. Unit values are collected at the firm and product level. Therefore, the price increase we observe could be due to a composition effect occurring at within firm and narrowly defined product categories. As discussed in section 5, the more natural composition effect biased toward the most expensive goods is the Alchian Allen effect which is based on the presence of per unit transport costs. Consequently, this alternative explanation also supports the use of per unit rather than iceberg transport costs.

The rest of the paper is organized as follows. Section 2 reviews the related literature. Section 3 presents the data and provides stylized facts on the impact of distance on firm pricing policy. Section 4 describes the theoretical impact of distance on firm pricing policy depending on the nature of demand and the structure of transport costs. Section 5 discusses alternative explanations. Finally, Section 6 concludes.

## 2 Related literature

The present paper participates in the literature on the impact of distance on trade prices. Most of the literature has focused on *average* prices. Empirical studies have shown that average prices are higher in more remote countries.<sup>7</sup> Hummels & Skiba (2004) and Baldwin & Harrigan (2007) propose two distinct models explaining the positive impact of distance on prices. Hummels & Skiba (2004) build a model in which, due to additive trade costs, the relative price of high quality goods decreases with the distance ensuring a higher share of high quality goods in the exports toward remote countries. Since high quality goods are also more expensive, the average

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<sup>7</sup>See Schott (2004), Hummels & Klenow (2005), Mayer & Ottaviano (2007), Baldwin & Harrigan (2007), Hummels & Skiba (2004), Fontagné, Gaulier & Zignago (2008) or Crozet, Head & Mayer (2009).

price increases with distance.<sup>8</sup> Baldwin & Harrigan (2007) modify a Melitz-type model by assuming heterogeneity in terms of quality rather than in terms of productivity. In that context, only high quality firms, setting higher prices, are able to serve remote countries. Therefore, average price increases with distance through a composition effect; because prices are different *across* firms. But, in these two models, *fob* prices are identical within firms, across destinations. Complementary to the literature aforementioned, our paper focuses on the impact of distance on the variation of prices within firms, across destinations *ie* on *individual* rather than *average* prices.

Three contemporaneous papers investigate the determinants of exporters pricing behaviors. Using Portuguese, Chinese and Hungarian firm level data respectively, Bastos & Silva (2008), Manova & Zhang (2009) and Görg et al. (2010) find that firms set higher prices in more distant markets.<sup>9</sup> Furthermore Manova & Zhang (2009) presents evidence that firms use different input qualities. Manova & Zhang interpret it in the following way. (i) Firms differ in their use of inputs and in the quality they produce and (ii) firms adjust both markups and quality depending on destination country characteristics. We focus on the impact of distance on markups and quality. Hence, compared with other works, we restrict the scope of our research but we propose an interpretation built on a theoretical analysis explaining why quality and markup can change with transport costs.

The present paper is also related to an old and rich literature studying spatial price discrimination. This literature explores the reaction of firms' markups to change in the distance of the buyer. One of the seminal contributions to this literature is Hoover (1937). The author shows that firm spatial pricing policy depends on the functional form of demand. In this literature, Greenhut, Ohta & Sailors's (1985) paper is one of the few dealing with reverse dumping i.e. a positive relationship between prices and distance.

Some papers in the trade literature focus on dumping strategies (also named freight ab-

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<sup>8</sup>Hillberry & Hummels (2008) present evidence supporting Hummels & Skiba (2004) paper using data on shipments within the US.

<sup>9</sup>They also find that prices are higher in richer markets. Manova & Zhang (2009) find a negative impact of country' size on prices, but the other papers do not.

sorption): firms reduce their markup when exporting toward more distant countries to remain competitive (Brander 1981, Brander & Krugman 1983, Ottaviano et al. 2002, Melitz & Ottaviano 2008). But most of the international trade literature gets rid of price discrimination in the interest of tractability. In models à la Krugman (1980) or Melitz (2003), the combination of monopolistic competition, CES utility function and iceberg trade costs implies that firms do not price discriminate across countries.

Price changes across destinations may be the consequence of changes in marginal costs driven by quality upgrading. Three papers provide a theoretical framework to think about firms adapting product quality to the destination country: Hallak & Sivadasan (2009), Verhoogen (2008), and Antoniadis (2008).

This paper also participates in the literature on the structure of transport costs. The two types of trade frictions widely used in the literature are the iceberg and the per unit transport costs. In trade models, the iceberg formulation is the most commonly used since it contributes to models' *elegance*. Popularized by Samuelson (1954), this specification has been widely used, but not much questioned in the trade literature.<sup>10,11</sup> Using data on transport costs, Hummels & Skiba (2004) show transport costs do not react proportionally to a change in prices which empirically rejects the iceberg hypothesis.<sup>12</sup>

Last, this paper is closely related to a recent paper by Irarrazabal et al. (2009). The authors introduce per unit costs in a Melitz type model. Their estimates suggest that per unit transport costs are substantial, and that changes in iceberg and per unit costs have different impact on welfare. While general equilibrium considerations are beyond the scope of this paper, we provide two results that are not in their paper. First, we show that firms can respond to change in transport costs by upgrading the quality of their product. Second, we explore other models than

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<sup>10</sup>Answering Pigou (1952) criticism, Samuelson introduced (in a model à la Jevons-Pigou) a transport cost. Instead of modeling a transport sector, Samuelson assumes that "*as only a fraction of ice exported reaches its destination*", only a fraction of the exported good reaches its destination.

<sup>11</sup>Nevertheless one can mention the words of Bottazzi & Ottaviano (1996) "*we wonder whether the passive devotion to the iceberg approach is covering some of the most relevant issues that arise when trying to think realistically about the liberalization of world trade*".

<sup>12</sup>We do not have information on *cif* prices in our data. Thus, we cannot infer the value and the form of bilateral transport costs using information on *cif* and *fob* price.

the CES one and show that they are not consistent with the firm level price-distance relationship we find in the data.

### 3 Empirics: export prices and distance at the firm level

This section presents empirical evidence that within firm and product pairs, prices are higher in more distant markets. The section first describes the data. Then it presents the empirical strategy. Last, it reports and comments the results.

#### 3.1 Data

The empirical analysis in this paper is based on a French customs database.<sup>13</sup> The database covers yearly bilateral shipments of firms located in France in 2003. Data are disaggregated by firm and product at the 8-digit level of the Combined Nomenclature (CN8). The raw data cover 96,467 firms and 10,050 products for a total exported value of 3.5 hundred billions euro. Since this paper deals with firm price discrimination, only products sold by a firm on at least two markets are considered. This restriction reduces the number of observations. Actually, only 46 % of firms export toward several destinations. However, these multi-destinations exporters realize more than 74% of French exports (in value). For each flow, the  $fob$  value and the shipped quantity (in kg) are reported. A flow is described by a firm number, a product number (CN8), and a destination country. Unit values are computed as the ratio of value of the flow over its quantity. The unit value set by firm  $f$  for product  $k$  exported toward country  $j$  is:  $P_{fjk} = \frac{V_{fjk}}{Q_{fjk}}$  where  $V_{fjk}$  and  $Q_{fjk}$  are value and quantity of good  $k$  exported by firm  $f$  to country  $j$ .

Unit values are known to be a noisy measure of prices. The main criticism was formulated by Kravis & Lipsey (1974) (see also Silver 2007). The authors state that unit values do not take into account quality differences among products. The high level of disaggregation of the data and their firm dimension limits the main drawback of unit values and more particularly the

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<sup>13</sup>Berthou & Fontagne (2008), Méjean & Schwellnus (2009), Crozet et al. (2009) or Berman et al. (2009) use the same source.



quality mixed effect. Actually with more than 10,000 products, the possibility to have goods with highly different characteristics within these unit values is limited.<sup>14</sup>

There are some errors in declarations or in reporting. To deal with outliers, we follow Méjean & Schwellnus (2009) by dropping observations where unit value is 10 times larger or lower than the median unit value set by the firm on its different markets are dropped. This procedure keeps 73% of total exports.

Like most of the papers in the literature, we proxy transport cost by distance in the empirical analysis. We also use GDP and GDP per capita as a control in our econometrical analysis. We further use the average multilateral import unit value of destination countries to control for the level of competition in the different markets. These variables are described in the appendix.

### 3.2 Econometric strategy

First, we estimated the following equation:

$$\log(P_{fkj}) = \alpha \log(dist_j) + FE_{fk} + \epsilon_{fkj} \quad (1)$$

where  $P$  is the unit value computed at the firm and product level,  $dist$  is the distance between France and country  $j$ ,  $FE_{fk}$  is a firm and product fixed effect, and  $\epsilon$  is the error term. Three different samples of countries are used to test the robustness of the results: all the countries, the OECD countries and the euro members. The OECD sample allows comparing prices toward countries with similar levels of development. Focusing on euro members is a way to get rid of the firm price discrimination due to (i) incomplete exchange rate pass-through and (ii) country specific tariffs.

The impact of distance on prices can be non linear. Regressions of the log of prices on dummies for different intervals of distance are run to tackle this problem. With firm  $\times$  product fixed effects, interval coefficients yield average prices set by each firm according to the distance

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<sup>14</sup>For instance, the product CN8 52081296 describes a *Woven fabrics of cotton, containing 85 % or more by weight of cotton, unbleached, Plain weave, weighting more than 100 g/m2 but not more than 130 g/m2 and of a width not exceeding 165 cm*. For a deeper discussion on the use of unit values as a proxy for prices for this database, see Méjean & Schwellnus (2009).

interval.<sup>15</sup>

Part of the literature emphasizes the impact of the size and the wealth of countries on bilateral unit values. GDP and GDP per capita are used to control for these effects.<sup>16</sup> The expected signs are the following. In large countries, competition is tougher which should reduce prices. By contrast, wealthy countries are expected to have a higher willingness to pay which should contribute to higher prices.<sup>17</sup>

Models with quadratic utility functions suggest that prices depend on the average price on the market. Multilateral average unit values of imported products for the different countries are introduced in regressions to control for this.

Some models predict that the elasticity of price to distance is nil. Therefore, the significance of estimated coefficients is important. In the regressions, standard errors can be biased by the correlation within groups of observations. To deal with this bias, estimated standard errors are clustered in the country dimension. However this clustering procedure assumes a large number of clusters whereas in our dataset the number of clusters (number of countries) is rather small compared to the number of observations. This point was raised by Harrigan (2005) (see Wooldridge (2005) for a technical discussion). Results with clustered standard errors are in the main text. In Appendix, we describe the methodology proposed by Harrigan (2005) and the results it yields.

### 3.3 Results

This section presents empirical findings concerning the relationship between prices and distance at the firm level. Results unambiguously suggest that distance has a positive impact on *free-on-board* prices. Table 1 presents regressions of the logarithm of the price on the loga-

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<sup>15</sup>This method is used at lower levels of disaggregation by Baldwin & Harrigan (2007) or Eaton & Kortum (2002) among others.

<sup>16</sup>Using manufacturing output instead of GDP leads to similar results.

<sup>17</sup>Baldwin & Harrigan (2007) use these controls and Hummels & Lugovskyy (2009) bring theoretical foundations to these explanatory variables in a generalized model of ideal variety. One can also interpret the GDP per capita coefficient with respect to transport costs. If the additive cost includes a distribution cost paid in the destination country, then the additive cost is expected to increase with the wealth of the country, because wages are higher there for instance (see Corsetti & Dedola 2005, Berman et al. 2009).

rithm of distance. In all the regressions, the estimated elasticity of prices to distance is positive and almost always significant. In column (1), the sample contains all destination markets of French exporters. The estimated elasticity is 0.042. If the distance doubles, the average exporter increases its *fob* price by 3% ( $2^{0.042} - 1$ ). Focusing on the OECD sample (Column 2), one observes that the elasticity is larger. The estimated elasticity reaches 0.45. Column (3) focuses on the euro sample. This sample is interesting because the pricing to market in the euro area cannot be due to incomplete exchange rate pass-through, and there are no country specific tariffs for French goods. The elasticity is much lower and weakly significant but still positive (0.011).

In columns (4-6) one controls for market characteristics by introducing the size (GDP) and the wealth (GDP per capita) of the destination country. One can see that the size of the country has no significant impact on prices whereas wealth has a positive impact. The distance coefficient remains positive, significant and even higher than without controls. This is particularly true for the Eurozone, where the distance elasticity is greater and more significant (column 3 vs column 6). The point is that within the Eurozone, the closest countries from France are also the countries with the highest GDP per capita which has a strong positive impact on *fob* prices.

The average unit value takes into account the competition on the market. Columns (7) to (9) present the results once the average unit value is introduced. As expected, the mean unit value coefficient is positive (even though it is not significant for Eurozone sample regressions).

However, even with this control, the distance coefficient remains positive and significant.<sup>18</sup>

Table 2 presents regressions on distance interval dummies. Since the dummies are collinear with the constant and the fixed effects, the first interval is dropped. For the reasons mentioned formerly, firm×product specific fixed effects are added. To have enough information in each interval, regressions are run on the entire sample of countries.

Overall, the regressions suggest that prices increase with distance. The only point is that this increase is not always significant toward countries ranging between 1,500 and 3,000 kilo-

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<sup>18</sup>Table D.1 in Appendix presents the results obtained when applying the two steps methodology developed by Harrigan (2005). With this methodology, estimated coefficients are still positive and significant and even of higher magnitude.

meters. Exporting in close countries (less than 3,000 km) increases prices by 2 log points while exporting in remote countries (more than 12,000 km) increases prices by 14 log points. In the three regressions, a F-test allows rejecting the equality of distance intervals' coefficients.<sup>19</sup>

To sum up, estimations suggest that French exporters set higher prices toward more distant markets. This result seems quite robust. In earlier versions of this paper, identical results for years 2004 & 2005 were obtained.

## 4 Theory: Prices & Transport Costs

Firms can change their prices with transport costs because of two different mechanisms: (i) firms can charge a different markup (ii) they can offer a product with a slightly different quality (and with different marginal cost of production) depending on the distance to the destination market. This section discusses the impact of transport costs on markups, quality and prices depending on the structure of transport costs, the nature of demand and the capacity of firms to adapt the quality of their products.

### 4.1 Transport costs

To carry goods to another country, a transport cost has to be paid. Here, no assumption is made on who pays or how transport costs are passed-on to the consumer, but the structure of transport cost is imposed:

$$Transport\ Cost = p_{fj}^{cif} - p_{fj}^{fob} = (\tau_{fj} - 1)p_{fj}^{fob} + T_{fj} \quad (2)$$

Rewriting it we get the relationship between consumer (cif) price and producer (fob) price:

$$p_{fj}^{cif}(\tau_{fj}, T_{fj}, w_f) = \tau_{fj} p_{fj}^{fob}(\tau_{fj}^{ij}, T_{fj}, w_f) + T_{fj} \quad (3)$$

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<sup>19</sup>In Appendix, Table D.2 presents the results when introducing country random effects instead of clustering at the country level. Coefficients are still significant and increasing with the distance which comforts the previous results. Even close intervals become statistically significant.

where  $f$  and  $j$  denote respectively the firm and the destination country,  $p^{fob}$  is the *fob* price,  $p^{cif}$  is the price faced by the consumer,  $w$  is the marginal cost of production and  $T$  and  $\tau$  are the additive and multiplicative components of the transport cost. If  $T$  is nil the transport cost has an iceberg form whereas if  $\tau$  is one, it is a per unit transport cost.<sup>20</sup> As long as  $T$  is strictly positive, the transport cost is less than proportional to the *fob* price.

## 4.2 Production side

We focus on a firm  $f$  exporting to country  $j$ . Several assumptions common in trade models bear on firms behavior. First, it is assumed that the firm's strategy in a given market is independent from its strategy in other markets. Thus, one focuses on firm pricing behavior in a given market. The second assumption is that in market  $j$ , the firm faces a mixed transport cost (see Equation 3). Last, it is assumed that the firm maximizes the following operational profit:

$$\pi_{if} = [p_{fj}^{fob} - w_f] q_{fj} = [(p_{fj}^{cif} - T_{fj})/\tau_{fj} - w_f] q_{fj} \quad (4)$$

where  $q_{fj}$  is the quantity sold on market  $j$  (that depends on the *cif* price) and  $w$  is firm specific but constant across markets. We further assume that firms are in monopolistic competition.

## 4.3 CES demand

In Krugman (1980) or Melitz (2003) type models, firms face the following inverse demand:

$$p_{fj}^{cif} = k_j q_{fj}^{-1/\sigma} \lambda^{(\sigma-1)/\sigma} \quad (5)$$

with  $k$  a positive parameter, exogenous for the firm, and  $\sigma$  the elasticity of substitution, greater than 1. In this type of model,  $k$  is in general a function of the size of the destination country and

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<sup>20</sup>This formulation is restrictive, but it allows us to highlight the different predictions one can get when modifying  $\tau$  and  $T$ . It is similar to Hummels & Skiba (2004) but here it is assumed that both the ad-valorem and the additive parts increase with distance. In Harrigan & Deng (2008), the transport cost also depends on physical characteristics of the good. Here we implicitly assume that physical characteristics of a product sold on different markets by a firm are identical.

the price index in the destination country.  $\lambda$  is a taste/quality parameter. A high quality shifts up the demand for the variety. In a first step,  $\lambda$  is supposed to be exogenous.

**Exogenous quality.** Since  $\lambda$  is exogenous, it is dropped in this paragraph. This assumption is relaxed in the next paragraph.

Firm  $f$  maximizes its operational profit (eq. 6) on market  $j$  considering a CES demand (eq. 5). Since firms are in monopolistic competition the strategic variable is not important.<sup>21</sup> The program is given by:

$$\arg \max_{p^{cif}} \left[ (p_{fj}^{cif} - T_{fj}) / \tau_{fj} - w_f \right] \left[ \frac{1}{k_j} (p_{fj}^{cif})^{-\sigma} \right] \quad (6)$$

For clarity purpose, we drop the subscript in the rest of this paragraph. The first order condition of the maximization program yields:

$$p^{cif} = \frac{\sigma}{\sigma - 1} T + \frac{\sigma}{\sigma - 1} \tau w \quad (7)$$

Using the relationship between the  $fob$  price and the  $cif$  price one gets:

$$p^{fob} = \frac{1}{\sigma - 1} \left( \frac{T}{\tau} \right) + \frac{\sigma}{\sigma - 1} w \quad (8)$$

If the transport cost has the standard iceberg structure ( $T = 0$ ), the fob price is a constant markup over marginal costs. This is the textbook case of a large part of trade models (eg. Krugman 1980, Melitz 2003, Baldwin & Harrigan 2007).

By contrast, if the transport cost is per unit ( $\tau = 1$ ), then the markup is increasing in transport costs. That is the first possible channel through which prices may increase with distance.

**Proposition 1.** *Under monopolistic competition, in CES models, the free-on-board price depends positively on the additive part ( $T$ ) of the transport cost and negatively on its multiplicative*

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<sup>21</sup>Maximization with respect to prices or quantities yields the same results. It is also equivalent to maximize with respect to  $cif$  or  $fob$  prices.

part ( $\tau$ ). With iceberg transport cost ( $T=0$ ), the price does not depend on the transport cost. With per unit transport cost ( $\tau = 1$ ), the price is increasing with the transport cost.

Proof is immediate when deriving the price (eq. 8) with respect to  $\tau$  and  $T$ .

**Destination specific endogenous quality.** It is possible that firms adjust the quality of their product depending on market characteristics. Here, the analysis focuses on the impact of transport cost on the level of quality produced by the firm. If quality is costly, then the relationship between prices and transport costs could be driven by changes in the quality of the exported product.<sup>22</sup>

The inverse demand is given by equation 5. In a first step, the optimal price is computed. The first order condition of the maximization of firm's profit with respect to price gives the same result as the exogenous quality case but the marginal cost depends on the quality level:

$$p^{fob} = \frac{1}{\sigma - 1} \left( \frac{T}{\tau} \right) + \frac{\sigma}{\sigma - 1} w(\lambda) \quad (9)$$

Here we see that the price depends on transport costs through  $\tau$  and  $T$  but transport cost could also impact the price indirectly by affecting  $\lambda$  and so  $w(\lambda)$ .

To find the optimal level of quality, the firm maximizes its profit with respect to  $\lambda$ , replacing price by the expression of the first step. Firms maximize the following profit:

$$\Pi = \frac{\sigma^{-\sigma}}{(\sigma - 1)^{1-\sigma}} \frac{k^\sigma \lambda^{\sigma-1}}{\tau} (T + \tau w(\lambda))^{1-\sigma} \quad (10)$$

Assumption that  $w$  is exogenous is relaxed when considering that quality is market specific. Producing a better quality increases your demand but is costly. Thus, we consider that the marginal cost  $w(\lambda)$  is a function of quality. The following assumptions are donemade. The

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<sup>22</sup>An existing model where the quality is explicitly destination specific is Verhoogen (2008). The author sketches a model where demand has a logit form and there is not transport cost. When adding an iceberg cost, higher trade costs decrease the quality offered by the firm. Actually, in this model, an increase in  $\tau$  increases the relative price of the good which reduces the demand and finally the offered quality. In Hallak & Sivadasan (2009), heterogeneous firms facing a CES demand choose the same optimal quality for all markets. In the appendix it is shown that modifying the model by assuming that firms maximize their profit independently on each market implies firms set lower quality toward the more remote countries when facing iceberg transport costs.

marginal cost is increasing in quality and convex ( $\partial w(\lambda)/\partial \lambda > 0$  and  $\partial^2 w(\lambda)/\partial \lambda^2 > 0$ ). If marginal cost does not increase in quality then a price increase cannot be thought as a quality upgrading phenomenon. This assumption is in line with recent empirical evidence showing that quality requires high skilled workers and higher quality inputs.<sup>23</sup> The second assumption ensures that it is sufficiently costly to produce quality to not choose an infinite quality. The third assumption,  $w(0) > 0$ , states that even if the firm produces a nil quality, it faces a positive cost. Under this assumption, the elasticity of costs to quality is not a constant which is a necessary condition to have finite solution. Last, the elasticity is supposed to be greater than or equal to one for all positive levels of quality ( $\partial \ln(w(\lambda))/\partial \ln(\lambda) \geq 1, \forall \lambda \geq 0$ ). This last assumption is in fact a combination of assumptions on convexity of costs and non nil marginal costs. It is useful to check the second order condition.

**Proposition 2.** *Under monopolistic competition, in CES models, if firms can adjust the quality of their product and given the technology of production specified before:  $\partial \lambda / \partial \tau = 0$  if  $T = 0$ ,  $\partial \lambda / \partial \tau < 0$  if  $T > 0$  and  $\partial \lambda / \partial T > 0$  if  $\tau \geq 1$ . See proof in appendix.*

Therefore under CES demand, if they have the possibility, firms increase the quality of exported product when per unit transport costs increase. Since prices depend positively on marginal costs, that marginal costs increase with the level of quality and the level of quality itself increases with per unit transport costs, then prices increase with per unit transport costs. However, neither the quality nor the markup vary when transport costs have an iceberg formulation, nor the price.<sup>24</sup>

**Corollary 1.** *Under monopolistic competition, in CES models, if firms can adjust the quality of their product and given the technology of production specified before:  $\partial p_{fob} / \partial \tau = 0$  if  $T = 0$ ,  $\partial p_{fob} / \partial \tau < 0$  if  $T > 0$  and  $\partial p_{fob} / \partial T > 0$  if  $\tau \geq 1$ .*

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<sup>23</sup>See Kugler & Verhoogen (2007).

<sup>24</sup>In appendix, it is shown that if quality increases fixed costs, then a decrease in pure iceberg transport cost reduce the exported quality and the price.



## 4.4 Quasi linear demand

While CES models are omnipresent in international trade, several papers consider quasi linear demand (see Ottaviano et al. 2002, Melitz & Ottaviano 2008). In such models, firms face the following inverse demand function:

$$p_{fj}^{cif} = z_j - k_j q_{fj} \quad (11)$$

where  $j$  and  $f$  denote the firm and the destination country respectively, and  $z$  and  $k$  are a positive parameters, exogenous for the firms.  $z$  includes the price index.<sup>25</sup>  $k$  is a positive parameter capturing the degree of differentiation across varieties. In the rest of the paper, we drop the subscripts  $f$  and  $j$ .

**Exogenous quality.** Here we assume that quality is exogenous. The program of the firm is to maximize its operational profit (eq. 6) given the linear demand (eq. 11). The first order condition yields:

$$p^{cif} = \frac{1}{2}(z + T) + \frac{\tau w}{2} \quad (12)$$

Using equation 3, one gets the following *fob* price:

$$p^{fob} = \frac{1}{2}\left(\frac{z}{\tau} - \frac{T}{\tau}\right) + \frac{w}{2} \quad (13)$$

The price net of transport cost negatively depends on transport costs whatever their structure. This has already been verified in the literature: Ottaviano et al. (2002) use a per unit transport cost whereas Melitz & Ottaviano (2008) use an iceberg one and in both models firms absorb part of the transport costs.

**Proposition 3.** *Under quasi-linear demand,  $\partial p_{fob}/\partial \tau < 0$  and  $\partial p_{fob}/\partial T < 0$  ie. firms reduce their markups to sell goods in more distant countries, whatever the structure of transport costs.*

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<sup>25</sup>For expositional ease, we consider a population of size 1.

Proof is immediate when deriving price with respect to transport cost either iceberg or per unit.

**Destination specific endogenous quality.** This paragraph explores the link between prices and transport costs in a quasi linear demand model when firms choose the level of quality they produce. Quality is introduced in this framework through an additive shifter as in Antoniadis (2008):

$$p^{cif} = z - kq + \alpha\lambda \quad (14)$$

In Antoniadis (2008) the marginal cost does not depend on the level of quality. Instead, the fixed cost is increasing in quality. As shown in appendix this does not change the results concerning the relationship between prices and transport costs. In what follows, it is assumed the marginal cost is increasing and convex in quality. We further assume that  $w'(0) = 0$  which is a sufficient condition for the first order condition to be verified.

In the first step, firms set their optimal price, taken quality as given. The price is the same as without quality.

$$p^{fob} = \frac{1}{2} \left( \frac{z + \lambda}{\tau} - \frac{T}{\tau} \right) + \frac{w(\lambda)}{2} \quad (15)$$

Visual inspection shows quality impacts prices through two channels: it increases the prices through a demand effect and increases the marginal cost of production. Therefore, even if the marginal cost of production is exogenous, quality can impact the price. This is the case in Antoniadis (2008) for instance. In a second step, the firm maximizes its profit with respect to quality level. Firm's profit is:

$$\Pi = \frac{1}{4k\tau} (z - T + \lambda - \tau w(\lambda))^2 \quad (16)$$

**Proposition 4.** *When firm can adjust the quality of their exported product, under quasi-linear demand and monopolistic competition,  $\partial\lambda/\partial\tau < 0$  and  $\partial\lambda/\partial T = 0$ .*

Under quasi-linear demand, firms reduce the quality they export when iceberg transport costs increase. The level of quality is independent of per unit costs. Since under this framework

firms reduce their markup, the overall effect of transport costs on prices is negative, whatever the structure of transport costs.

**Corollary 2.** *When firm can adjust the quality of their exported product, under quasi-linear demand and monopolistic competition, firms set lower prices in more remote markets, whatever the formulation of transportation costs.*

## 4.5 Discussion

The results presented above are driven by a single key variable: the elasticity of demand. The introduction of a per unit cost changes the results concerning the relationship between prices and transport costs because it introduces a disconnection between the elasticity of demand to the *cif* price and the elasticity of demand to the *fob* price. Actually, assuming that the transport cost has both an additive and a multiplicative component, it is easy to show that the elasticities of demand to *cif* and *fob* prices are linked by the following equation.

$$\epsilon^{fob} = \epsilon^{cif} / (1 + \frac{T}{\tau p_{fob}}) \quad (17)$$

where  $\epsilon^m = \frac{\partial \log(\text{demand})}{\partial \log(p_m)}$  with  $m \in (cif, fob)$ . In the case of pure iceberg transport cost,  $T$  is nil and the elasticities of demand to *fob* and *cif* prices are the same. By contrast, for a given elasticity of demand to the *cif* price, the elasticity of demand to *fob* price decreases in  $T$ . All else equal, with an additive transport cost, the demand is less responsive to changes in prices. Therefore, remote firms are able to set higher *fob* prices, this allows them to compensate a part of the loss due to the lower demand they face because of freight costs.

The last discussion assumes that distance impacts the *fob* price only through  $T$ . However, in a lot of models such as quasi linear demand models, the elasticity positively depends on *cif* price. Consequently with additive transport costs, two opposite forces are at stake. The elasticity of demand to *fob* price tends to decline due to the additive cost, but it also increases because the *cif* price increases due to higher transport costs. In linear demand models, the price

effect dominates, therefore the elasticity increases with transport costs and distance and prices decrease with distance.

## 5 Alternative explanations

The main part of the analysis, in this paper, implicitly assumes that prices increase because markups and or marginal costs increase. However, the empirical evidence that prices increase toward more distant countries is based on unit values. While these unit values are computed at the firm level for broadly defined products, it is possible that they reflect average prices.

The first mechanism is a selection effect. This selection effect should look like the selection effect à la Baldwin & Harrigan (2007) but at a higher level of disaggregation. Namely, distance would select the more expensive goods within firms and highly detailed product categories. Such mechanism is entirely driven by the exit of cheap goods in more distant markets. However, to model such mechanism it is needed to assume that the firm has to pay a different fixed cost for each good, in each market. This seems to be a strong assumption for goods sold by a given firm and belonging to the same 8 digit level category.

The second mechanism is present in Hummels & Skiba (2004). Whereas their paper models the Alchian Allen effect at the product level, the model would remain valid at the firm level. The framework would build on three conditions: firms face CES type demand, they are in perfect competition, and each of them produces two qualities of a given good. With additive transport costs, the relative *cif* price of the high quality (more expensive) variety of the good decreases with distance. Consequently, in remote market, the firm faces a higher demand for the high quality version of its good. At the firm and product level, the share of goods of higher quality increases with distance. Thus, the average price of the good increases with the distance.

Interestingly, this mechanism relies on the presence of per unit transport costs. Therefore, the Alchian Allen story supports the main claim of this paper: to reproduce the positive impact of distance on prices set by exporting firm, the per unit transport costs seems more appropriated than the iceberg one. Nonetheless, models incorporating the Alchian Allen story also assume

that firms price at their marginal cost. The profusion of empirical evidence on incomplete passthrough and pricing to market by exporters suggest that firms charge positive markups. The framework developed in the theoretical part is more in line with these evidence.

## 6 Conclusion

This paper investigates the impact of transport costs on firm pricing policy. The empirical part shows a typical exporting firm sets higher prices toward more distant countries. This empirical regularity suggests that firms set higher markups and/or sell more expensive quality up-graded versions of their product when facing higher transportation costs. None of these two mechanisms is present in models of international trade. Even models with firm heterogeneity in terms of quality fail in explaining the firm pricing policy observed in the data. We demonstrate that, in existing models of trade, for firms to set higher markups or to upgrade the quality of their product toward more distant countries it is necessary to relax the mill pricing assumption and to use *per unit* rather than *iceberg* transport costs.

In addition of explaining why firms set higher prices when facing higher transport costs, the per unit structure of transport costs has important consequences on trade models. First it allows firms to set variable markups in intensively used CES models that used to exhibit constant markups. Second, by distorting relative prices, it generates a new composition effect through the intensive margin in addition of the selection effect of new trade models. Last, this structure modifies the nature of gains from trade compared with the iceberg structure.

A remaining interesting question is how much markups and quality respectively contribute to the price increase we observe in the data. We let this question for future research.

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Table 1: Price and distance, 2003

Dependent variable:	Price (log)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Distance (log)	0.042 <sup>a</sup> (0.012)	0.045 <sup>b</sup> (0.017)	0.011 <sup>c</sup> (0.005)	0.050 <sup>a</sup> (0.010)	0.051 <sup>a</sup> (0.013)	0.019 <sup>b</sup> (0.007)	0.050 <sup>a</sup> (0.010)	0.051 <sup>a</sup> (0.013)	0.019 <sup>b</sup> (0.007)
GDP (log)				-0.004 (0.004)	0.000 (0.006)	0.003 (0.002)	-0.004 (0.004)	0.000 (0.006)	0.003 (0.002)
GDP per capita (log)				0.020 <sup>a</sup> (0.006)	0.047 <sup>b</sup> (0.020)	0.014 (0.010)	0.018 <sup>a</sup> (0.006)	0.046 <sup>b</sup> (0.020)	0.014 (0.010)
Mean UV (log)							0.018 <sup>a</sup> (0.005)	0.010 <sup>c</sup> (0.005)	0.003 (0.002)
Firm $\times$ Product									
Sample:	All	OECD	Eurozone	All	OECD	Eurozone	All	OECD	Eurozone
Observations	1199711	910108	591733	1199711	910108	591733	1198282	909398	591268
$R^2$	0.003	0.004	0.000	0.004	0.005	0.000	0.005	0.005	0.000
rho	0.911	0.923	0.933	0.911	0.923	0.933	0.910	0.922	0.933

This table investigates the impact of distance on firm's export prices. It uses the variance of prices across destination country within firm-product pairs by including firm  $\times$  product fixed effects. The dependent variable is the log free on board export unit value by firm, destination and CN8 product. Explanatory variables are the distance to the destination country, the wealth of the destination country measured by the GDP per capita, the size of the destination country measured by the GDP, and the level of competition in the destination country measured by the average unit value of imports in this country. In columns 1, 4, 5 all destinations are considered. In columns 2, 5, 7 only exports toward OECD countries are considered. In columns 3, 6, 9, only exports toward euro countries are considered. Reported standard errors are clustered by country. <sup>c</sup>, <sup>b</sup>, <sup>a</sup> indicates significance at 10%, 5% and 1% level.

Table 2: Price and distance intervals

Dependent variable:	Price (log)		
	(1)	(2)	(3)
1500< distance <3000	0.024 (0.015)	0.026 (0.017)	0.026 (0.017)
3000< distance <6000	0.085 <sup>a</sup> (0.017)	0.108 <sup>a</sup> (0.016)	0.108 <sup>a</sup> (0.016)
6000< distance < 12000	0.115 <sup>a</sup> (0.021)	0.136 <sup>a</sup> (0.017)	0.135 <sup>a</sup> (0.017)
12000< distance	0.145 <sup>a</sup> (0.020)	0.141 <sup>a</sup> (0.020)	0.140 <sup>a</sup> (0.020)
GDP (log)		-0.006 (0.004)	-0.006 (0.004)
GDP per capita (log)		0.022 <sup>a</sup> (0.007)	0.021 <sup>a</sup> (0.006)
Mean UV (log)			0.018 <sup>a</sup> (0.005)
Fixed effects	Firm $\times$ Product		
Sample:	All	All	All
Observations	1199711	1199711	1198282
$R^2$	0.004	0.005	0.006
rho	0.911	0.911	0.910

This table investigates the impact of distance on firm's export prices. It uses the variance of prices across destination country within firm-product pairs by including firm $\times$ product fixed effects. The dependent variable is the log free on board export unit value by firm, destination and CN8 product. Explanatory variables are the distance to the destination country, the wealth of the destination country measured by the GDP per capita, the size of the destination country measured by the GDP, and the level of competition in the destination country measured by the average unit value of imports in this country. Distance is measured using distance interval. Dummy is equal to 1 if the destination country belongs to the interval and 0 else. Reported standard errors are clustered by country. <sup>c</sup>, <sup>b</sup>, <sup>a</sup> indicates significance at 10%, 5% and 1% level.

## A Appendix. Data.

Distance are from the dataset developed by Mayer & Zignago (2006).<sup>26</sup> Real GDP and GDP per capita in PPP, from the IMF database, are used as control variables. We also use average imported unit values by country. These unit values are computed from BACI, the database of international trade at the product level developed by Gaulier & Zignago (2008).<sup>27</sup> For each hs6 product and country, average unit value weighted by the quantities are computed. For product  $k$  in country  $j$  :  $UV(kj) = \sum w_{ijk} UV_{ijk}$ . Where  $UV_{ijk}$  is the unit value of the good  $k$  imported from country  $i$  to country  $j$ . And  $w_{ijk}$  is the weight of good  $k$  exports from country  $i$ . Then these hs6 unit values are merged with customs data. Thus for each product exported from a French firm in 2003, one gets the corresponding average unit value in each potential destination market.

## B Appendix. Methodology.

The alternative methodology to clustering proposed by Harrigan (2005) consists in a two way error component model. The basic idea is to introduce both firm  $\times$  product fixed effects and country random effects. Since one cannot run such regression, one first removes the firm and product means from all variables and then runs the random effects regressions on the transformed variables as indicated in this paper.

## C Appendix. Theory.

**Proof of Proposition 2.** . The first order condition with respect to  $\lambda$  is equivalent to:

$$\frac{\partial \Pi}{\partial \lambda} = 0 \Leftrightarrow T/\tau + w(\lambda) - \lambda w'(\lambda) = 0 \quad (\text{C.1})$$

Let's consider the function  $H(\lambda, \tau, T) = T/\tau + w(\lambda) - \lambda w'(\lambda)$ . The function  $H$  is a decreasing function of  $\lambda$  ( $\partial H/\partial \lambda = -\tau \lambda w''(\lambda)$ ) because costs are convex in  $\lambda$ .  $H()$  is a positive function of  $T$ . It is a negative function of  $\tau$  if  $T$  is non nil and does not depend on  $\tau$  else.<sup>28</sup>

$H(0, \tau, T)$  is positive, when  $\lambda$  tends to infinity, the limit of  $H(\lambda, \tau, T)$  is negative and  $H$  is a decreasing function of  $\lambda$ . Therefore there exists a unique point  $\lambda^*$  such that  $H(\lambda^*, \tau, T) = 0$ . To understand how  $\lambda$  changes with per unit and iceberg transport costs we use the property that in the neighborhood of  $\lambda^*$  the total derivative of  $H$  with respect to  $\tau$  or  $T$  should be equal to zero. Hence:

$$\frac{\partial H(\lambda, \tau, T)}{\partial \tau} + \frac{\partial H(\lambda, \tau, T)}{\partial \lambda} \frac{\partial \lambda}{\partial \tau} = 0 \quad (\text{C.2})$$

<sup>26</sup>Data are available on CEPII's website: [http : //www.cepii.fr/anglaisgraph/bdd/distances.htm](http://www.cepii.fr/anglaisgraph/bdd/distances.htm). Note that with this variable, distance is destination country specific. For mono-plant firms, a distance specific to the firm and the destination country can be computed. However, this greatly reduces the number of observation. Since it does not affect the results, they are not reported here. I thank Fabrice Defever and Farid Toubal who kindly provided me with the programs to compute these distances. Results are available upon request.

<sup>27</sup>For a description of the database, see [http : //www.cepii.fr/anglaisgraph/bdd/baci.htm](http://www.cepii.fr/anglaisgraph/bdd/baci.htm).

<sup>28</sup>Note that the derivative of  $H$  with respect to  $\tau$  is negative if the elasticity of costs to quality is equal to or greater than 1. If not, there is no solution to this equation. The first order condition cannot be verified but if  $\lambda = 0$  which implies a nil demand.

and

$$\frac{\partial H(\lambda, \tau, T)}{\partial T} + \frac{\partial H(\lambda, \tau, T)}{\partial \lambda} \frac{\partial \lambda}{\partial T} = 0 \quad (\text{C.3})$$

Since  $H$  is decreasing in  $\lambda$  and  $\tau$  and increasing in  $T$ , for the two identity to hold one must have:  $\partial \lambda / \partial \tau < 0$  if  $T$  is strictly positive,  $\partial \lambda / \partial \tau < 0$  if  $T$  is nil, and  $\partial \lambda / \partial T > 0$ .

**CES, monopolistic competition and endogenous choice of quality.** Demand in country  $j$  for a given variety with quality  $\lambda$  is:

$$q_j = p_j^{-\sigma} \lambda_j^{\sigma-1} \frac{E}{P} \quad (\text{C.4})$$

where  $p_j$  is the *cif* price in the market  $j$ ,  $\sigma$  is the elasticity of substitution (greater than one),  $\lambda$  is the quality offered by the firm on the market  $j$ ,  $E$  is the level of expenditure, and  $P$  is a price aggregator. The *cif* price is linked to the *fob* price by the following formulation :  $p_{cif} = \tau p_{fob} + T$  where  $\tau$  and  $T$  have the properties described previously.

The production function is similar to the one used in Section 4, but it varies with the quality. Producing a greater quality is costly because it increases the marginal cost, but also because it forces to pay a higher fixed cost. The profit of a firm serving country  $j$  can be written:

$$\pi_j = \left( p_j^{fob}(\lambda) - c(\lambda) \right) q_j(p, \lambda) - F(\lambda) \quad (\text{C.5})$$

For technical convenience, both the form of the marginal and the fixed costs are specified. Functional forms are the same as in Hallak & Sivadasan (2009). The marginal cost is given by  $c(\lambda) = w\lambda^\beta$  where  $\beta$  lies between zero and one. The fixed cost is given by  $F(\lambda) = g\lambda^\alpha$ . The maximization process occurs in two steps. First, the firm sets its optimal price, considering the quality as given. Then, substituting the optimal price in the profit function, the firm maximizes its profit with respect to the quality.

The profit derivative with respect to the *fob* leads to same result than above:

$$p_{fob} = \frac{1}{\sigma-1} \frac{T}{\tau} + \frac{\sigma}{\sigma-1} c(\lambda) \quad (\text{C.6})$$

Using expression (C.6), the first order condition with respect to  $\lambda$  leads to the following expression:

$$H(\lambda, \tau, T) = \left( \frac{\sigma}{\sigma-1} \right)^{-\sigma} \frac{E}{P} \tau^{-\sigma} \left[ \lambda^{\sigma-2} \left( \frac{T}{\tau} + w\lambda^\beta \right)^{-\sigma} \left( \frac{T}{\tau} + w\lambda^\beta(1-\beta) \right) \right] - g\alpha\lambda^{\alpha-\sigma+1} = 0 \quad (\text{C.7})$$

The expression  $H(\lambda, \tau, T) = 0$  does not have close form solution except if one sets  $T = 0$ . In that case, the (Hallak & Sivadasan 2009) solution for  $\lambda$  is:

$$\begin{aligned} H(\lambda, \tau, 0) &= 0 \\ \Leftrightarrow \lambda &= \left[ \tau^{-\sigma} \left( \frac{\sigma-1}{\sigma} \right) \frac{E}{P} \frac{(1-\beta)}{\alpha} \frac{1}{wg} \right]^{1/\alpha'} \end{aligned} \quad (\text{C.8})$$

where  $\alpha' = \alpha - (\sigma-1)(1-\beta)$  and  $\alpha' > 0$ . Visual inspection shows that quality decreases with

the iceberg trade cost. If  $T = 0$  the price is a constant markup over the marginal cost. Since the marginal cost is an increasing function of  $\lambda$ , then price decreases with distance since quality decreases.

**Proof of Proposition 4.** The first order condition with respect to  $\lambda$  yields:

$$H(\lambda, \tau, T) = 1 - \tau w'(\lambda) = 0 \quad (\text{C.9})$$

Function  $H$  is positive if  $\lambda = 0$  and limit of  $H$  tends to negative infinite when  $\lambda$  tends to positive infinity. There exist a optimal point in which  $H$  is nil. At the neighborhood of this point, the derivative of  $H$  with respect to  $\tau$  has to be nil:

$$-\frac{\partial w(\lambda)}{\partial \lambda} - \frac{\partial^2 w(\lambda)}{\partial \lambda^2} \frac{\partial \lambda}{\partial \tau} \tau = 0 \quad (\text{C.10})$$

Since costs are increasing in  $\lambda$  and convex, the equality holds if  $\partial \lambda / \partial \tau$  is negative.

**Quasi linear demand, endogenous quality and fixed costs.** The alternative way to consider the impact quality is to assume that quality affects only a fixed cost. As in Antoniadis (2008) the firm maximizes the following profit:

$$\Pi = \frac{1}{4k\tau} (z - T + \lambda - \tau w)^2 - \lambda^2 \quad (\text{C.11})$$

Where  $\lambda^2$  is a fixed cost, increasing in  $\lambda$ . The first order condition with respect to  $\lambda$  yields:

$$\lambda^* = \frac{z - T - \tau}{4\tau k - 1} \quad (\text{C.12})$$

The optimal level of quality is a negative function of both iceberg and per unit transport costs.

## D Appendix. Empirical Results.

Table D.1: Price and distance, mixed effects, 2003

Dependent variable:	Price (log)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Distance (log)	0.057 <sup>a</sup> (0.001)	0.059 <sup>a</sup> (0.001)	0.055 <sup>a</sup> (0.002)	0.068 <sup>a</sup> (0.001)	0.081 <sup>a</sup> (0.002)	0.092 <sup>a</sup> (0.002)	0.068 <sup>a</sup> (0.001)	0.081 <sup>a</sup> (0.002)	0.093 <sup>a</sup> (0.002)
GDP (log)				-0.006 <sup>a</sup> (0.001)	-0.002 (0.001)	0.017 <sup>a</sup> (0.001)	-0.006 <sup>a</sup> (0.001)	-0.002 (0.001)	0.017 <sup>a</sup> (0.001)
GDP per capita (log)				0.022 <sup>a</sup> (0.002)	0.036 <sup>a</sup> (0.002)	0.030 <sup>a</sup> (0.003)	0.021 <sup>a</sup> (0.002)	0.036 <sup>a</sup> (0.002)	0.030 <sup>a</sup> (0.003)
Mean UV (log)							0.016 <sup>a</sup> (0.001)	0.010 <sup>a</sup> (0.001)	0.007 <sup>a</sup> (0.001)
Fixed effects	Firm $\times$ Product								
Random effects	Country								
Sample:	All	OECD	Eurozone	All	OECD	Eurozone	All	OECD	Eurozone
Observations	1199711	910108	591733	1199711	910108	591733	1198282	909398	591268
rho	0.015	0.009	0.000	0.015	0.006	0.000	0.013	0.005	0.000

This table investigates the impact of distance on firm's export prices. It uses the variance of prices across destination country within firm-product pairs by including firm  $\times$  product fixed effects. The dependent variable is the log free on board export unit value by firm, destination and CN8 product. Explanatory variables are the distance to the destination country, the wealth of the destination country measured by the GDP per capita, the size of the destination country measured by the GDP, and the level of competition in the destination country measured by the average unit value of imports in this country. In columns 1, 4, 5 all destinations are considered. In columns 2, 5, 7 only exports toward OECD countries are considered. In columns 3, 6, 9, only exports toward euro countries are considered. Country random effects are added to control for unobserved heterogeneity. Robust standard errors in parenthesis. <sup>c</sup>, <sup>b</sup>, <sup>a</sup> indicates significance at 10%, 5% and 1% level.

Table D.2: Price and distance intervals, mixed effects

Dependent variable:	Price (log)		
	(1)	(2)	(3)
1500< distance <3000	0.024 <sup>a</sup> (0.002)	0.026 <sup>a</sup> (0.002)	0.026 <sup>a</sup> (0.002)
3000< distance <6000	0.085 <sup>a</sup> (0.003)	0.108 <sup>a</sup> (0.003)	0.108 <sup>a</sup> (0.003)
6000< distance < 12000	0.115 <sup>a</sup> (0.002)	0.136 <sup>a</sup> (0.002)	0.135 <sup>a</sup> (0.002)
12000< distance	0.145 <sup>a</sup> (0.006)	0.141 <sup>a</sup> (0.006)	0.140 <sup>a</sup> (0.006)
GDP (log)		-0.006 <sup>a</sup> (0.000)	-0.006 <sup>a</sup> (0.000)
GDP per capita (log)		0.022 <sup>a</sup> (0.001)	0.021 <sup>a</sup> (0.001)
Mean UV (log)			0.018 <sup>a</sup> (0.001)
Fixed effects	Firm $\times$ Product		
Random effects	Country		
Sample:	All	OECD	Eurozone
Observations	1199711	1199711	1198282
rho	0.000	0.000	0.000

This table investigates the impact of distance on firm's export prices. It uses the variance of prices across destination country within firm-product pairs by including firm $\times$ product fixed effects. The dependent variable is the log free on board export unit value by firm, destination and CN8 product. Explanatory variables are the distance to the destination country, the wealth of the destination country measured by the GDP per capita, the size of the destination country measured by the GDP, and the level of competition in the destination country measured by the average unit value of imports in this country. Distance is measured using distance interval. Dummy is equal to 1 if the destination country belongs to the interval and 0 else. Country random effects are added to control for unobserved heterogeneity. Robust standard errors in parenthesis. <sup>c</sup>, <sup>b</sup>, <sup>a</sup> indicates significance at 10%, 5% and 1% level.