Econometric analysis of the paper industry competitiveness: the role of energy costs

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Abstract
The energy issue is considered crucial for the paper industry competitiveness. This study analyses the effect of national differences in energy costs on the international trade of paper products. A gravity model is performed on a dataset of 32 countries for the 1995–2006 period. Energy costs, not only prices, are used. By this way, the impact of energy costs among others competitiveness determinants is isolated. The hypothesis is that higher energy costs reduce export flows. Our main contribution is to measure quantitatively this energy effect across paper producing countries. For this purpose, a new dataset combining energy and economic data on this industry has been developed.

Results indicate that differences in national energy costs per ton of paper produced, either for electricity or fossil fuels, play a significant role on the international trade. Higher energy costs in the exporting country, relatively to the importing country, decrease the level of paper exports. In fact, the study on bilateral flows demonstrates that a rise of 10 % in electricity or in fuels costs ratios between two trading countries, results respectively in a 0.92 % or in a 1.37 % decrease in exports.

Introduction
In Western Europe, many paper mills have closed during the last decade. For instance, in France, about 34 % of active paper mills in 2000 have been shut down in ten years. Paper manufacturers argue that high national energy prices are one of the main reasons for this loss in competitiveness. A report from the Confederation of European Paper Industries claims that energy is a 'deciding factor in European paper industry competitiveness' (CEPI, 2006). Indeed, the paper industry is one of the most energy-intensive industries. For a standard pulp and paper mill in Europe, energy costs stand for about 13 % of total costs per ton of paper produced in 2005. Other competitiveness factors are also important to explain the evolution of national paper industries, such as wages, productivity or raw materials abundance. Consequently, a proper understanding of what is driving the paper manufacturing location is necessary to assess future industrial consequences of increasing energy costs.

This study isolates the impact of differences in energy costs among these determinants on the international trade. The hypothesis is that higher energy costs reduce export flows. Our main contribution is to measure quantitatively this energy effect across paper producing countries. For this purpose, a new dataset combining energy and economic data on this industry has been developed. In this paper, the competitiveness concept is limited to the scope of a national industry. Competitiveness is not analysed in terms of profitability, but only as market shares.

In this aim, an econometric method is performed. This method is based on a panel data set of 32 countries across the world for the time period 1995–2006. This time interval stands for a relatively stable economic period with an increasing level of international trade. A gravity model is used, to identify the effects of energy costs asymmetries on paper bilateral trade flows.

Related literature on paper industry trade and location

Factors affecting paper trade and location of forestry industries have been studied in a limited set of empirical researches. These studies are often focused either on one geographical region or on all forestry products. Paper bilateral trade flows have been mainly analysed through gravity models of international trade. Then, studies analysing location determinants are mostly based on classical trade theory, as the Heckscher-Ohlin model (Bonnefoi and Buongiorno, 1990; Leamer, 1984; Lundmark, 2010; Trefler, 1993), or on concepts introduced by industrial organisation and international trade economics (Bergman and Johansson, 2002; Lundmark, 2001). All studies highlight the effects of input prices (raw materials, labour and energy) and market conditions (market size, agglomeration effects) as determinants of comparative advantages of the forest industry or as location decision factors.

Two papers introduce international gravity models to analyse trade flows in forestry and in pulp and paper products (Kangas et al., 2003; Karikallio et al., 2011). Kangas and Niskanen (2003) have assessed trade patterns in forest products between the European Union and Eastern Europe access countries in order to evaluate the potential effect from EU enlargement on bilateral flows. Trade flows within both regions, econometrically estimated on the basis of countries' income and distance between economic centres, are considered to be 'normal' trade patterns. Consequently, any deviation below these estimated levels reflects potential trade opportunities for concerned countries. Karikallio et al. (2011) examine the degree of competition in the global pulp and paper industry using, amongst others, a gravity model to calculate the price elasticities of the export demand. Their data cover countries across the world from 1997 to 2004, but are restricted to a total of 40 observations only. Export prices data are added to the model so as to explain variations in export demands. The gravity model is consequently specified to control for potential factors affecting demand other than price, and to avoid possible omitted variable bias in estimation (Karikallio et al., 2011).

In our study, energy variables are introduced in the gravity model so as to estimate energy costs effects on the paper industry bilateral trade. Our dataset includes information about prices and consumption in the paper industry for different types of energy. Countries in our sample make up for 94 % of the paper world production and are major trading partners. Consequently, this dataset enables us to assess the role of energy at the international scale for an industry for which competition is increasingly global (Karikallio et al., 2011).

Competitiveness and energy variables description

COMPETITIVENESS VARIABLES

Competitiveness is a difficult notion to define. In this paper, this concept is limited to the scope of a national industry for a specific sector in the short term: the paper industry. The paper industry definition does not include the pulp production, but aggregates all types of paper and paperboard products as defined by the section 48 of the Harmonised System 1996 nomenclature. In addition, competitiveness is not analysed in terms of profitability, but only as market shares. Bilateral flows of paper are used as a proxy for national paper industries competitiveness on the world market. A country with a growing competitive advantage in paper production relative to other trading partners is likely to increase its exports.

ENERGY PRICES AND COSTS IN ECONOMETRIC MODELS

Higher energy prices usually induce the introduction of more energy efficient processes. There is a strong relation between energy prices and consumption. Therefore, higher energy prices would not reflect exactly the cost that paper producers have to pay. As these two variables are linked, it is difficult to analyse separately energy prices and process efficiency with statistical methods. For technical reasons, national paper industries may not react to an increase in energy prices in the same way. A country with old-fashioned processes can easily invest in new machines; however countries with up-to-date technologies would have to innovate in new processes. This mechanism is better studied in bottom-up technical models of energy consumption, as in the PULPSIM model of Szabó et al. (Szabó et al., 2009). Results of this paper can be integrated in such a model, coupling evaluation of the technological potential in each country and energy costs economic impact.

In addition, fuel mixes used for the paper production are very different depending upon the country[1]. Therefore, the price for a specific type of fuel may not have an effect on a national paper industry. The study of energy asymmetries only in terms of energy prices between countries could therefore lead to important estimation biases.

Consequently, energy costs per ton of paper produced are used. These energy costs are further decomposed in one variable for electricity and another one for fossil fuels. These variables have been built by multiplying national data on energy prices[2] and on energy consumption in the paper industry from the Enerdata database (Enerdata, 2010), and by dividing them on the total paper production level in volume[3]. Only the paper production step is evaluated for energy costs estimation, not including the pulp production step as energy use may vary according pulp grades. Estimated energy related elasticities combine the effects of changes in energy prices and in the energy efficiency of processes.

Impact of energy costs on paper products bilateral trade flows

GRAVITY MODEL OVERVIEW

Effects of energy costs on bilateral paper trade flows can be described with a gravity model. Eaton and Kortum (2002) developed a Ricardian model that can identify productivity and domestic costs of production using structural equations for

1. In fact, all paper industries in panel countries use electricity. However, the fuel mix used for heat production varies a lot depending upon the country. Then, if the paper industry of a country does not use a type of fuel, there is no relationship between the price of this type of fuel and the paper industry competitiveness in this country.

2. Energy prices are for the industry.

3. However, national energy consumption data do not distinguish between pulp and paper production. So, energy consumption of pulp processes has been calculated by multiplying pulp production per type of process (refined mechanical pulp, thermo-mechanical pulp and kraft) with standard energy consumption for these processes (Djemaa, 2009; International Energy Agency, 2009). Then, energy consumption for pulp production has been subtracted.

bilateral trade. This model applies to the entire economy or to only one sector, the paper industry in our case. The gravity equation is given a structural interpretation[4], in which market shares are determined by exporter and importer fixed effects and by geographic barriers. Controlling for the typical gravity determinants of trade, a high level of exports from one country reveals either lower costs of production, a better productivity or lower trade barriers. Fixed effects control for national productivity and cost structure. As a consequence, in a standard gravity model including both these fixed effects and explicit energy costs variables, we can quantify how important energy costs are in the production of paper. The level of export is therefore explained by energy costs in addition to national specificities represented by countries' income, geographic barriers and fixed effects (Levchenko & Zhang, 2011).

The following equation is the standard form of the gravity equation. $F_{i,j}$ represents trade flows between countries i and j, Y_i and Y_j the countries' sizes approximated by their GDP, $d_{i,j}$ the distance between them and A, α, β and γ parameters to be estimate:

$$F_{i,j} = A * \frac{Y_i^{\alpha} * Y_j^{\beta}}{d_{i,j}^{\gamma}} \qquad (1)$$

This study is limited to paper products. Pulp is not included. Bilateral trade flows are in value. The gravity model is performed on a data set of 32 developed and emerging countries across the World for the 1995–2006 period.

Standard gravity model variables are used, as countries' income (GDP) and distance between them. The GDP reflects the exporter's supply capacity and the importer's demand. High GDP for both countries are expected to increase bilateral trade between them. In one of the model specification, a GDP per capita variable is added[5]. The distance variable is constructed as the population weighted distance between countries' main cities. In theory, kilometric distance approximates trade costs, so it should reduce bilateral trade. In addition, other dummies, as a common official language, frontier or regional free trade agreement are added so as to reduce model biases.

Exogenous variables for energy costs in trading countries are then added to the standard gravity model equation. As the competitiveness effect of energy costs directly depends on costs asymmetries between two countries, the energy variable is introduced as a ratio of energy costs for the exporting country on these costs for the importing country.

The mean bilateral trade flow of paper products between countries in the study has been about 73 million dollars and has increased by 40 % in constant value between 1995 and 2006 (Table 1). The average economic size, measured in GDP, is equivalent to the size of South Korea or Mexico. Electricity costs have been relatively stable for this period around $\$87_{2005}$ per ton of paper thanks to improvements in electricity use efficiency. Nevertheless, fuels costs have increased by about 45 % around a mean of $\$27_{2005}$ per ton.

ESTIMATION METHODS FOR THE GRAVITY MODEL

In order to find the best estimation method, different models are performed for the gravity equation. Usual methods of panel data estimation, restricted form (ordinary least squares, OLS), fixed (FE) and random (RE) effects for each country-pair, are introduced. These methods differ in their use of individual effects. For all models, fixed time invariants are added. In addition, robust standard errors are used to correct for heteroskedasticity problems. Results of the F-test for fixed effects and of the Breusch and Pagan test for random effects demonstrate that an unrestricted form model is needed (Breusch & Pagan, 1979). The Hausman test was run to check which of the fixed or random effects model is the more efficient (Hausman, 1978). The random-effects model has been rejected by this test in favour of the existence of individual country-pair fixed effects.

In addition, a more developed panel data method adapted to gravity models is added. This method is recommended for trade gravity studies by Fratianni et al. (2010). They suggest, according to best practices issued from recent theoretical and empirical developments, to use a combination of fixed and random effects methods[6]. This method uses country and year fixed effects with country-pair random effects. It gives information on time-invariant variables (i.e. distance) and reduces the number of country-pair dummies necessary in a fixed effects model. Fratianni et al. argue that this specification is the most adapted for gravity models without numerous zero-values. We call it the RE/FE model.

For all models, a log-linearization form of the gravity equation is used. Consequently, the specification of the gravity model is as follows, where Y_i and Y_j are exporter's (i) and importer's (j) GDP, El_i and El_j are electricity costs per ton of paper produced, Co_i and Co_j are combustible costs per ton of paper and $Dl_{i,j}$, $Db_{i,j}$ and $Dr_{i,j}$ are dummies for a common language, border or regional trade agreement:

$$\begin{aligned} ln\, F_{i,j,t} &= \mathrm{A}_{i,j,t} + \alpha_1 * ln\, Y_{i,t} + \alpha_2 * ln\, Y_{j,t} \\ &+ \alpha_3 * ln\, d_{i,j,t} + \alpha_4 * ln\left(\frac{El_{i,t}}{El_{j,t}}\right) + \alpha_5 * ln\left(\frac{Co_{i,t}}{Co_{j,t}}\right) \\ &+ \alpha_6 * Dl_{i,j,t} + \alpha_7 * Db_{i,j,t} + \alpha_8 * Dr_{i,j,t} + \varepsilon_{i,j,t} \qquad (2) \end{aligned}$$

4. The model developed by Eaton and Kortum, follows the framework of a General Equilibrium model incorporating realistic geographic features. It is based on the following assumptions: (i) there is a continuum of good, (ii) countries have a differential access to technology, (iii) the cost of a bundle of inputs is the same across commodities within a country, (iv) there are geographic barriers implemented with a "iceberg" transportation cost assumption, (v) there is a perfect competition, (vi) buyers purchase individual goods in order to maximise a CES objective function, (vi) there is a probabilistic representation of production technologies (Eaton, et al., 2002).

5. However, there is no clear expectation for the sign of the GDP per capita variable. GDP per capita coefficients estimation should be interpreted cautiously in a single commodity gravity model (Kangas, et al., 2003). On the one hand, exporting country's GDP per capita reflects the capital (positive sign) or inversely labour intensity (negative sign) of the industry. On the other hand, a positive importing country's GDP per capita demonstrates that the paper products are luxury products and not necessity products (Bergstrand, 1989; Deardoff, 1982).

6. A second method is also recommended by Fratianni et al. (2010), the Poisson pseudo-maximum likelihood (PPML) estimator. This estimation strategy has been developed by Santos Silva and Tenreyro (2006; 2011). This method is more adapted in the presence of numerous zero-values in trade. As the gravity equation is under a log-linear form, zero-values are undefined and so not used. If these observations are removed, important information may be lost. The PPML estimator is a non-linear method that is able to estimate a gravity model including zero-values. However, this method is often used when there are a significant number of zero-values in the dataset. In our dataset, only 448 of 11,904 observations are zero values, as only 32 medium or large countries are studied, and not all world trade flows. As a result, it is assumed that zero-values do not have a significant effect on estimations.

Table 1. Summary statistics (data sources, mean, standard deviation [Std. Dev.], minimum [Min.] and maximum [Max.]). The number of observations for each bilateral trade flow is T=12. This gives a total of 11,456 observations.

Variable		Unity	Sources	Mean	Std. Dev.	Min.	Max.
Paper export flow	F	In value, \$1000 ($\$_{2005}$)	BACI (Gaulier and Zignago, 2010)	72 789	372 703	0	$10{,}8*10^6$
GDP	Y	\$1,000,000 ($\$_{2005}$)	Enerdata, (2010)	1 094 940	1 997 576	73 410	$12.7*10^6$
GDP per capita	Y/L	\$1,000/capita	Enerdata	19.7	16.1	0.47	66.4
Distance	d	Population weighted distance between countries (km)	CEPII (Mayer and Zignago, 2006)	7 331	4 841	80	19 370
Common language	Dl	First official language, no unit	CEPII	0.05	0.23	0.00	1.00
Common border	Db	No unit	CEPII	0.04	0.19	0.00	1.00
Common regional trade agreement	Dr	European Union, NAFTA, ASEAN, Mercosur		/	/	/	/
Electricity costs per ton of paper	El	\$/t ($\$_{2005}$)	Enerdata	87	57	13	418
Fuel costs per ton of paper	Co	\$/t ($\$_{2005}$)	Enerdata	27	17	2.1	81
Electricity costs ratio	$\left(\frac{El_i}{El_j}\right)$	No unit	/	1.44	1.59	0.03	29.24
Fuel costs ratio	$\left(\frac{Co_i}{Co_j}\right)$	No unit	/	1.89	3.11	0.02	40.01

The econometric specification is slightly different according estimation methods. For country-pair fixed and random effects; $A_{i,j,t} = x_{i,j} + u_t$ where $x_{i,j}$ are country-pair constants (estimated either by fixed effects or random effects) and u_t are time effects constants. In the RE/FE model, $A_{i,j,t} = x_i + x_j + \mu_{i,j} + u_t$, where x_i and x_j are respectively exporters and importers time-invariant fixed effects constants, $\mu_{i,j}$ are the country-pair random effects and u_t are country-invariant time fixed effects. In addition, $\varepsilon_{i,j,t}$ is the residual error term.

HIGHER ENERGY COSTS REDUCE NATIONAL PAPER EXPORTS

Following previous econometric tests, statistical results from the FE and FE/RE models are preferred to OLS and RE models. Results are close between models, except with the introduction of the GDP per capita, highlighting the robustness of the econometric specification. For traditional gravity equation variables, exporter's and importer's incomes (GDP) are significant determinants of bilateral trade for all models. Bilateral flows of paper products occur mainly from countries with a large production capacity to countries with a large demand. When GDP per capita is introduced, only the exporter's GDP and importer's GDP per capita are positive and significant at the 5 % level. This indicates that paper products are more luxury products for which the demand is strongly linked to the country's income per capita growth.

Coefficients for the distance between two countries and for a common official language are significant and have the expected sign. The remoteness of two countries reduces their paper trade; however a common language improves it. A common border does not appear as a significant variable, except in OLS model where it enhances bilateral flows. Regional trade agreement dummies give ambiguous results. Integration in such area is beneficial in OLS and RE models, but not in other models where coefficients are not significant or with negative signs.

Energy costs play a significant role in the international paper trade. Results suggest that higher electricity and fuel costs in the exporting country, relatively to the importing country, decrease the level of paper products exports. A rise of 10 % in electricity or in fuel costs ratios (all else constant) results respectively in a 0.92 % or a 1.37 % decrease in exports (for the RE/FE model). This effect is clearly less important than for income or distance variables, but can still be quantified. By this way, it is possible to predict the potential impact of a change in energy costs on the international trade of paper products, either resulting from varying energy prices or energy efficiencies.

Conclusion

The aim of this study is to demonstrate and to quantify the effect of energy costs on the competitiveness of one energy-intensive sector; the paper and paperboard industry. By using a pooled data set of 32 countries over the 1995–2006 period, this paper determines the impact of energy on international trade with a gravity model.

Results indicate that differences in national energy costs per ton of paper produced, either for electricity or fossil fuels, play a significant role on the international trade. Higher energy costs in the exporting country, relatively to the importing country, decrease the level of paper exports. In fact, the study on bilateral flows demonstrates that a rise of 10 % in electricity or in fuels costs ratios between two trading countries, results respectively in a 0.92 % or in a 1.37 % decrease in exports.

Energy costs may not be the deciding factor for the paper and paperboard industry competitiveness, but are still a relevant issue. Competitive advantages of paper producing coun-

Table 2: Gravity model results. The RE/FE model is a combination of fixed effects for exporting and importing countries with random effects for each bilateral trade flow.

Explained variable: Paper bilateral exports	Ordinary Least Squares (OLS)	Fixed effects (FE)	Random effects (RE)	RE/FE	RE/FE (with income per capita)
Exporter's GDP	1.129 ***	0.861***	1.194***	0.851***	2.488***
	(0.016)	(0.232)	(0.051)	(0.233)	(0.951)
Importer's GDP	0.758***	1.459***	0.889***	1.464***	-1.412
	(0.017)	(0.262)	(0.055)	(0.262)	(0.863)
Exporter's GDP per capita	/	/	/	/	-1.734*
	/	/	/	/	(1.001)
Importer's GDP per capita	/	/	/	/	3.011***
	/	/	/	/	(0.853)
Distance	-1.411***	/	-1.544***	-1.923***	-1.931***
	(0.023)		(0.057)	(0.065)	(0.066)
Common language	1.185***	/	1.301***	1.086***	1.086***
	(0.066)		(0.217)	(0.189)	(0.189)
Common border	0.324***	/	0.239	-0.010	-0.014
	(0.081)		(0.275)	(0.191)	(0.191)
Ratio of electricity costs (exporter/importer)	-0.132***	-0.095**	-0.129***	-0.092***	-0.89**
	(0.024)	(0.039)	(0.034)	(0.039)	(0.039)
Ratio of fuel costs (exporter/importer)	-0.210***	-0.136***	-0.137***	-0.137***	-0.156***
	(0.020)	(0.035)	(0.032)	(0.035)	(0.034)
European Union	0.537***	/	0.265***	0.030	-0.009
	(0.058)		(0.058)	(0.059)	(0.061)
NAFTA	1.192***	/	0.857***	0.341	0.329
	(0.100)		(0.301)	(0.344)	(0.344)
Mercosur	2.795***	/	2.824***	2.333***	2.325***
	(0.178)		(0.532)	(0.317)	(0.317)
Asean	2.478***	/	2.630***	-1.074***	-1.087***
	(0.142)		(0.168)	(0.334)	(0.334)
Constant	-4.436***	-21.99***	-5.939***	-5.206	7.789
	(0.332)	(4.563)	(1.071)	(4.307)	(13.518)
Time Fixed Effects (FE)	No	Yes	Yes	Yes	Yes
Exporter & Importer Effects	No	No	No	Fixed	Fixed
Country-Pair Effects	No	Fixed	Random	Random	Random
N	11,456	11,456	11,456	11,456	11,456
R-sq	0.518	0.916	0.515	0.790	0.791

Standard errors in parentheses.
** p<0.10, ** p<0.05, *** p<0.01*

tries depend on a set of factors including input prices or abundance, local market features and efficiency of the production process. These factors are already central to the competitiveness debate in the paper industry, but this study demonstrates and especially weights the impact of energy.

These results are helpful for the design of an energy policy, as for energy taxation or changes in the energy mix of a country (e.g. introduction of renewable energy). Increase in energy expected costs can thus be interpreted in terms of competitiveness for the paper industry, one of the most energy-dependent industries. Similarly, results can be helpful to quantify competitiveness benefits associated with previous energy efficiency public policies and to compare it with related induced costs. In this way, it is possible to evaluate the most efficient policies, based either on national energy efficiency support programmes or on increasing energy taxes.

Energy costs do not involve only energy prices but also the energy efficiency of paper production processes. No assessment is done in this study on the behavioural reaction of paper producers to higher energy prices. This mechanism can be better modelled with a technical bottom-up model including accurate information on available technologies. For instance, with their model Szabó et al. explain that "the sector has a distinctive responsiveness to the climate change policy in comparison to other energy intensive sectors" (Szabó et al., 2009). Therefore, it would be relevant to couple results of this study with such a model in order to develop a complete overview of energy prices consequences on paper technologies and competitiveness. Another outlook is to extend this analysis to other energy-intensive industries. It would then be possible to highlight similarities and differences about the energy issue among these sectors.

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