Spatial Price Discrimination in International Markets: from Models to Data
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Abstract

This paper focuses on the spatial price discrimination in an international context, $i.e.$ the impact of distance on fob prices set by exporting firms. The theoretical part of this paper points out the importance of the trade cost formulation on the pricing policy adopted by the firms. The empirical part shows that French firms adopt a reverse dumping strategy. In other word, firms increases their fob price with the distance. The main models of international trade fail to predict such positive relation at the firm level, even when introducing quality. Moreover, with or without quality, models need an additive part in their transport cost to generate the observed positive relationship between price and distance which questions the use of iceberg costs.

1 Introduction

The positive relationship between trade unit values and distance at *the product level* is a well established empirical fact; see Mayer and Ottaviano (2007), Schott (2004) or Hummels and Klenow (2002). Several papers contribute to explain this fact. Hummels and Skiba (2004) and Baldwin and Harrigan (2007) propose two distinct models in which the average quality at the product level level increases with the distance. Since higher quality goods are also more expensive, product unit value increases with the distance.[1] Empirical evidence highlighted in this paper suggest that trade unit values also increase with the distance at *the firm and product level*. Although quality differential might be suspected to play a role at this lower level of disaggregation, this paper proposes a complementary (and simpler) explanation to this phenomenon: the spatial price discrimination.

International trade is strongly affected by geographical distance. Besides, numbers of papers stress the importance of national borders showing that countries are segmented markets. These two points suggest that international markets provide a fruitful framework to think about spatial price discrimination. If markets are segmented enough, exporting firms can adopt different pricing policies. A first possibility is to set the same fob price whatever the destination country, which corresponds to the well known *mill*

[1]The first work is due to Hummels and Skiba (2004). The authors build a model in which 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 more expensive, the mean price increases with the distance. In fact, the authors model the Alchian-Allen conjecture (which states that the demand for high quality goods increases with the distance) in an international context. The second work is due to Baldwin and Harrigan (2007). The authors modify a Melitz-type model by assuming heterogeneity in terms of quality rather than in terms of productivity. In this context, only high quality firms (setting the higher prices) are able to serve remote countries. Therefore, the average price price measured by the unit value increases with the distance.

pricing strategy (no price discrimination).[2] Another possibility is to absorb part of the freight cost, and thus set an lower fob price toward the more remote countries. This strategy is called *dumping*. The last alternative is to set a higher fob price toward more remote countries. This behavior is often referred as *reverse dumping*. The objective of this paper is to shed light on the following questions: Which theoretical ingredients justify the choice of those pricing policies? and What is the empirical prevalence of these policies in trade data?

In a first step, I discuss the type of pricing policy chosen by the firm depending on (i) the form of the preferences and (ii) the formulation of trade costs. I show that, like the form of the demand, the formulation of transport costs is crucial in explaining firm pricing policy. For instance, in a CES framework under monopolistic competition, with iceberg trade costs, firms adopt a mill pricing strategy. Interestingly, keeping the same preferences but using additive trade costs justifies a reverse dumping strategy. Last, a mix of the two aforementioned transport cost formulations might lead firms to adopt dumping strategy. To sum, firms are expected to adopt different pricing policies, depending on the form of the demand and the formulation of transport costs. Theoretical relevance of opposite strategies call for empirical evidence. Despite the long tradition of theoretical works on spatial price discrimination, few empirical studies exist.

To fill this gap, in a second step, this paper provides empirical insight on the pricing policy of French exporters. Namely, I use highly detailed firm level data to evaluate the impact of distance on fob prices set by French firms. Considering the pooled sample, I find that prices increase with the distance. Then, I turn to a more detailed analysis, estimating the elasticity of prices to distance for each exporter. On average, firms turn out to set higher prices toward more remote countries. In a nutshell, data suggest that French exporters are likely to adopt reverse dumping strategies. These results are striking since the main models of international trade predict either mill pricing or freight absorption. More interestingly again, models using iceberg trade cost cannot get such predictions (under reasonable assumptions) which questions the use of this formulation when looking at trade prices.

An alternative explanation of the positive relationship between unit values and distance is that unit values increase because the (average) quality increases with the distance. Data seems to comfort the price discrimination hypothesis. Anyway, models with quality also needs an additive part in their transport cost to generate such predictions.

This paper is related to a number of different strands of existing literature. Theoretically, it relies on the long tradition of works on spatial price discrimination. One of the seminal contribution to this literature is due to Hoover (1937). The author shows that the firm pricing policy depends on the characteristics of the elasticity of demand. He already distinguishes mill pricing, dumping and reverse dumping strategies. A small part of the trade literature focuses on dumping strategies. For instance, Brander (1981) and Brander and Krugman (1983) explain trade between similar countries by reciprocal dumping.[3] Another part of the international trade literature gets rid of price discriminatory to favor models' tractability. Models of the new trade literature built on the seminal work of Krugman (1980) adopt this strategy.[4] In these models, the combination of monopolistic competition, CES utility function and iceberg trade costs implies non-discriminatorily pricing. Note that the reverse dumping strategy attracts little attention in the literature. Nevertheless, Greenhut et al. (1985) reaffirm the possible existence of reverse dumping i.e. a possible positive relation between prices and distance.

Price changes might also be the consequence of changes in terms of quality sold by the exporters. This type of behavior is not a pricing but a quality policy. While this is not the core of their study,

[2] fob stands for free-on-board. A fob price is a price net of transport costs.

[3] The contribution of Ottaviano et al. (2002) and more recently Melitz and Ottaviano (2008) also emphasize dumping strategies in new trade with quasi linear demand functions.

[4] Melitz (2003) type models also exhibit mill pricing strategy.

two papers allows to think about firm spatial quality discrimination: Hallak and Sivadasan (2008) and Verhoogen (2008).

The relation between fob prices and distance is obtained through the existence of a transport cost which is positively related to the distance. Here I underline the importance of the transport cost formulation on firm pricing policy. I notably point out the strong implications of iceberg type transport costs. In international trade, the iceberg trade cost is the most widely used formulation because of its analytical tractability. This modeling has been popularized by Samuelson (1954). It states that "*as only a fraction of ice exported reaches its destination*", only a fraction of the exported goods reach its destination. Krugman (1980) also uses this modeling but states that "*this is a major simplifying assumption*". The use of an iceberg trade cost is convenient since it affects the fob price in a multiplicative way which contributes to the model's *elegance*. However, iceberg trade costs have strong implications. In particular, such modeling implies that all increase in the fob price (of a good) leads to a proportional increase in the transport cost. An alternative formulation of trade costs is the additive transport cost. Unlike iceberg transport cost, it impacts the price in an additive way. This formulation is used in the IO models of price discrimination. Empirically, Hummels and Klenow (2002) shows that the elasticity of trade costs to prices is lower than unity which rejects the iceberg formulation.

From an empirical point of view, few papers investigate the impact of distance on pricing policies. Greenhut (1981) explores the pricing policy of West German, Japanese and US firms. He underlines that spatial pricing is a common practice for these firms. However, this work focuses on sales in the domestic market. A recent and growing literature also analyzes the relation between trade prices and distance at the product level as mentioned above. They find a positive relationship between unit values and distance through explained by a quality composition effect. However, models explaining this fact assume mill pricing at the firm level. By contrast, here I precisely focus on the relation between price and and distance *at the firm level*: Theoretically, I focus on firm pricing policies, and empirically, I evaluate the impact of distance on prices at the individual level, trying to get rid of composition effects.

This paper contributes to the literature in three ways. Firstly it points out the role of transport cost formulation in the firm pricing strategy. Secondly, it offers empirical evidence of spatial pricing using highly detailed firm level data. Particularly, it highlights the significant existence of reverse dumping behaviors in the data. Last it emphasizes that (i) no one existing models of international trade reproduces this special feature (fob prices increase with the distance) of the data even if we introduce quality and (ii) that iceberg trade costs do not seem convenient at all to study the relationship between trade prices or unit values and distance.

The theoretical section of this paper intends to analyze how firm pricing strategies can be affected by the form of the transport costs. Hence, I specify the form of a so called mixed trade cost which iceberg and additive trade costs are particular cases. This "mixed" trade cost has still a specific form but it is enough general to discuss the link between pricing policy and trade cost formulation. I derive the optimal price set by a firm facing a transport cost without specifying the form of the demand. I also compute the elasticity of the fob price to distance in this general case. I show how both the form of the elasticity of the demand and the formulation of transport costs impact firm pricing policies. Then, I explore more in depth the CES case. This is a highly interesting case for a least two reasons. The first reason is that CES utility function in a monopolistic competition framework can be considered as the star of the new trade models. The second reason is that under these preferences, the elasticity of demand to the cif price is exogenous. In that case, prices depend on the distance only through the transport cost channel which highlights the role of transport cost formulation in the firm pricing policy.

The empirical part aims at evaluating the relation between trade prices and distance. I use highly detailed firm level data provided by French customs. The database reports bilateral values and quantities of shipments of French exporters, over the period 1995-2005. For each flow, I use the information about value and quantity to compute unit values. A great advantage of these data is that firms declare their exports free-on-board which means that the unit values are not contaminated by transport costs neither by the retailer margins, or destination countries taxes. This is particularly appropriated to study firm pricing strategy. The main difficulty lies in the use of these unit values instead of prices to analyze the firm pricing policy. Actually, unit values can be claimed to be an average price of different goods. Particularly, differences in unit values might reflect differences in terms of quality.

Empirical investigations are conducted at two distinct levels. In a first step I run regressions over the pooled sample using appropriated fixed effects and adding control variables for robustness. I also analyze this relation on two subsamples, restricting the destination countries to have similar (not huge differentials) levels of development by focusing on OECD countries; or two have similar (and close to zero) tarifs by concentrating on euro countries. The results are clear: in all the regressions the distance has a positive impact on prices. To asses this result, I then run regressions for each "firm-product" couple. Hence I get thousands coefficients describing the relation between price and distance for French firms. One observes that in the data the relation might be positive, negative or non significant but that the major part of French trade is done by firms and products which elasticity of prices to distance is positive.

In the empirical part, prices are approximated by unit values. Consequently, the increase in the unit values with the distance might be interpreted as quality increase. There be two possible explanations. First spatial quality discrimination: the firms set a specific quality for each market.[5] Second Alchian Allen effect: the firms sold several goods (all regrouped in a identical CN8 category) with different level of quality, the share of high quality goods increasing with the distance. Our data do not allows us to disentangle these two types of discrimination (price discrimination or quality discrimination) Nevertheless, unit values are built at the firm and product level, with highly detailed categories of product (CN8, more than 10,000 products) which limit the composition effects. Moreover, I find qualitatively little magnitude of the elasticities to distance of unit values which suggests that my results reflect more price discrimination than quality discrimination. Moreover, models describing the mechanisms aforementioned have to incorporate additive trade costs. This conforts the main message of this paper: iceberg trade cost is not appropriate to study the relation between prices and/or quality and distance.

The rest of the paper is organized as follow. The next section discusses the role of the form of the utility function and the formulation of transport costs on firm pricing policy. Section 3 presents the empirical methodology and the data. Section 4 describes the empirical results. Section 5 considers alternative explanations to spatial price discrimination. Finally, Section 6 concludes.

2 Theoretical Models

In this section, I start with a presentation of the two alternative formulations for trade costs. Namely I present the iceberg and the additive trade costs. I also present the 'mixed' transport cost used in the rest of the paper (which iceberg and additive costs are particular cases). Using the 'mixed' formulation, I show how the introduction of an additive part in the trade cost allows to get differentials between the elasticity of demand to the cif and to the fob prices. Then I turn to the description of the elasticity of fob price to distance. I first consider a general case where I do not specify the form of the elasticity of demand. Then, in a monopolistic competition setting I focus on the CES utility function and derive the predictions for prices according to the formulation of trade costs.

2.1 Iceberg and additive trade costs

Among the different ways to introduce frictions in trade models, the iceberg formulation is the most commonly used. It has been popularized by Samuelson (1954). Answering to Pigou (1952) criticism,

[5] I show that the existing models generate a negative relationship between the quality and the distance (all else equal). By contrast, in a CES framework, with an additive trade cost, I show that the quality increases with the distance. Nevertheless, these type of models do not offer closed form solution.

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. Therefore, to serve x unit of good, the firms have to produce τx units, with τ greater than one. Since this work, this modeling is widely used, but not much questioned in the trade literature.[6]

The iceberg formulation of trade cost can be seen as an ad-valorem cost since it impacts the price in a multiplicative way. Let us denote p_{ij}^{fob} the fob price and τ_{ij} the iceberg trade cost to export from country i to country j. Then the cif price is given by:

$$p_{ij}^{cif} = \tau_{ij} p_{ij}^{fob} \tag{1}$$

The main problem with this formulation is that every change in the fob price of the shipped good is passed on the value of the trade cost. This means that the level of trade cost is proportional to the fob price. Actually, measuring the transport cost as the difference between the cif price and the fob price, one gets:

$$p_{cif} - p_{fob} = (\tau_{ij} - 1) p_{fob} \tag{2}$$

the cost to export a good between country i and country j increases with the fob price.

The other limit of the iceberg transport cost is that, since it is payed in term of quantity produced, it implicitly assumes that the transport technology is similar to the technology used to produce goods.

These drawbacks are absent when the transport cost (f_{ij}) is modeled in an additive way:

$$p_{ij}^{cif} = p_{ij}^{fob} + f_{ij} \tag{3}$$

With this formulation, the transport cost can be good-specific but it does not fluctuate with the price of the good. Models with (quasi) linear demand such as spatial pricing model for instance often use this modeling.

In this paper I consider a formulation of trade costs combining the two type of trade costs:

$$p_{ij}^{cif} = p_{ij}^{fob} \tau_{ij} + f_{ij} \tag{4}$$

Rewriting it:

$$p_{ij}^{fob} = \frac{p_{ij}^{cif} - f_{ij}}{\tau_{ij}} \tag{5}$$

This formulation is still highly restrictive, but it allows to highlight the oppositive predictions one can get when modifying τ and f. This transport cost is similar to the expression developed by Hummels and Klenow (2002) but here I consider that both the ad valorem and the additive parts increase with the distance.

To see in which extent the 'mixed' formulation of trade costs allows to depart from the iceberg formulation, I discuss the impact of the formulation on the difference between elasticity of demand to fob and cif prices. Let's denote ϵ_i the elasticity of demand, with $i \in \{fob, cif\}$.

$$\epsilon_{cif} = -\frac{\partial log(q_{ij})}{\partial log(p_{ij}^{cif})} = \left(1 + \frac{f}{\tau p^{fob}}\right) \epsilon_{fob} \tag{6}$$

[6] Nevertheless one can mention the words of Bottazzi and 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*". This sounds as a clear will to discuss this modeling. An other criticism is done by McCann (2005). The author argues that the main problem with the trade cost appears when the geographical distance is related to it. Last, Hummels and Klenow (2002) show that transport costs do not react proportionally to a change in prices which empirically rejects the iceberg trade costs.

From equation(6), the elasticity to cif price is greater than or equal to the elasticity to fob price. Said otherwise, the demand is most sensitive to a one percent change in the cif price than to a one percent change in the fob price. The extent of the differentiation between the cif and the fob elasticities is given by the ratio additive trade costs over multiplicative trade cost and price. Intuitively, if additive trade costs are high relative to the fob price times the iceberg cost, a change in the fob price is weakly passed on the cif price. Conversely, if the fob price is high relative to the trade costs, the change in the fob price is nearly identical than a change in the cif price.

If f is nil, the elasticities to fob and cif prices are the same. This limit case is with an iceberg trade cost. In that case, any increase in the cif price is entirely passed on the fob price. Now let's assume that the additive part of the transport cost increase. Therefore, all else equal, the elasticity to fob price decreases with respect to the elasticity to the cif price. In general the higher is the additive part of the transport cost with respect to the multiplicative one, the lower is the sensitivity of the demand to changes in prices.

In fact, the difference between fob and cif elasticities of demand is the main channel through which distance (through transport costs) impacts firm pricing strategy. The introduction of an additive part allows the demand to react in a different a way to change in fob prices.

To end this first section, let me precise the assumptions I do about the 'mixed' transport cost. I assume that f and τ are two differentiable and increasing functions of the distance such as:

$$f : \Re_+ \rightarrow \Re_+ \tag{7}$$
$$dist \rightarrow f(dist) \tag{8}$$

$$\tau : \Re_+ \rightarrow [1, \infty[\tag{9}$$
$$dist \rightarrow \tau(dist) \tag{10}$$

I also assume that τ and f are exogenous (for the producer). To be clear, individual choices cannot impact the level of these two variables.

2.2 Production side

In this section, I try to be as general as possible. I focus on a firm exporting from country i to country j. The firm faces a cost of production w to produce one unit of good. I assume market segmentation, thus the firm strategy in a given market is independent from its strategy in other markets. In market j, the firm maximizes the following operational profit:

$$\pi_{ij} = \left[p_{ij}^{fob} - w\right] q_{ij} \tag{11}$$

where q is the quantity sold abroad (that depends on the cif price) and p^{fob} is the fob price. To make the model simpler I assume that the firm maximizes its profits with respect to the cif price. I use equation (3) to rewrite the last equation. The profit can be written:

$$\pi_{ij} = \left[\left(\frac{p_{ij}^{cif} - f_{ij}}{\tau_{ij}}\right) - w\right] q_{ij} \tag{12}$$

where p^{cif} is the price faced by the consumer. The first order condition gives:

$$\frac{q_{ij}}{\tau_{ij}} + \left[\left(\frac{p_{ij}^{cif} - f_{ij}}{\tau_{ij}}\right) - w\right] \frac{\partial q_{ij}}{\partial p_{ij}^{cif}} = 0 \tag{13}$$

Let us note ϵ^{cif} the elasticity of demand to the cif price:

$$\epsilon^{cif} = -\frac{p_{ij}^{cif}}{q_{ij}}\frac{\partial q_{ij}}{\partial p_{ij}^{cif}} \tag{14}$$

Rearranging equation (13), I get:

$$p_{ij}^{cif} = \frac{\epsilon}{\epsilon - 1}[f_{ij} + w\tau_{ij}] \tag{15}$$

Thus the fob price set by the firm is (subtracting f_{ij} and dividing by τ_{ij}):

$$p_{ij}^{fob} = \frac{1}{\epsilon^{cif} - 1}\frac{f_{ij}}{\tau_{ij}} + \frac{\epsilon^{cif}}{\epsilon^{cif} - 1}w \tag{16}$$

I now have the optimal fob price set by a firm as a function of (i) transport costs , (ii) the marginal cost of production, (iii) the elasticity of demand to the (cif) price.

The next section evaluate the sensitivity of the fob price to distance.

2.3 Spatial price discrimination

2.3.1 General case

The main channel through which distance might impact the fob price are the transport costs. Here I consider that the elasticity of demand might also vary with the distance. I start from equation (16). I do not specify the form of the elasticity of demand ϵ, so $\frac{\partial \epsilon}{\partial dist}$ is not supposed to be nil.

The price is given by:

$$p_{ij}^{fob} = \frac{1}{\epsilon - 1}\frac{f_{ij}}{\tau_{ij}} + \frac{\epsilon}{\epsilon - 1}w \tag{17}$$

Since I assume that τ, f and ϵ depends on the distance between the firm country and the destination country. The elasticity of the fob price to the distance is given by:

$$\begin{aligned} \underbrace{\frac{\partial p^{fob}}{\partial dist}\frac{dist}{p}}_{elsticity\ of\ price\ to\ distance} &= \overbrace{\left[\frac{\partial f}{\partial dist}\frac{dist}{f} - \frac{\partial \tau}{\partial dist}\frac{dist}{\tau}\right]}^{elasticity\ of\ trade\ costs\ to\ distance} / \left[1 + \frac{\tau}{f}\epsilon c\right] \\ &- \underbrace{\left(\frac{\partial \epsilon}{\partial dist}\frac{dist}{\epsilon}\right)}_{elasticity\ \ of\ ..\ elasticity\ of\ demand} \underbrace{\left(\frac{\epsilon}{\epsilon - 1}\right)\left(\frac{1}{f/\tau + \epsilon c}\right)\left(\frac{f}{\tau} + c\right)}_{positive\ term} \end{aligned} \tag{18}$$

Therefore, the sign of the impact on price of distance for a given firm depends on the elasticities of the additive and multiplicative parts of the transport costs to the distance and the elasticity of the elasticity of demand to the distance.

The sign of the first term on the right hand side is given by the difference between the elasticity to distance of the additive part of trade cost and the multiplicative one. If the additive part is more sensitive, the sign of this term is positive. The magnitude of this term is given by the ratio $\frac{\tau}{f}$. The higher is f, the higher is the impact of this term. By contrast, if f is close to zero, this term tends to zero.

The second term is the elasticity of elasticity to distance. Said otherwise, this term says how varies the elasticity of demand when the distance increases. The sign of this term is uncertain. Actually, even if part of the trade cost is absorbed by the firm, the cif price is expected to increase with the distance. [7] Since the cif price increases, the elasticity is expected to increase with the distance, therefore the

[7] This is true even if the fob price decreases with distance. Theoretically, this prevent arbitrage behaviors.

relation between distance and elasticity is expected to be positive. Nevertheless, since elasticity is not specified, one can expect it to lower with the distance because firms have less competitors from their country in remote markets. Finally, one can ask wether the elasticity of demand of a product is firm specific. Said otherwise, one can believe that the elasticity of demand is country specific and does not depend on the distance from a given firm. One observes the importance of the form of the elasticity of demand (and therefore the form of the preferences). A first result is that mill pricing (a nil elasticity of price to distance) appears only under highly restrictive conditions.

Table 1 provides the fob price and its elasticity to distance in the cases of CES and quadratic utility functions (in monopolistic competition), and in two particular formulations of transport costs: the iceberg and the additive ones. It shows that the quadratic utility function leads to a negative impact of distance on prices for the two types of trade cost. This suggests that dumping in trade models is a consequence of quasi linear demand. For the CES utility function, with the iceberg trade cost, one finds the standard nil relation between prices and distance, but the additive trade cost changes the story. Actually, the introduction of an additive trade cost allows to observe a positive impact on prices of distance.

Table 1: Elasticity of fob price to distance

Utility function	Trade costs	fob Price	elasticity to distance	sign
CES	iceberg	$\frac{\sigma}{\sigma-1}w$	0	nil
CES	additive	$f_{ij}\frac{1}{\sigma-1}+\frac{\sigma}{\sigma-1}w$	$\frac{f_{ij}}{p_{ij}^{fob}}\frac{1}{\sigma-1}$	+
Quadratic	iceberg	$\frac{a+cP_j}{2\tau_{ij}(b+cN)}+\frac{1}{2}w$	$\frac{-1}{\tau_{ij}p_{ij}^{fob}}\frac{a+cP_j}{2(b+cN)}$	-
Quadratic	additive	$\frac{a+cP_j}{2(b+cN)}+\frac{1}{2}w-\frac{1}{2}f_{ij}$	$\frac{-1}{2}\frac{f_{ij}}{p_{ij}^{fob}}$	-

Since the CES utility function is widely used in the trade literature, and that it seems to be sensitive to the form of transport costs, let me investigate more in depth the relation between price and distance with this utility function.

2.3.2 More in depth in the CES

In a monopolistic competition framework, with a CES utility function, the price elasticity is constant and equal to the elasticity of substitution σ. In other words, the CES case allows to discuss the impact of distance on price depending on the formulation of trade cost, and taking the elasticity of demand as exogenous.

$$p_{ij}^{fob} = \frac{1}{\sigma-1}\frac{f_{ij}}{\tau_{ij}} + \frac{\sigma}{\sigma-1}w \tag{19}$$

Therefore the elasticity of price to distance is given by:

$$\frac{\partial p}{\partial dist}\frac{dist}{p} = \left(\frac{\partial f}{\partial dist}\frac{dist}{f} - \frac{\partial \tau}{\partial dist}\frac{dist}{\tau}\right) / \left(1+\frac{\tau\sigma w}{f}\right) \tag{20}$$

The sign of the elasticity of price to distance is given by the sign of the difference between the elasticity of additive trade cost to distance and the elasticity of iceberg cost to distance. Note, that by assumption these two elasticities are positive. There are two opposite effects: the increase in distance increases the price through the additive cost and decreases the price through the iceberg cost. If the additive cost is non zero, the iceberg part has a negative impact on the fob price. If the additive cost is nil, thus the impact of the iceberg cost is nil: one turns back to mill pricing. Table 2 summarizes the sign of the elasticity to distance of prices depending on the formulation of trade costs in the CES case.

Table 2: Elasticity of fob price to distance (CES case)

additive part (f)	multiplicative part (τ)	elasticity to distance
f=0	$\frac{\partial log(\tau)}{\partial log(dist)}$>0	0
$\frac{\partial log(f)}{\partial log(dist)} = 0$, f > 0	$\frac{\partial log(\tau)}{\partial log(dist)}$>0	-
$\frac{\partial log(f)}{\partial log(dist)} > 0$	τ=1	+
$\frac{\partial log(f)}{\partial log(dist)} > 0$	$\frac{\partial log(\tau)}{\partial log(dist)}$>0	sign of $\frac{\partial log(f)}{\partial log(dist)} - \frac{\partial log(\tau)}{\partial log(dist)}$

With pure iceberg trade cost, exporters adopt a mill pricing strategy: the elasticity of price to distance is nil. Adding a constant additive cost (a cost which does not depend on the distance) to the iceberg cost leads exporters to adopt a dumping strategy. With a pure additive trade cost, exporters adopt a reverse dumping strategy. Last, if the two part of the trade cost are 'active' (both increase with the distance), the pricing policy of exporters depends on the relative sensitivity of the two parts of the transport cost to the distance.

The point of interest with a CES utility function is that changing the formulation of transport costs, one makes appear the different pricing policies namely mill pricing, dumping and reverse dumping.

2.4 First conclusions

The last sections shows that distance can have opposite impacts on firms' prices depending on the form of the preference and the formulation of transport costs.

The first conclusion from the former analysis is that the mill pricing strategy (widely suppose in the trade literature) is highly specific to both the CES utility function and the iceberg trade cost. The second conclusion is that the freight absorption existing in a few trade models is due to the form of the linear demand. Whatever the form of the transport cost, the linear demand leads to freight absorption. A corollary of the last two conclusions is that common models of international trade do not lead to reverse dumping. The third conclusion is that if transport cost are pure iceberg costs, then reverse dumping appears only if the elasticity of demand decreases with the distance. This last hypothesis is not really realistic: Why do the elasticity of demand faced by French exporters would be higher in UK than in US? An implication of it is that in the presence of pure iceberg trade costs, reverse dumping should not appear. The fourth conclusion is that if the elasticity of the demand to the cif price is exogenous, the unique determinant of the pricing policy is the transport cost formulation.

Mill pricing, dumping, reverse dumping: opposite theoretical predictions about firm pricing policies co-exist in the literature. These predictions rely on hypothesis on (i) the form of the preferences and (ii) the formulation of transport costs. The rest of the paper intends to evaluate exporters' pricing strategies and infer theoretical conclusions from the results. To reach this objective, I use highly detailed firm level data data about French exporters. Data and empirical strategy are both described in the next sections.

3 Empirical Implementation

I do not do a structural estimation of the relation between prices and distance. Instead I evaluate the elasticity of prices to distance with linear regressions. I use two different methods focusing on the pooled sample and then running regressions by firms. Before detailing my empirical strategy, I present the data. The two data I need to my estimations are export prices distances. Both are described in the next section.

3.1 Data

The trade data I use are provided by the French customs. The database covers bilateral shipments of firms located in France over the period 1995-2005. The data are disaggregated by firm and product at the 8-digit level of the the Combined Nomenclature (CN8). The raw data cover 305,661 firms and 13,507 products for a total exported value of 3,16 trillion euro. For each flow, the fob value and the shipped quantity (in kg) are reported. In a nutshell, a flow is described by a firm number, a product number (CN8), a destination country and a year.

In the empirical part of this paper, I approximate prices by unit values. The unit value set by the firm f for the product k exported toward the country j at time t is:

$$uv_{fjkt} = \frac{v_{fjkt}}{q_{fjkt}} \tag{21}$$

Values are declared free-on-board. Therefore, unit values are also free-on-board.

Unit values are well known to be a biased measurement of prices. The main criticism was formulated by Kravis and Lipsey (1974). The authors argue that unit values does not take into account quality differences among products.[8] More generally, unit values differentials are claimed to be due to composition effects. Nevertheless, the high level of disaggregation of our data limits the main drawback of unit values $i.e.$ the composition effect and more particularly the quality mixed effect. Actually, at the firm and product level the composition in terms of quality seems to be largely lessened. In usual databases, unit values are provided at the product level. Since I work with individual data, unit values I use are not biased by a firm composition effect. Furthermore, the high level of disaggregation of the data (10,000 products) limits to have goods with different characteristics within these unit values. However, I cannot affirm that the different unit values set by a firm for a given product exported toward several country are fully exempt of quality composition effects.

Despite the quality of the data, I have to deal with some errors in declarations or in the reporting made by the customs. To account for this I adopt a specific procedure relying on the deviation of the unit values from the median. Namely, I delete the observations where the unit value is 5 time larger or lower than the median unit value set by the firm. With this procedure, I keep 97% of the total exports. Even if the quality mixed effect is greatly lessen, if the outliers are deleted, unit values remains proxies for prices. How does it affect the regressions? If this error is randomly distributed, since prices are the dependent variable of our regressions, the measurement error does not bias the estimations, if the error is firm product and time specific, I control for it with the fixed effects.[9]

The other variable of interest, for this paper, is the distance. In the literature, several methodologies are used to compute the geographic distance between two countries. I retain the method developed by Mayer and Zignago. The idea is to take into account the distribution of the population within the countries. Therefore, instead of computing the distance between two towns of the two countries, the bilateral distances between several towns of each country are computed, and then aggregated weighting the distances with the population of each city.

[8] For a recent criticism of unit values see Silver (2007).

[9] If the measurement error is not correlated with the explanatory variables (which is the case sine the main explanatory variables are distance, GDP and GDP per capita).

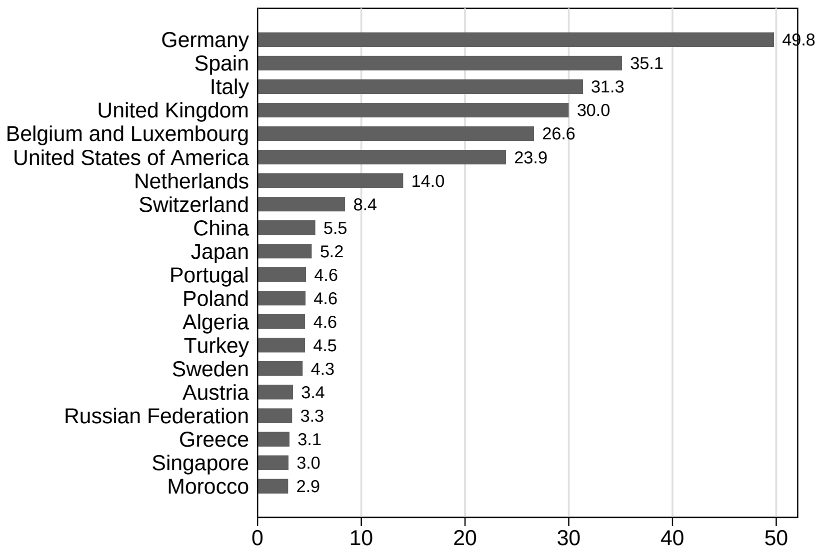
GDP and GDP per capita, from the IMF database, are used as control variables. I also use average unit values by country. These unit values are computed from BACI, the database of international trade at the product level developed by Gaulier and Zignago.[10] By hs6 product, year and country, I compute the average unit value weighted by the quantities. To be clear I compute the average unit value of the product k in country j at time t

$$uv(kjt) = \sum w_{ijkt} uv_{ijkt} \tag{22}$$

where uv_{ijkt} is the unit value of the good k exported from country i to country j at time t. And w_{ijkt} is the weight in terms of exported quantity of good k exports from country i at time t.[11] Then I merge this hs6 unit values with the custom data. Thus for each product exported from a French firm I have the corresponding average unit value for all the destination markets. I have this information for OECD countries only and over the period 1995-2004 in order to keep good quality data, and because BACI covers the period 1995-2004.

Let me turn to a short description of the French exports. Figure 1 plots the exported values from France to its main partners. A visual inspection shows the importance of Germany. Other partners are the major European countries, the two other members of the triad (USA and Japan), China but also Algeria and Morroco. Figure 2 presents the distance between France and its main partners. I can sort the

Figure 1: Top 20 French trade partners



Value of exports, in billions of euro, in 2005.
Source: French custom data, author computation.

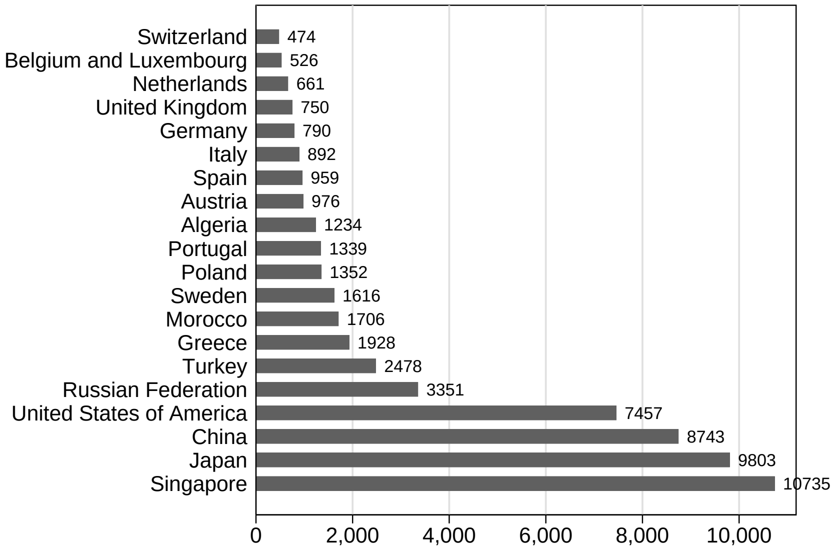
countries in two groups: the close countries mainly European, and distant of less than 2,000 km. The remote but attractive countries such as the USA or Japan, really far away from France (more than 7,000 km), but attractive markets in terms of demand.

3.2 Empirical strategy

My empirical question is the following: How do fob prices change when distance increases? Since the relationship between prices and distance is given by the impact of transport costs on prices and the impact

[10]For a description of the database, see $http://www.cepii.fr/anglaisgraph/bdd/baci.htm$.
[11]Note that i) I do not have unit values at the CN8 level but at the hs6 one ii) I have all the unit values but the domestic ones.

Figure 2: Distance from the main trade partners



Distances in kilometers, computed as the population weighted average of the distance between cities.
Source: CEPII.

of distance on transport costs, then a 2-step methodology would be ideal. But I do not have transport costs data. Therefore, I use different other methodologies to answer this question.

The theoretical discussion is oriented around the sign of the elasticity of fob prices to distance. A first way to evaluate firm pricing policy is thus to compute this elasticity. An approximation of this elasticity is given by the regression of the logarithm of prices over the logarithm of distance. The relation between price and distance is not supposed to be linear (elasticity is not constant), but in the theoretical cases developed above the relation is always monotonous. Therefore I have to (and I can) focus on the sign of this elasticity. The potential biases related to linear regression obviously exist in our case. I try to tackle them, as explained latter.

Another way to verify the sign of the relation between the fob price and the distance is to observe the average price set by exporters toward different areas. The areas I refer to are geographical areas defined as the group of French partners lying between two given distances from France. This method is used by Baldwin and Harrigan (2007) or Eaton and Kortum (2002) among others.

3.2.1 Estimate the elasticity

The easiest way to measure the elasticity of prices to distance is to regress the logarithm of the price over the logarithm of the distance. I want to measure this relation at the firm level. The data have 4 dimensions: country, product, firm and year. In the models previously presented a firm produces and exports a single good toward a single destination. In the data a firm can export several goods. Thus I want to measure the elasticity at the firm and product level.

There is a possible correlation between price and distance that I do not want to measure. According to Melitz (2003), the more remote markets are served by the more productive firms which also set the lower price, thus there is a possible negative correlation between price and distance. By contrast, following Baldwin and Harrigan (2007), only the firms producing high quality will export toward remote markets, thus prices will be positively related to distance. But, the two former stories deal with selection effect, I do not want to measure this selection effect, since I am interested in the differentials of prices set by a given firm exporting toward different markets. Moreover, to have unbiased estimations I have to take into account the possible correlation between the elasticity and firm characteristics. These considerations lead me to introduce a firm, product and time fixed effect.

In a first step, I run the simple equation to check the impact of distance on the fob prices:

$$log(uv_{fkjt}) = \alpha log(dist_{fj}) + FE_{fkt} + \epsilon_{fkjt} \tag{23}$$

Where uv is the unit value computed at the firm and product level, $dist$ is the distance between France and partner j, FE_{fkt} is a fixed effect firm, product and year, and ϵ is the error term.

To test the robustness of the results, I use three different samples of countries: all the countries, the OECD countries and the euro members. The OECD sample allows me to verify that my results are not driven by outliers countries. The use of euro members sample is a way to get rid of the firm price discrimination due to (i) incomplete exchange rate pass-through and (ii) country specif taxation.

I also test possible non-lineararity with the distance. To take into account the eventual non linear relationship between the elasticity and the distance, I introduce in the regressions the squared of the logarithm of the distance. The drawback of this method is that I force the form of the non linearity. The estimated equations is:

$$log(uv_{fkjt}) = C + \alpha log(dist_{fj}) + \beta \left[log(dist_{fj})\right]^2 + FE_{fkt} + \epsilon_{fkjt} \tag{24}$$

From the estimated coefficients one can know the reversal point, $i.e.$ the distance for which the impact of distance on price is nil. This point is such as: $log(dist) = -\alpha/2\beta$.

3.2.2 By interval regressions

Another way to evaluate the sign of the relation between the fob price and the distance is to observe the average price set by the firm in different areas. The areas I refer to are geographical areas defined as the group of French partners lying between two given distances from France. By regressing the log of prices on dummies for these different intervals of distance, I get the average price in each distinct interval. The firm, product and year fixed effect allow to interpret the coefficient as the average price set by each firm according to the distance interval. This method is used by Baldwin and Harrigan (2007) or Eaton and Kortum (2002) among others. The regression is:

$$log(uv_{fkjt}) = \beta D[1,1500] + \gamma D[1500,3000] + \eta D[3000,6000] + \nu D[6000,...] + FE_{fkt} + \epsilon_{fkjt} \tag{25}$$

where $D[a, b]$ is a dummy equal to one for distances greater than a and smaller than b.

I choose these intervals to conserve enough countries in each group.

3.2.3 Control variables

The main problem of the previous regressions is the omitted variable bias. Actually, omitted variable can bias the coefficient of the distance if they are correlated with both the distance and the price. Moreover, if the correlation between the omitted variable and distance is negative, the estimated coefficient can have the wrong sign.

Which variables can bias our estimations? Part of the literature emphasizes the impact of the size and the wealth of the country (see Baldwin and Harrigan (2007) for instance) on trade unit values. I will use GDP and GDP per capita to control for these effects. The exected sign are the following. In a large country, competition is hard which should lead to reduce prices. By contrast, wealthy countries are expected to have a higher willingness to pay which should contribute to higher prices.

Models with quadratic utility function suggest that the price depends on the average price on the market. To control for this I can use average unit values of the different countries. To have average unit values, I use BACI, the world database for international trade at the product level. Average unit values are really interesting since they take into account a lot of information of the country such as: the level of competition on the market, the remoteness of the market from its suppliers, the extent of the demand i the market.[12]

Another possible source of omission bias is the competition with French firms. Assuming that prices set by a French firm depends on the competition with other French firms, it might be the case that French firms face less competition in remote markets and thus are able to fix higher prices. Another story for this effect deals with ideal variety. The idea is that the elasticity of substitution is not constant. And the more firms enters a markets, the higher is the elasticity of substitution. The more French firms are present in a market, the lower is the price. To control for this competition effect, I introduce in different regressions the number of French firms selling the same product in the destination market.

3.2.4 Scope of interest

I show in the previous section that the elasticity depends on the value of the fob price. Consequently, I have to compute the elasticity from samples of goods sharing close unit values. The firm, product and time fixed effect allow to control for this. Nevertheless, with fixed effect estimations run over the pooled sample, I constrain the coefficients to be the same for all products. Elasticities at the product level have different magnitudes and maybe different signs. The pooled regressions offer an average elasticity. However, it mights be the case that the implicit aggregation is not pertinent.[13] Therefore, I also study the elasticity of prices to distance at the firm and product level.

Estimates at the firm and product level are done using simple OLS. To avoid time composition effects I study the elasticity of price to distance in cross section. I have potentially as much regressions as firm and product couple. In those regressions, the number of observations is the number of destinations served by the firm for this product. As a consequence, I have to keep only the firms serving a large number of countries. For the basic regression of the logarithm of the price over the logarithm of the distance, I decide to keep only the firms exporting toward more than 15 countries. Control for GDP and GDP per capita needs more observations: I conserve only the firms exporting toward more than 30 destinations. Consequently, the sample of firms is highly restricted. One knows that firms exporting toward such a great number of destinations are really specific. They are likely to be the largest, the most productive and so on. Nevertheless, it is interesting to study the coefficients at this level of estimation.

3.2.5 Significativity

In all these regressions I am interested in the significativity of the estimated coefficients. Actually, the CES model with iceberg trade costs predicts that the elasticity of price to distance is nil. Therefore, estimation of the standard error is important. In the regressions conserning the pooled sample, part of the heteroscedasticity is captured by the fixed effects. However, with such a great number of observations, the variance can be bias by the correlation between groups of observations. To limit the bias in the estimated standard errors, I estimate firm, product and time clustered standard errors.

[12]The price depends on the remoteness of the country. Not from France but from the world. In other words, because Australia is far from the rest of the developed countries she faces high prices. But a given firm, exporting toward Australia, will absorb part of the trade costs. These remoteness is captured by the average unit value on the market.

[13]See for instance Imbs and Méjean (2008).

4 Results

In this section, I first study the pooled sample. In other word, I constrain the coefficients to be the same over the all products. This first step provides us with an idea about the average impact of distance on the firm pricing strategy. In a second step, I compute the elasticity of prices to distance for each firm an d product couple with a sufficient number of observations. Results suggests that distance have a positive impact on prices which can be seen as a proof of the empirical prevalence of reverse dumping strategies.

4.1 Pooled sample

I start with the basic regression of the logarithm of the price on the logarithm of the distance.

$$log(uv_{fkjt}) = \alpha log(dist_{fj}) + FE_{fkt} + \epsilon_{fkjt} \tag{26}$$

Columns (1) to (3) of Table 3 display results from estimations of the equation (23). Columns (4) to (6) present the results with wealth and size controls. In all the regresions, the estimated elasticity of prices to distance is positive and significant. In column (1), the sample contains all destination markets of French exporters. The estimated elasticity is 0.03. If the distance doubles, the exporters, on average, will increase its fob price of 3%. Focusing on the OECD sample (Column 2), one observes that elasticity is in line (and even larger) with the last estimation. The estimated elasticity reaches 0.034. 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 their are not country specific taxes for French goods. The elasticity is 0.12. If the distance double, exporters, on average, will increase their fob price of 1.2%.

These first results suggest that French exporters adopt a reverse dumping pricing policy.

Table 3: Prices and distance at the firm level

Dependent variable			Price (log)			
	(1)	(2)	(3)	(4)	(5)	(6)
Distance (log)	0.030^a	0.034^a	0.012^a	0.037^a	0.040^a	0.026^a
	(113.62)	(97.13)	(20.10)	(126.25)	(113.25)	(33.44)
GDP (log)				-0.004^a	-0.003^a	-0.003^a
				(-24.37)	(-17.19)	(-10.92)
GDPc (log)				0.017^a	0.047^a	0.034^a
				(65.07)	(90.18)	(31.41)
Constant	2.666^a	2.617^a	2.638^a	2.474^a	2.123^a	2.224^a
	(1347.63)	(1081.78)	(634.15)	(683.85)	(349.80)	(155.07)
Fixed effects			Firm × Product × Year			
Sample:	all	OECD	Eurozone	all	OECD	Eurozone
Observations	14639227	10554957	6795574	14196464	10554957	6795574
R^2	0.003	0.003	0.000	0.003	0.005	0.000
rho	0.936	0.945	0.951	0.937	0.945	0.951

Clustered *t* statistics in parentheses

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Nevertheless, these results might be the consequence of an omitted variable biais. Actually, the quasi linear demand models states that prices depend on global market characteristics. Since the markets characteristics could be correlated with distance from France (France is close to the easy markets for instance) I have to control for market characteristics introducing measurements of both the size (GDP) and the wealth (GDP per capita) of the destination countries. The results are presented in Table 3, columns (4) to (6). One can see that the size of the country has a negative impact on prices whereas wealth has a positive impact. The distance impact is positive, significant and even higher than without controls. This is particularly true for eurozone, where the distance elasticity is more than doubled (column (3) vs column (6)). These results suggest that on average firms set a low price toward easy markets (high GDP, low distance) but a high price toward rich (high GDPc) markets.

The GDP and the GDP per capita are two raw measurements of market specificities. I thus add the average unit value in destination market, by product (6 digit).[14] The average unit value allows to take into account the competition on the market and its remoteness. Note that the average unit value does not measure the remoteness from France but the remoteness from the entire world. It might be the case distance is positively linked with the price only because French firm set high prices toward remote-from-the-world markets and that these markets are also remote from France. If that is true, thus the average unit value should have a positive impact and the distance should be negative (as in the quasi linear demand models of Ottaviano Tabuchhi and Thisse). The results are proposed in Table 4. Columns (1) and (2) are a benchmark. They allow to show that this sample is really close from the one used above.[15] Columns (4) to (6) offer the same result: as expected the mean unit value coefficient is positive, but even with this control, the distance coefficient remains positive and significant.

I run regressions including the number of firms to take into account the possible correlation between the number of French firms on the market and the price they set. Results are presented in Table 5. As expected the higher is the number of firms on the market, the lower is the price. However this effect is weak and do not change the predictions about the distance. This comfort the basic predictions. Table 6 depicts the results when adding a squared term to test the non linearity. Columns (1) to (3) presents the regressions with only wealth and size control. The coefficient on distance is negative and the coefficient on the squared term is positive. This suggests a U-shape relation between price and distance. The reversal point is give line $(\partial ln(p)/\partial ln(dist) = 0)$. For the Euro sample the reversal point is 70 km. Since no one country is that close from France, this means that the price increases more than proportionally with distance. For the all sample and the OECD sample, the reversal point is higher suggesting that firms decrease and then increase their prices with the distance. Nevertheless, this reversal point is really sensitive to the control variables (columns (4) to ((6)). For Euro countries the add of contiguity control reverse the price and distance relation. On the interval of distance of euro countries, price still increase with distance but less than proportionally. Thus the introduction of a squared term by forcing the form of the non linearity, lead to not highly robust results.[16] Table 7 presents regressions on dummies for intervals of distance (equation 25). Since the dummies are collinear with the constant, I suppress one dummy. For the reasons mentioned formerly, I add a firm, product and time specific fixed effect. The results, presented in Table 7, have to be read in the following way: the constant provides the average price and the dummies give the gap to the average price in the different interval of distance. I run the regression on the three subsamples formerly detailed. For the whole sample, I observe that the average price is 2.88 (first column, line Constant), that the price is the first interval is lower than the average; whereas between 3,000 and 6,000 km, the price is higher than the average, and still higher for the highest distance. To sum, the average price fixed by a firm increases with the distance.[17] These positive relation

[14] In linear demand models, the average price is a structural determinant of the price set by the firm.

[15] As described in Section 3, data constrains me to provide results for OECD countries only and over the period 1995-2004 when I control for the mean unit value.

[16] The introduction of a cubic term does not contribute to the robustness of the results.

[17] These results are not sensitive to the choice of the interval.

Table 4: Prices and distance, controlling for the average price on the market

Dependent variable	Price (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
Distance (log)	0.035[a]	0.013[a]	0.035[a]	0.013[a]	0.041[a]	0.026[a]
	(91.91)	(18.17)	(91.35)	(18.61)	(104.42)	(28.69)
Mean unit value (log)			0.015[a]	0.005[a]	0.011[a]	0.004[a]
			(38.90)	(9.03)	(28.56)	(8.61)
GDP (log)					-0.003[a]	-0.002[a]
					(-14.86)	(-7.81)
GDPc (log)					0.043[a]	0.029[a]
					(75.84)	(24.19)
Constant	2.548[a]	2.597[a]	2.509[a]	2.583[a]	2.681[a]	2.636[a]
	(944.75)	(549.15)	(863.33)	(521.78)	(611.30)	(397.62)
Fixed effects	Firm × Product × Year					
Sample	OECD	Eurozone	OECD	Eurozone	OECD	Eurozone
Observations	7769845	5108937	7769845	5108937	7769845	5108937
R^2	0.003	0.000	0.003	0.000	0.005	0.000
rho	0.944	0.951	0.943	0.951	0.943	0.951

t statistics in parentheses

[c] p<0.1, [b] p<0.05, [a] p<0.01

period 1995-2004

Table 5: Prices and distance, controlling for GDP and GDP per capita and number of French firm on the market.

Dependent variable	Price (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
Distance (log)	0.035^a	0.038^a	0.024^a	0.035^a	0.038^a	0.024^a
	(115.27)	(101.19)	(28.15)	(115.27)	(101.19)	(28.15)
Number of French firms.	-0.000^a	-0.000^a	-0.000^a	-0.000^a	-0.000^a	-0.000^a
	(-29.05)	(-25.60)	(-5.25)	(-29.05)	(-25.60)	(-5.25)
GDP (log)	-0.003^a	-0.002^a	-0.002^a	-0.003^a	-0.002^a	-0.002^a
	(-17.29)	(-9.71)	(-9.84)	(-17.29)	(-9.71)	(-9.84)
GDPc (log)	0.017^a	0.046^a	0.033^a	0.017^a	0.046^a	0.033^a
	(64.23)	(88.97)	(29.43)	(64.23)	(88.97)	(29.43)
Constant	2.493^a	2.145^a	2.249^a	2.493^a	2.145^a	2.249^a
	(679.93)	(348.58)	(147.64)	(679.93)	(348.58)	(147.64)
Fixed effects	Firm × Product × Year					
Sample:	all	OECD	Eurozone	all	OECD	Eurozone
Observations	14196464	10554957	6795574	14196464	10554957	6795574
R^2	0.003	0.005	0.000	0.003	0.005	0.000
rho	0.937	0.946	0.951	0.937	0.946	0.951

t statistics in parentheses

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

Table 6: Prices distance with non linearity

Dependent variable	Price (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
Distance (log)	-0.153^{a}	-0.205^{a}	-0.051^{b}	-0.082^{a}	-0.077^{a}	0.773^{a}
	(-42.40)	(-45.86)	(-2.51)	(-18.81)	(-12.78)	(16.38)
[Log of distance]^2	0.012^{a}	0.016^{a}	0.006^{a}	0.007^{a}	0.008^{a}	-0.051^{a}
	(51.78)	(53.90)	(3.76)	(26.69)	(19.54)	(-15.58)
GDP (log)	-0.004^{a}	-0.004^{a}	-0.002^{a}	-0.004^{a}	-0.004^{a}	0.013^{a}
	(-29.58)	(-20.97)	(-6.47)	(-23.87)	(-15.44)	(13.13)
GDPc (log)	0.015^{a}	0.037^{a}	0.033^{a}	0.018^{a}	0.036^{a}	0.034^{a}
	(55.62)	(68.31)	(29.74)	(65.11)	(64.71)	(26.83)
1 if euro-country				-0.043^{a}	-0.036^{a}	0.000
				(-83.98)	(-66.82)	.
1 for contiguity				0.018^{a}	0.015^{a}	-0.026^{a}
				(34.11)	(23.85)	(-14.35)
1 if a language				0.005^{a}	0.014^{a}	0.066^{a}
				(7.61)	(15.27)	(18.85)
Constant	3.229^{a}	3.144^{a}	2.495^{a}	2.955^{a}	2.689^{a}	-0.561^{a}
	(222.55)	(163.12)	(34.25)	(166.57)	(106.57)	(-3.24)
$\partial ln(p)\ \partial ln(dist) = 0$ *	587	605	70	350	123	1955
Fixed effects	Firm × Product × Year					
Sample:	All	OECD	Eurozone	All	OECD	Eurozone
Observations	14196464	10554957	6795574	14196464	10554957	6795574
R^2	0.004	0.005	0.000	0.005	0.006	0.001
rho	0.937	0.945	0.951	0.937	0.945	0.951

Clustered *t* statistics in parentheses

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

* distance in kilometers

is verified on the two other subsamples. [18]

Table 7: Prices and distance intervals at the firm level

Dependent variable	Price (log)					
	(1)	(2)	(3)	(4)	(5)	(6)
1< km <1500	-0.020^a	-0.025^a		-0.074^a	-0.023^a	0.000
	(-38.36)	(-40.89)		(-80.34)	(-36.71)	
1500< km <3000			0.020^a	-0.049^a	0.000	0.022^a
			(24.27)	(-51.24)		(25.48)
3000< km <6000	0.033^a					
	(34.93)					
6000< km	0.068^a	0.091^a		0.028^a	0.100^a	
	(86.20)	(79.99)		(30.30)	(81.37)	
GDP (log)				-0.005^a	-0.006^a	-0.001^a
				(-31.25)	(-32.59)	(-5.86)
GDPc (log)				0.018^a	0.034^a	0.017^a
				(69.14)	(68.47)	(19.62)
Constant	2.888^a	2.863^a	2.720^a	2.794^a	2.557^a	2.555^a
	(6294.89)	(5278.90)	(40041.22)	(1192.21)	(529.73)	(296.62)
Fixed effects	Firm × Product × Year					
Sample:	all	OECD	Eurozone	all	OECD	Eurozone
Observations	14645148	10554957	6795574	14196464	10554957	6795574
R^2	0.003	0.004	0.000	0.004	0.005	0.000
rho	0.936	0.945	0.951	0.937	0.945	0.951

Clustered *t* statistics in parentheses

^{c} p<0.1, ^{b} p<0.05, ^{a} p<0.01

The first estimations let us think that French exporters increase their prices with the distance. This result is highly surprising since this policy is not the textbook case of spatial price discrimination. Note that the regressions over a sample restricted to manufacturing goods provides highly similar estimations. I also use the BEC classification to distinguish the effect of distance on prices for intermediate, consumption, capital and primary goods. The coefficients on prices remain positive and significant with similar magnitude whatever the type of good.[19]

4.2 Detailed analysis

In this section, I estimate the elasticities of prices to distance for each firm and product couple. Since I keep only the firms serving at least 15 (or 30) countries, there is a selection bias. Nevertheless, pooled estimations on this sample provides similar coefficients than the entire sample.

[18]Note that, for the OECD and the euro samples, some of the dummies are dropped. For instance, the euro countries are closer from France than 3,000 km. Consequently, the dummies with distance upper than 3,000 are dropped.

[19]Results are available upon request.

To estimate the elasticities for each firm and product, one conserves only the firms serving more than 15 observations. There are 18,649 estimated coefficients for the elasticity of price to distance. 10,523 are positive (56%). A binomial test allows to reject the hypothesis that signs are randomly distributed. This result states that the majority of firms increase their unit values with the distance which suggest that the majority adopt a reverse dumping strategy.

Looking at the share of positive, negative and not significant coefficients, one observes that 20% of the coefficient are positive, 12% are negative and the rest is not significant. Positive coefficients represent 26% of the traded value, negative ones represent 13% and non significant coefficients represent 60%.

I then run regressions by firm and product controlling for GDP and GDP per capita. I restrict the sample to the exporters serving at least 30 countries. There are 3,670 distinct firm product couples. Therefore, there are 3,670 estimated elasticities of price to distance which 2,085 are positive. A binomial test allows to conclude that the probability to be positive is significantly greater than one half.

4.3 Discussion

Results presented above sound as a clear evidence of reverse dumping. This means that French exporters seem to add phantom freight costs when the distance increases. Although the positive link between fob prices and distance appears in a CES model with additive trade costs, this result goes against the main models used in international trade. Namely, models with quasi linear demand predict dumping whereas model with CES utility function and iceberg trade costs predict mill pricing. Moreover, as explained in the theoretical part, a model with pure iceberg trade costs does not seem to be able to reproduce this positive relation under reasonable assumptions. In a nutshell this result has three consequences. First, it shows the limit of the existing models in their predictions about prices. Second, it questions the use of the iceberg trade cost when studying the relation between prices or unit values and distance. Third, it suggests that the introduction of an additive component in the transport costs helps to obtain more realistic predictions.

However, since the regressions use unit values instead of prices, the results might be interpreted as an evidence in favor of quality differentials. I discuss this eventuality in the next section.

5 Alternative explanations

The main empirical result of this paper, is that unit values set by French exporters increase with the distance. The last part intended to show the robustness of this result. This section considers this result as given. Two alternative explanations to spatial price discrimination are now considered, namely spatial quality discrimination and the Alchian Allen effect. In a first step I described theoretically the two mechanism. Then, I discuss their convenience to explain the data.

5.1 Spatial quality discrimination

This section studies the possible case of spatial quality discrimination, and the impact of the transport cost formulation on it. Spatial price discrimination refers to the behavior of firms choosing a distinct quality for each markets.

Existing models assumes either iceberg trade costs or no trade costs at all. It is quite complicated to introduce an additive part in such model. Therefore I decide to specify the form of the utility function, the form of the fixed cost and the form of the marginal cost. The two costs are suppose to depend on the quality (hereafter λ). In fact, the framework is really close to Hallak and Sivadasan (2008) but with a mixed trade cost instead of an iceberg one.[20]

[20] In the Verhoogen (2008) model, there is not transport cost. Adding an iceberg one leads to a similar conclusion: higher trade costs decrease the quality offered by the firm.

The conclusions of this section are the following. In the Hallak and Sivadasan (2008) model, at the firm level, quality decreases with the transport costs. The use of an additive part in the transport costs allows to get a positive relationship between the quality (and the price) of the good and the distance. Nevertheless, there is not closed form solution in this case.

5.1.1 CES, monopolistic competition and endogenous choice of quality

The utility function is a CES augmented to take into account the quality. The demand in country j for a given variety with quality λ is:

$$q_j = p_j^{-\sigma} \lambda_j^{\sigma-1} \frac{E}{P} \tag{27}$$

where p_j is the cif price in the market j, σ is the elasticity of substitution (greater than one), λ 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 : $p_{cif} = \tau p_{fob} + f$ where τ and f have the properties described previously.

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

$$\pi_j = \left(p_j^{fob}(\lambda) - c(\lambda) \right) x_j(p, \lambda) - F(\lambda) \tag{28}$$

For technical convenience, I specify both the form of the marginal and the fixed costs. The marginal cost is given by $c(\lambda) = w\lambda^{\beta}$ where β 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:

$$p_{fob} = \frac{1}{\sigma-1}\frac{f}{\tau} + \frac{\sigma}{\sigma-1} c(\lambda) \tag{29}$$

Using expression (29), the first order condition with respect to λ leads to the following expression:

$$H(\lambda, \tau, f) = \left(\frac{\sigma}{\sigma-1} \right)^{-\sigma} \frac{E}{P} \tau^{-\sigma} \left[\lambda^{\sigma-2} \left(\frac{f}{\tau} + w\lambda^{\beta} \right)^{-\sigma} \left(\frac{f}{\tau} + w\lambda^{\beta}(1-\beta) \right) \right] - g\alpha\lambda^{\alpha-\sigma+1} = 0 \tag{30}$$

The expression $H(\lambda, \tau, f) = 0$ do not have close form solution excepted if one sets $f = 0$. In that case, appears the Hallak and Sivadasan (2008) solution for λ:

$$\begin{aligned} & H(\lambda, \tau, 0) = 0 \\ \Leftrightarrow & \lambda = \left[\tau^{-\sigma} \left(\frac{\sigma-1}{\sigma} \right) \frac{E}{P} \frac{(1-\beta)}{\alpha} \frac{1}{wg} \right]^{\alpha'} \end{aligned} \tag{31}$$

where $\alpha' = \alpha - (\sigma-1)(1-\beta)$ and $\alpha' > 0$. Visual inspection shows that the quality decreases with the iceberg trade cost. If $f = 0$ the price is a constant markup over the marginal cost. Since the marginal cost is an increasing function of λ, then the price decreases with the distance as far as the quality decreases.

Does the additive part of the transportation cost change the sign of this relation? There is not close form solution for λ in that case. Nevertheless one can discuss what happens when τ increases (keeping

f constant) and when f increases (keeping τ constant). This discussion is done around the solutions of the equation.

Since $H(0, \tau, f)$ is positive and $H(\lambda, \tau, f)$ tends to negative infinity when λ tends to positive infinity, then it exists at least one λ such as $H(\lambda, f, \tau) = 0$. In that case, assuming f and τ independent, one has:

$$\frac{\partial H(\lambda, \tau, f)}{\partial \tau} + \frac{\partial H(\lambda, \tau, f)}{\partial \lambda}\frac{\partial \lambda}{\partial \tau} = 0 \tag{32}$$

and

$$\frac{\partial H(\lambda, \tau, f)}{\partial f} + \frac{\partial H(\lambda, \tau, f)}{\partial \lambda}\frac{\partial \lambda}{\partial f} = 0 \tag{33}$$

knowing the signs of $\frac{\partial H(\lambda,\theta)}{\partial \theta}$ and $\frac{\partial H(\lambda,\tau,f)}{\partial \lambda}$, it is easy to find the signs of $\frac{\partial \lambda}{\partial f}$ and $\frac{\partial \lambda}{\partial \tau}$.

Since λ is positive, $H(0, \tau, f)$, is positive and $H()$ reaches a limit in negative infinity, then $\frac{\partial H(\lambda,\tau,f)}{\partial \lambda}$ is on average negative.[21] In appendix, I compute the sign of $\frac{\partial \lambda}{\partial \tau}$ which turns out to be negative and the sign of $\frac{\partial \lambda}{\partial f}$ which turns out to be positive. Consequently, for a given, f, an increase in τ reduces the quality whereas, given τ an increase in f increases the quality. In a nutshell, the price (and the quality) increases when the additive trade cost increases whereas it decreases when iceberg transport costs increases.

5.2 the Alchian Allen effect

The Hummels and Klenow (2002) story can be an alternative explanation to spatial price discrimination and spatial quality discrimination. Their paper models the Alchian Allen effect at the product level but the model would remain valid at the firm and product level. In words, the model would be the following. Each firm can produce two (or more than two) qualities for a given good. With additive trade cost, the relative price of the high quality (more expensive) version of the good decreases with the distance. Consequently, the firm faces a higher demand for the high quality version of its good. At the firm and product level, the share of good of the high quality version increases with the distance. Thus, the average price of the good increases with the distance. The empirical positive relationship between prices and distance at the firm and product level would be the expression of a "quality" discrimination of French exporters.

5.3 Price or quality policy ?

Which explanation is the more sensible to explain the positive relationship between price and distance? The previous mechanism, introducing quality, assumes that what I measure in the data is not the price of a identical good but the (average) price of goods sharing different qualities. This first assumption might be partially amended because of the level of disaggregation of the data as detailed in Section 3.

The last argument is partial and technical. There is a second point, more robust which helps to convince that unit values changes reflect price changes more than quality differentials. The point is that the elasticity of price to distance measured in the data at the firm level is too weak to be interpreted as a quality discrimination.

In fact, Hummels and Skiba use the reverse argument in their working paper. They show that given the elasticity of substitution between goods and the elasticity of transport cost to distance, then, the elasticity of price to distance in the case of price discrimination should be about 0.007. This result is far from the elasticity they estimate (their coefficients lye between 0.7 and 1.4). Their estimation is done using product level data, not firm level data. Here, I find elasticities lying between 0.012 and 0.041. which is more in line with the expectation for price discrimination.

[21] In fact, $\frac{\partial H(\lambda,\tau,f)}{\partial \lambda}$ is always negative. A formal proof is developed in appendix.

Last, looking at the relation between prices and distance for each firm, one observes that this relation is indeed positive on average, but can be negative for a significant number of firms. This remains true within industries. Models with an Alchian Allen effect cannot predict a negative relationship between prices and distance.

In a nutshell Two (possibly complementary) phenomena can explain the positive relationship between prices and distance at the firm level. First, firms might adopt a reverse dumping strategy when setting their prices. Second if it exists a heterogeneity in terms of quality within firms, then, the increase in unit values might be a composition effect: the share of high quality (more expensive) goods increases with the distance which increases the observed unit value.

In the first case, reverse dumping appears under reasonable conditions only if trade costs have an additive part. In the second case, quality increases with the distance if there is an additive part in the trade cost. Therefore, the two explanations have a common determinant: the presence of an additive component, moving with the distance, in the transport cost. In other words, pure iceberg trade costs are not convenient to model these facts.

6 Concluding remarks

This paper focuses on the impact of distance on the pricing policy of French exporters. The theoretical part of this paper intends to point out the importance of the form of the trade costs on the pricing policy adopted by the firms. The empirical part shows that French firms adopt a reverse dumping strategy. In other word, firms increases their fob price with the distance. Robustness checks confirm this result. Nonetheless prices are approximated by unit values, thus, quality might play a role in this relation. Further research should verified this positive relation using another sample and trying to fully disentangle price and quality policies. Anyway, the main models of international trade failed to reproduce the positive relationship between trade and unit values at the firm and product level, even when introducing quality. The use of an additive part in the transport cost seems necessary to obtain such predictions. It would be interesting to have a new formulation, more tractable than the additive trade cost (or the mixed trade cost using in this paper) but also more realistic than the iceberg ones.

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