Trade and Transport modes, a differentiated impact of distance.

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Introduction

In the last decades, international trade has undergone a significant number of major changes: tariff barriers were reduced through the WTO negotiations and new technologies were developed in the sector of transport, increasing at the same time the speed of delivery and the capacity of transportation. Finally, costs of communication have deeply decreased, during this period.

These evolutions were expected to increase the integration of world trade. According to Guillaumont, Brun, et De Melo (1998), this higher integration should have resulted in a significant decrease of the impact of distance on trade; from then on value exchanged depends mainly on specific characteristics of countries and no more on the distance separating these countries. Nevertheless, they find that distance still have a considerable impact on trade.

Recently, literature has taken high interest in the impact of distance on world trade, and it has widely shown that distance remains an important determinant of the exchanged value between two countries. Numerous papers point this impact out, and calculate a strong negative elasticity of distance on trade. Disdier et Head (2008) performed a meta-analysis on elasticities calculated in more than 100 papers, and they obtain an average value for the elasticity of distance on trade equal to -0.9 showing that distance still plays a major role.

Most of the time, these authors calculate their estimates only on positive values of trade, which means they do not take into account the fact that some pairs of country are not exchanging. In their study (Helpman, Melitz, et Rubinstein 2007) underline that not taking into account non-trade may bias estimates, they develop a model predicting positive or zero trade flows between two countries.

Moreover, trade is often taken on its whole, but to export a good to a destination country, several types of transport modes are available. Each transport mode has its specific characteristics: they do not have the same speed, the same capacity, and above all, they don’t face the same costs. Thus, we can think that trade resistances, especially distance, won’t act the same according to the transport mode. However, the distinction between a transport mode and another is not always drawn, which is frequently due to the lack of data on transport. In this study, we calculate the elasticity of distance on trade according to transport modes, and we look if these coefficients are statistically different.

The main contribution of this paper doesn’t lie only in the question that is asked: what the impact of distance (presented here as a proxy of transport costs) on trade? But more in the way that we deal with it, first we disaggregated the more possible our dataset, in studying export of products at a 8 digit level and in taking into account the transport mode used. Then, we add in our dataset zero value of trade, because not considering this could bias our estimates. We perform our estimation on the French export of agricultural and food processed product for the year 2003.

The remain of the paper is organized as follows, in the next section we present the theoretical model on which our empirical application will be applied, then we describe the data and the econometrical method used; and finally we present the results of the estimation.

Theoretical specification

To estimate the highness of the impact of distance as a trade barrier we use a gravity equation. Despite its high success and the high significance of results obtained, the gravity equation had originally no theoretical foundation; so that numerous authors have taken interest in this issue. Among others, Anderson and Van Wincoop have produced several papers on this question [Anderson (1979); Anderson et Wincoop (2001); Anderson et Wincoop (2004)] and we will use their approach to define our theoretical specification. Their model is based on constant elasticity of substitution preferences and it assumes that goods follow the Armington assumption: they are differentiated by country of origin. Moreover, trade separability is taken as a hypothesis, which implies that production and consumption of a product k are considered as fixed.

For the construction of our model, we place our study on the world market of a given product k, with index i standing for the exporting country and index j for the importing country. The utility function of importing country j for product k is given by:

$$U_j^k = \left[\sum_i b_i^{k\,\frac{1-\sigma_k}{\sigma_k}} c_{ij}^{k\,\frac{\sigma_k - 1}{\sigma_k}} \right]^{\frac{\sigma_k}{\sigma_k - 1}}$$

Where b_i^k is a positive distribution parameter, c_{ij}^k the quantity of good k coming from country i and consumed in country j and σ_k the elasticity of substitution between goods.

After maximizing U_j^k subject to budget constraint and using the market clearance (calculations are available in the Annex A), we finally obtain the value of exports of product k from country i to country j, given by the following equation:

$$X_{ij}^k = \frac{Y_i^k E_j^k}{Y_w^k} \left(\frac{\tau_{ij}^k}{P_j^k R_i^k} \right)^{1-\sigma_k}$$

With: Y_i^k the total value of export of product k from country i; E_j^k total expenditure of country j for the import of product k from all countries. Y_w^k: the world total export of product k. The ratio $\frac{E_j^k}{Y_w^k}$ represents the market share of the country j for the import of product k, from now on it will be denoted θ_j^k. P_{jk} is the CES price index of the importing country, and R_{ik} a resistance factor for the export from i.

τ_{ij}^k represents trade costs between i and j for product k. Trade costs gather all costs faced by an exporter in addition to production costs that are needed to reach a final consumer. It includes transport costs, information costs, tariffs and other barriers to trade. Following Peridy (2005) and Emlinger, Jacquet, et Lozza (2008), we define trade costs as a decomposition of various variables. It is written:

$$\tau_{ij}^k = d_{ij}^{\alpha} t_{ij}^{k\,\beta} O_{ij}^{k\,\gamma} e^{\delta B_{ij}}$$

Distance, d_{ij}, is used as a proxy of transport costs,

t_{ij}^{k} is tariff applied for the import of product k from country i in country j. In the econometrical model, we will use a dummy variable to describe custom duties according to the region to which the considered importing country belongs (3 custom regions will be defined: European Union countries and the members of the European free trade agreement, other European countries and Southern and Eastern Mediterranean countries);

O_{ij}^{k} is the costs that are not observed, in our study this variable will be replaced by a product fixed effect, at a two-digit level;

B_{ij} is a dummy variable indicating if both countries are sharing a common border.

This is important to underline that the equilibrium obtained is a conditional general equilibrium (indeed offer and demand are considered as exogenous). Implying that, comparative static analysis can't be performed.

Taking the natural logarithm of this equation we obtain:

$$\ln X_{ij}^{k} = \ln Y_{i}^{k} + \ln \theta_{j}^{k} + (1-\sigma)\ln\left(\tau_{ij}^{k}\right)$$

$$\ln X_{ij}^{k} = \ln Y_{i}^{k} + \ln \theta_{j}^{k} + (1-\sigma)\ln(\alpha \ln\left(d_{ij}\right) + \gamma t_{ij}^{k} + \delta O_{ij}^{k} + \varepsilon B_{ij}$$

For detailed calculation, please refer to annex A.

Data and econometrical specification.

Data

The main database in this paper has been provided by the French Custom services. It describes the volume and value of French exports of agricultural and food processed products, which are described at an 8-digit level, the destination country and the transport mode used (maritime, rail, road, air or inland water) for the period 1995-2007.

Other bases are used to add other variables we need. *Distance* and *BACI*, two bases constructed by the CEPII (a French research centre in international economics), are merged with our initial database. The first one gives a weighted distance between countries, it is calculated as an average geodesic distance between the biggest cities of both countries; this distance is weighted by the share of the population of these cities in the total population of the country. The second one gathers all the data of international trade for all countries. The CEPII worked on a harmonization procedure in order to have the most complete database on world trade possible. The level of disaggregation of products is 6 digit, this last base allows us to construct the variable *market share*, θ_{j}^{k}.

However as it has been said above, our base only contains positive values. We only have an observation when France does export a product to a country by a given transport mode. Nevertheless, the non-export may contain information, it may result from high barriers to exchange, put these “zeros” observations aside may bias our estimates, because we would ignore a part of the information.

Consequently, we decide to modify our data to include the non-export observations. We add lines in order to have an observation for each combination {destination country, transport mode, product}. When a line of this new base doesn’t match with any real export, it takes the value of 0. So our new database is composed of (number of transport modes)*(number of destination countries)*(number of exported products) lines. Yet we must be aware that all the “zeros” observations do not have the same meaning, and don’t contain the same kind of information. They cannot all be taken into consideration in our study and have the same interpretation. These zeros need to be carefully sorted. Indeed several types of zero are present in the base:

1. Not all modes of transport are available for every destination. For example, it is impossible to export from France to the USA by road. This type of zero results from a structural impossibility. They are excluded from our database.
2. The demand of a country for a given product is null. This country won’t import this product from any country in the world. This can explain the [presence/existence] of some “zeros”. These zeros are not relevant for our study; they must be excluded from our base. A sorting out is undertaken thanks to the BACI database described previously.
3. In certain cases, even if the demand for a given product is positive for a country, France has no export for this product to this country at all.
4. France actually exports a product k to a country j but not all available transport modes are used for the delivery. The use of this transport mode is too constraining on this route and it will not be used.

Only the two last types of zeros are kept, because they can be explained by the explicative variables of our model. The other types of zeros are deleted, they result from structural impossibility.

The diagram below summarizes all the cases described before. The numbers are the same as before.

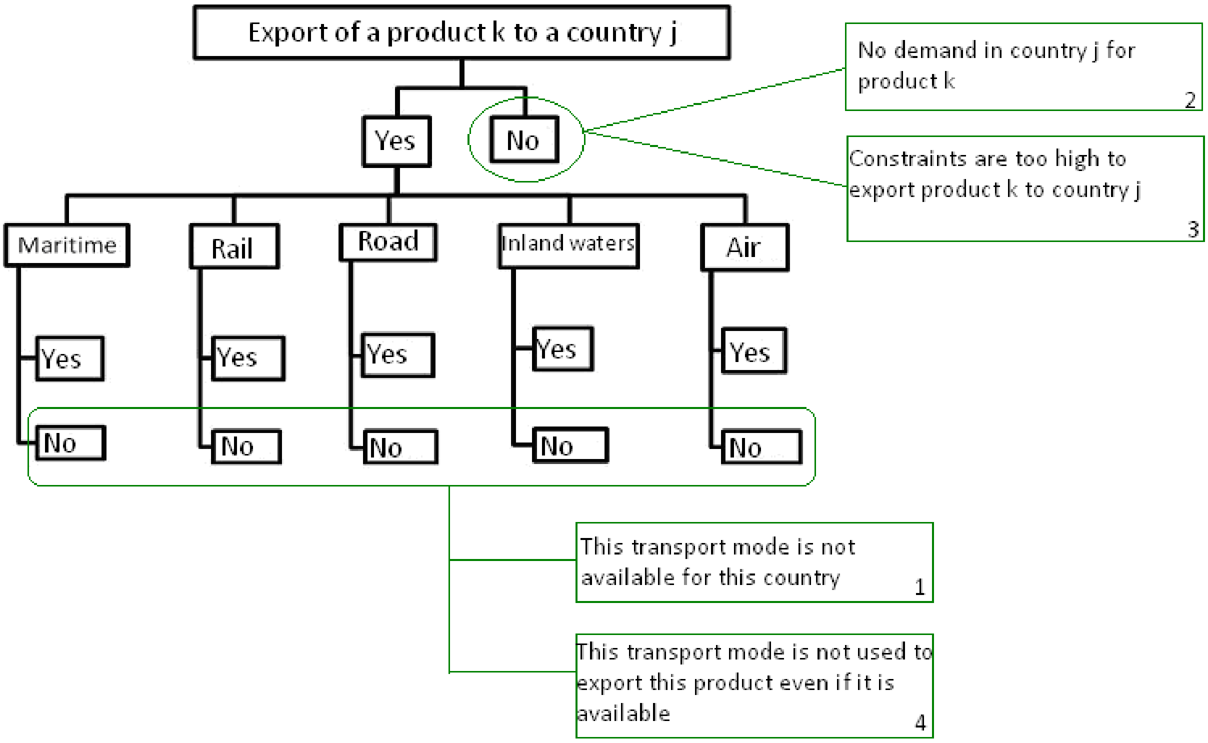

Figure 1: The different types of zeros

Henceforth one of the main objective of this study is to try to take into account the information contained in « zeros » observations the most accurately possible in international trade. And we must use an appropriate econometrical method.

Double stage model

As we stressed previously, it is of high importance to be aware that our base is composed with several types of zeros (due to the presence of transport modes) which should not be considered equally. These zeros contain specific information. Thus, we have to use a specific method in our study that can take into account that difference. One of the most common methods used for estimating equations when the dependant variable takes zero values is the one developed by James Tobin (Tobin 1958), the Tobit model. But in our case we cannot use this method, because it doesn't distinguish the different types of zeros, when we have in our base two types of zeros with distinct information.

The first type of zero accounts for the constraints applying at the entry of France on a given market. The second type of zero is used to explain the value of exchange with each transport mode. These two steps are not explained by the same sets of variables and thus need to be separated.

We decide to use a method with two steps, a first step called the participation equation and a second step explaining the value exported by each transport mode, the gravity equation will be used for this second part of the estimation.

Participation equation:

The participation equation is the first step of our estimation, we look whether a country i exports a product k to a country j or not. The estimated equation is:

$$w_{ij}^k = \alpha z_{ij}^k + \eta_{ij}^k \qquad \eta_{ij}^k \sim N(0,1)$$

$$d = \begin{cases} 1 & \text{if} \quad w > 0 \\ 0 & \text{otherwise} \end{cases}$$

With z_{ij}^k a set of explaining variables. i does export to country j a product k when d=1. We perform a probit model to calculate the estimates of this equation, with d the explained variable and w_{ij} the latent variable.

Gravity equation

Then, when d=1, we estimate the value of export from France through the gravity equation, which estimates the value of export of a product k by a given transport mode to a country j. The observed dependent variable noted $y_{ijm}^k$and a latent variable $y_{ijm}^{k\;*}$ is defined. This equation is similar to a Tobit estimation:

$$y_{ijm}^k = \begin{cases} y_{ijm}^{k\;*} & \text{if} \quad y_{ijm}^{k\;*} > 0 \quad \& \quad w > 0 \\ 0 & \text{otherwise} \end{cases}$$

with a latent variable $y_{ijm}^{k\;*} = x_{ijm}^k \beta + \upsilon_{ijm}^k \qquad \upsilon_{ijm}^k \sim N(0, \sigma^2)$

This approach is a reasoning in two steps, we first determine the probability to participate in the market. Once this hurdle passed, we look at the value of export for each transport mode with the Tobit procedure. The model is then estimated by using maximum likelihood estimation.

Empirical application

We estimate our model on the French exports of agricultural and food processed products for the year 2003. The partner countries included in our study are European countries and Southern and Eastern Mediterranean countries, which together represents 80% in value of French exports of agricultural and food products.

Variables and expected signs

As explained above we perform a two-stage estimation, the variables playing in each of these stages are different.

Participation equation:

For the participation equation, we assume that the probability of exporting a product to a given country depends on the strength resistance. This trade resistance is given by the trade costs, if they are too high no export will be observed to this destination country for this product. Besides the variables contained in trade costs we add two other dummy variables: landlocked, which indicates that this country has no sea coast, maritime transport for this country is impossible; Island, which indicates on the contrary that this country is inaccessible by road. These two variables are of high importance, because the lack of a given transport mode could be a constraint that would make the export of a given product impossible. The equation estimated in the first stage is:

$$w_{jk} = \alpha_1 \ln \tau_{ij}^k + \alpha_2 landlocked + \alpha_3 island + \eta_{jk} \qquad \eta_{jk} \sim N(0,1)$$

The study of the literature on determinants of international trade, allow us to have an idea of the sign the coefficients applied to the explaining variables will have.

The expected sign for the elasticity of *distance* is negative, indeed the further a country is, the smaller the probability to export to this country a given product is. We expect a negative sign for the variables *landlocked* and island because it adds an additional constraint on transport mode. For the dummy variable *tariff* we expect a negative impact for the country outside the European Union. Finally we anticipate a positive impact of the variable *border*, because the intensity of exchanges with neighbours is higher.

Gravity equation:

We now take interest in the gravity equation of the second stage, whose specification was described above. The dependant variable of the model is the value of French export of a product k to a specified destination by a given transport. Some of the variables enhance trade, when others acting as brakes on exchanges. The market share, θ_j^k, of the importing country and the production of the exporting country, Y_i^k, are expected to have a positive impact on trade between both countries, indeed, the higher the demand (conversely the offer) of a country for a product is, the more this product will be exchanged. We foresee the same effect as described before for the dummy variables: *border* and *tariff*.

Concerning the *distance* it is difficult to have an accurate expectation, because the impact of distance/trade costs is really hard to grasp.

- First of all we are not sure that the impact of *transport costs* is linear, for example maritime transport faces very high fixed costs due by instance to the cost of loading, and variable costs are much smaller, which means that the cost of transport by kilometre will be higher for short distances than for long distances. That lets us think that the impact of distance on trade costs is not necessarily linear, thus we use for our estimation squared distance

- Then characteristics of products play a major role to determine the level of trade costs , Emlinger, Jacquet and Chevassus-Lozza (2008) proved that the impact of transport costs was not the same according to the perishability of product, a highly perishable product will be more expensive to transport, and they calculate a stronger impact of distance for perishable goods. To take into account the importance of product characteristics on transport costs, we construct four groups of products according to their unit value (calculated as the ratio value/volume), with the first group containing the less valuable products and the fourth, the goods with the highest unit values. Four interaction variables $distance\_UVI$ (UVI denoting the four unit value groups) are constructed.

Estimation

Given the issues raised in the previous sections, the two equations we are going to estimate take the following form:

- The participation equation:

$$w_{jk} = \alpha_1 \ln \tau_{ij}^k + \alpha_2 landlocked + \alpha_3 island + \eta_{jk} \qquad \eta_{jk} \sim N(0,1)$$

- The gravity equation

$$\ln X_{ij}^k = \varphi \ln Y_i^k + \rho \ln \theta_j^k + (1-\sigma)\left(\sum \alpha^{UVI} UVI \ln(d_{ij})^2 + \gamma t_{ij}^k + \delta O_{ij}^k + \varepsilon B_{ij}\right) + \upsilon_{ijm}^k$$

Nevertheless, we must bear in mind that in presence of heteroskedasticity or if the error terms are non-normal, our estimates will be inconsistent. To take into account heteroskedasticity, the variance of the error terms is assumed to take the following functional form:

$$\sigma = \exp(uh)$$

With u, a set of variables coming from x_{ijm}^k.

Estimation methodology:

The likelihood function of our model can be written as follow:

$$L = \prod_0 \left(\Phi(-\alpha z)^{1-d} \Phi(\alpha z) \Phi\left(-\frac{\beta x}{\sigma}\right)^d \right) \prod_+ \left(\frac{1}{\sigma} \Phi(\alpha z) \varphi\left(\frac{y-\beta x}{\sigma}\right) \right)$$

With Φ standing for the normal cumulative distribution function and φ the normal probability distribution function. The index "0" is used when the value of exports is null and the index "+" when the value of export is positive. Taking the natural logarithm of this likelihood function gives:

$$l = \sum_0 ln\left[(1-d)\Phi(-\alpha z) + d\Phi(\alpha z)\Phi\left(-\frac{\beta x}{\sigma}\right)\right] + \sum_+ \left[ln\big(\Phi(\alpha z)\big) + ln\left(\frac{1}{\sigma}\varphi\left(\frac{y-\beta x}{\sigma}\right)\right)\right]$$

The coefficients calculated through the maximization of this likelihood function cannot be interpreted as elasticities a transformation has to be done. Following Hurlin (2003) and Bierens (2004), elasticities of trade to transport costs can be calculated with the formula:

$$\varepsilon = (\beta_{ld} + 2.\beta_{ld^2}.ld)\left[1 - \frac{\varphi\left(\frac{x_i\beta}{\sigma}\right)}{\Phi\left(\frac{x_i\beta}{\sigma}\right)}\left(\frac{x_i\beta}{\sigma} + \frac{\varphi\left(\frac{x_i\beta}{\sigma}\right)}{\Phi\left(\frac{x_i\beta}{\sigma}\right)}\right)\right]$$

Results:

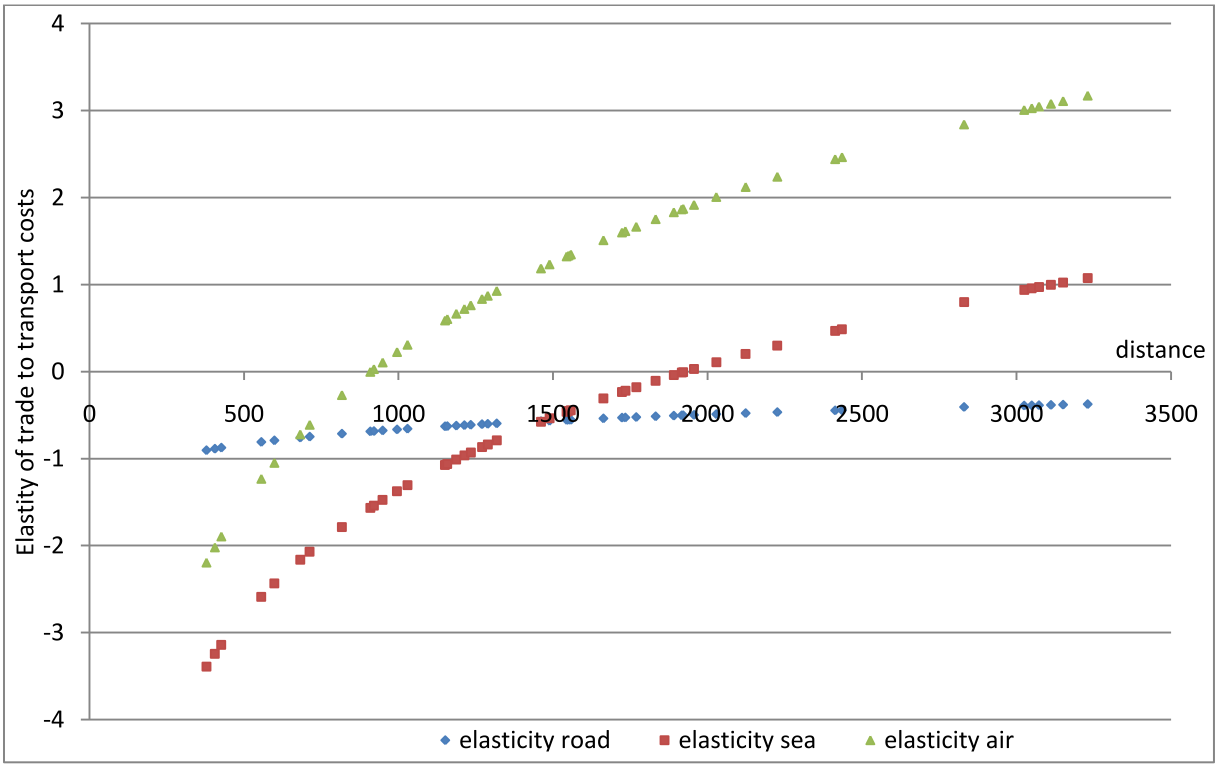

Figure 2 :Calculated elasticities of trade to transport costs

Figure 2 reports the calculated values for the elasticities of trade to transport costs. Each curve represents the elasticity for a given transport mode. Two main observations can be made from this graph. First of all, the elasticity differs widely from a transport mode to another, which means that transport costs won't have the same impact on trade according to the transport mode. Then we can notice that this elasticity is not linear across distance, thus the impact of transport costs will change with the distance.

<u>Maritime transport</u>

Concerning maritime transport, we can see that for short distances the elasticity is highly negative, and then it increases with distance and becomes positive at about two thousand kilometres. In the first part of the curve, transport costs act as a barrier on exports of French products to partner countries. Indeed as Korinek et Sourdin (2010) highlights maritime freight faces high fixed costs. On short distances the ratio of total costs (fixed costs plus variable costs) over distance will be very high, and so it will be very expensive to export to a close country with this mode. Moreover, loading and unloading of ships can be very long and so for export to countries which are near this can be considered as an additional constraint.

Nevertheless maritime transport has low variable costs (fuel for example), thus with an increasing distance, the ratio total costs over distance will decrease, and export by this mode will be smaller and smaller, so that the costs will not be a barrier anymore. That explains the second part of the curve where elasticity of trade to transport costs is positive, the value exported by this transport mode increase.

<u>Air transport:</u>

The shape of the curve of elasticity is the same as the maritime transport one. Air transport faces very high costs; it is very expensive to export by this transport mode. But it presents the major advantage of fast delivery. As Harrigan (2005)showed, consumers are ready to pay more for quickly delivered products. Hummels (2007) underlines that for an expensive product transport costs will represent a small part of the final price, the impact of high transport costs for these products is low. Nevertheless, controls and loading and unloading process takes a long time? So on short distances besides being expensive air transport have not its speed advantage. The impact of transport costs is higher It is not interesting to use this transport mode, but from a given distance, here about one thousand kilometres, the speed of delivery becomes significant and the value of export with the transport mode will increase.

Road transport:

Road transport has numerous advantages, the fixed costs are rather low, and the delivery is relatively quick. This makes that it is the most used transport modes within Europe. But it faces variables costs which increase with distance. As we can see on figure 2., elasticity of trade to transport cost is always negative and almost constant for this mode. The closer a country is, the higher the advantage to export to this country are, then when one wants to export further, transport costs are higher, so transport costs will be a barrier to export, and the total value of export with this mode will decrease with distance.

Conclusion

The impact of transport costs on trade will vary widely depending on the transport considered. This study that the impact of distance on trade is still very strong, and that distance acts as a barrier to trade. Moreover, the impact of distance is very different from a transport mode to another, thus shows that distance cannot be used as a unique proxy of transport costs, when studying exchanges without distinguishing for transport modes. Characteristics of each transport mode must be added to take this differences into account.

The European Union has launched a programme for the promotion of Short Sea Shipping, with among other projects, the development of programme for the promotion of Short Sea Shipping. This programme aims at reducing the road freight traffic which presents numerous drawbacks (lpollution, congestion, noise…). Our study shows that maritime freight has major disadvantages on short distances, and for improve its efficiency on these short distances, the fixed costs must be diminished, that means port efficiency must be improved to promote intermodal transfer in the ports and diminish the time of loading and unloading.

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