# Environmental regulation and international trade patterns for agro-industrial under a South-North Perspective

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*Abstract*— **This paper aims at examining the relation between the international trade and the environment, particularly focused on sensitive agribusiness sectors. It consists on an empirical test to the conflicting positions supported by economists, some following the traditional approach (trade-off or neoclassical), while others supporting the Porter's hypothesis, which considers that impacts of the stricter environmental regulation can benefit the trade competitiveness. A Heckscher-Ohlin-Vanek model was applied to net exports as the dependent variable. The agricultural products analyzed were total agriculture, rice, maize, soybean, wheat, dairy and swine; run for 97 countries, divided as developing and developed, in a cross-section approach. This modeling allows including the environmental endowment as explanatory variables. Moreover the Environmental Performance Index (Esty et al, 2008) was also tried as explanatory variables in order to catch any effect of the environmental regulation on the trade patterns. Results were not conclusively as they show that the net exports of the selected products, considered environmentally sensitive, can be affected even positively or negatively (neoclassical approach) by the environmental regulation. The results depend on the products. A remarkable outcome to highlight is that the dummy for developing countries and developed countries was significant, pointing that for rice, for example, it makes difference being a developing country, as well as it does for wheat, being a developed country.**

*Keywords*— **Trade, environmental regulation, agribusiness.**

## I. INTRODUCTION

Recently, there has been an increasingly interest about environmental questions. In a world context of increasing interdependence, the environmental policies tend to have some impacts on the level and pattern of commerce. Trade can be directly or indirectly influenced by environmental regulation, which imposes additional costs to the producers. The adequacy to new environmental patterns can demand changes on certain production techniques and final goods and these environmental regulations can be even supported by trade restrictions in order to become effective.

Regarding the ambiguity existent in the literature about the impacts of the environmental regulation on the trade patterns for goods and services, it became evident the need to bring about specific analysis (case-by-case) to have a better understanding on conclusions.

Despite of the recently increased number of studies focused on the relationship between national environmental policies and the international competitiveness, the debate on this topic is still polarized in two distinguished views, extremely antagonists. In one side, the traditional approach according to what there is an inevitable conflict (a trade-off) between environmental and economical gains, derived from the negative externality concept. On the other side of this debate, arise the revisionist approach, known as "Porter's followers". This approach emphasizes the potential synergic effects between environmental regulation and the competitiveness.

Thus, the main goal of this work is to support the identification of the real effects of heterogeneity in the environmental regulation through countries, caused on the world trade flows for agricultural products. To such a degree, two different aggregations on the environmental indexes were scrutinized for results in the modelling: i) the more general Environmental Performance Index (Esty et al, 2008) was included as an explanatory variable (Model I); ii) the individuals environmental indicators specifically relevant for agriculture were used as explanatory (Model II).

## II. METHODOLOGY AND DATA

The empirical tests were conducted following the Heckscher-Ohlin-Vanek (H-O-V) model for international trade, traditionally used to diagnose policies impacts on trade patterns. The H-O-V model adds a modification in the H-O theorem working with **n** production factors and establishing a relation between net exports, factor intensities and supply surpluses in factors. Thus, the generalization of H-O model for **n** factors, as specified by Vanek (1968) includes the ranking of the factorial intensities, such that the intensity of each factor is used as a reference for others to define an abundance ranking.

In the H-O-V model, the equations that comprise the measures for the domestic endowment of production factors are used to explain the trade flows observed. In order to examine if the environmental regulation distort trade patterns, variables that are representative of the regulation strictness are included in the model as well.

Algebraically, the eq. (1) below shows the value of the net exports by country, as a function of the domestic factors endowment:

$$W_{ij} = \sum_{k=1}^{S} b_k V_{kj} + c\Phi_{ij} + u_{ij} \qquad (1)$$

where $W_{ij}$ are the net exports originated from sector **i** from country **j**, $V_{kj}$ are the endowments of resources **k** in country **j,** $b_k$ are the coefficients to be estimated, $\Phi_{ij}$ is the variable representative of the environmental regulatory regime and $u_{ij}$ are aleatory disturbances.

In this study, a set of nine resource endowment variables for 97 countries over the 2003-2005 years was chosen to explain net exports of 6 agricultural commodities (maize, soybeans, wheat, rice, swine and dairy) and of the agricultural complex as a whole set. In order to test the hypothesis that stringent environmental policies have caused deviations on trade patterns, it is necessary to classify the commodities according to environmental abatement costs. Typically, it is done expressing the pollution abatement costs as a percentage of total production costs (Tobey, 1990; Jaffe et al. 1995). Unfortunately, this information is not available for agricultural commodities.

Thus, it is chosen to employ the Environmental Performance Index (EPI), which the most recent version (2008) evaluated the environmental schemes also for the agricultural sector. The 2008 EPI focuses on two overarching environmental objectives: i) reducing environmental stresses to human health; and ii) promoting ecosystem vitality and sound natural resource management. These broad goals also reflect the policy priorities of environmental authorities around the world and the international community's intent in adopting Goal 7 of the Millennium Development Goals, to "ensure environmental sustainability." The two overarching objectives are gauged using 25 performance indicators tracked into six well-established policy categories, which are then combined to create a final score.

The 2008 EPI deploys a proximity-to-target methodology, which quantitatively classify the national performance on a set of environmental policy goals for which every government should be held accountable. By identifying specific targets and measuring the lag between the target and the current national achievement, the EPI provides both an empirical foundation for policy analysis and a context for evaluating performance. Issue-by-issue and aggregate rankings facilitate cross-country comparisons, both globally and within relevant peer groups such as geography or economy.

The model estimated evaluates the impact of EPI 2008 in the more aggregated possible form and only for agriculture. Indicators of agricultural comprised the following factors: stress irrigation, agricultural subsidies, intensive cropland, burnt land area and pesticide regulation. The resource endowment variables encompass agricultural area, internal renewable water resources, physical capital, human capital and energy stock. However, as highlighted by Diakosavvas (1994), the performance of the agricultural sector is also strongly influenced by government policies. In particular, in most development countries the sector is highly supported, while in the developing countries the sector is, in general, taxed.

In this context, the model is set to evaluate the environmental issue from the perspective North-South. In order to take into account the fact that government policies with respect to agriculture are distinctly different in developed and developing countries a dummy variable, which takes on the value of 0 if the country is developed and 1 if it is not, is also included in the model. The resource endowment data were collected with the database of FAO, International Energy Agency, British Geological Survey and the World Bank's Development Indicators. The data on trade flows were collected from Faostat (FAO).

## III. ESTIMATION OF THE MODEL

The model represented by eq.(2) has been estimated by Ordinary Least Squares. The independent variables comprehend the capital stock, general and one specific for machinery employed for agriculture production; the active economic population, a proxy for labor; the cultivated area; energy, water, the political dummy (if the country is developed or developing) and the EPI, both for general regulation and for agriculture regulation:

$$W_{ij} = \alpha + \omega K_j + \beta TRAC_j + \psi HARV_j + \varepsilon MILK_j + \varphi PEA_j + \theta AREA_j + \gamma ENER_j + \partial MIN_j + \xi WAT_j + \rho DUM_j + \lambda_i EPI_{ij} \quad (2)$$

However, for reasons outlined in Branson and Monoyios (1977), we may expect heteroscedasticity to be present in this type of analysis. The test proposed by Breusch and Pagan (1979) effectively identified the heteroscedasticity in the models estimated. In order to correct this problem and give more robustness to the statistical inference, whenever was necessary the standard-errors were corrected through the technique Huber-White or *sandwich*[1].

[1] For further details on this technique see White (1980).

## IV. RESULTS AND CONCLUSIONS

In general, observing the regression results for models I and II, and considering possible particularities related to the *cross-country* data, the quality of adjustment was satisfactory, noticed by the regression coefficients ($R^2$) obtained.

For both models, some of the individual coefficients estimated presented opposite signs of those initially expected as considered the H-O model background. This was verified, for instance, for the coefficients related to the number of harvesters, included in the models in order to evaluate its effects on the trade balance for maize, soybean and swine. Apparently, such a result is only supported economically to the swine sector, because it is expected that the harvest mechanization for cereals and oilseeds shall be translated into their competitiveness improvements.

In model I (Table I), wheat was the only product for which the regression generated a statistically significant coefficient (even though it is only in 15 per cent), positive, to the $EPI_{tot}$ variable. This outcome supports the Porter's hypothesis, as it indicates that a higher environmental performance, in average, leads to an increase in the trade balance for the sector. *Ceteris paribus,* such increase would be about US$ 7.25 million for each point-percent that the country gets nearer the environmental goals.

Model II estimates equation 1 using the variables related to the environmental regulatory regime in their lower level of aggregation. From a total of 25 EPIs calculated by Esty et al. (2008), there were chosen a few that potentially have the greatest impacts on the agriculture sectors.

Table II shows results for model II. The model's adjustment was also satisfactory, except for the swine case ($R^2 = 0.1472$). The indicator for the intensive use of soil was statistically significant (at a 10 per cent level) and negative for the maize regression. The environmental aim of limiting at 60 percent the use of proper areas for cultivation, criteria used for building this index, seems to be an important caveat in terms of depressing competitiveness gains, particularly in countries where land is a scarce endowment. However, the coefficients estimated for the other agriculture sectors do not follow the same pattern, at least for the period considered in this study.

The trade performance for maize is also affected by the environmental indicator representing the stocks of forest resources. The coefficient shows a negative sign, statistically significant at 1 per cent. This suggests the presence of a *trade-off* between forest conservation and gains of trade for maize sector. The same environmental variable presented a negative and also statistically significant (at 15 per cent) coefficient for the wheat net exports.

Another environmental variable, which showed a significant coefficient (at 5 per cent), was the emissions of greenhouse gases, negatively impacting on the maize trade pattern. This result is in accordance with the neoclassical theory and can be partially explained by the increasing share of the corn used as input to produce ethanol, instead of being traded in the international market. Regression for the soybean case shows also this outcome.

The achievement of the environmental goal related to the subsidies and the elimination of gaps between domestic and international prices only had significant impacts on the net exports of soybean. According to the estimated coefficients, as the countries get nearer the bound established by the index criteria for this environmental variable, their soybean exports raise. Such a result is compatible with the advance of developing countries in this market. In these countries, usually, the governmental support is low, which does not seem to be jeopardizing their performance in the soybean competitiveness.

It is worth-mentioning that the estimated coefficients related to the use of pesticides and its effects on the net exports of maize, soybean and wheat were all significant. The international market is increasingly restrictive to non-conformities related to maximum residues limits established for food, in particular. Thus, such a result can highlight the effects of these regulations on exports.

Water stress and stress from irrigation variables, as well as the burning, were not significant statistically. Currently the competitiveness of the Brazilian soybean has been reported to the burnings in the Amazon region. However, in a world scope, this statement was not confirmed by the results.

In the regressions run for Model II econometrical tests were done aiming at verifying if when the environmental variables were considered all-together their estimated coefficients would be simultaneously zero. This hypothesis could be only rejected, at a 15 per cent level of significance, for the regression conducted to soybean.

A special comment is deserved to the animals sectors analyzed in this study. Although the dairy and swine sectors seem to be less influenced by the natural endowments and by the environmental indicators than the agriculture ones, it should be pointed that they are probably more intensively traded through their added-value byproducts. Moreover, it is also possible to consider the effects of a large amount of intra-trade and re-exports flows.

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TABLE 1: REGRESSION RESULTS – MODEL I

| | dairy_tot | maize_tot | pigs_tot | rice_tot | soybean_tot | wheat_tot | agri_tot |
|---|---|---|---|---|---|---|---|
| **K** | 0.0000473 | 0.000000310 | -0.0000002 | -0.000000103 | 0.0000008 | -0.00000021 | -0.00000324 |
| | (-0.0002541) | (0.0000002$^{d}$) | (0.000000.2 | (0.000000101) | (0.0000004$^{b}$) | (0.00000018) | (0.0000022$^{d}$) |
| **TRAC** | -163.1966 | 0.2902154 | 0.1646586 | 0.3899233 | 0.5454564 | 0.7121178 | 6.639668 |
| | (344.7887) | (0.1857307$^{d}$) | (0.2898851) | (0.1380714$^{a}$) | (0.4144954) | (0.1996168$^{a}$) | (2.617511$^{a}$) |
| **HARV** | -975.2355 | -4.045015 | -3.959649 | -0.135655 | -6.73625 | -1.077527 | -13.6468 |
| | (1587.726) | (1.426423$^{a}$) | (1.358436$^{a}$) | (0.5210557) | (2.140416$^{a}$) | (0.9381281) | (13.87531) |
| **MILK** | 2270.962 | - | - | - | - | - | -25.1157 |
| | (2984.305) | - | - | - | - | - | (16.76957$^{d}$) |
| **PEA** | 768.4039 | -1.294534 | 0.0308831 | 0.7905037 | -10.16005 | -6.50649 | -38.1345 |
| | (2205.472) | (1.889145) | (2.679134) | (0.7825152) | (4.592557$^{b}$) | (1.489225$^{a}$) | (19.64604$^{b}$) |
| **AREA** | 2208.021 | 6.38727 | 2.00476 | 0.7009503 | 16.91832 | 3.679738 | 60.37443 |
| | (2055.78) | (2.936226$^{b}$) | (3.159987) | (0.4410952$^{d}$) | (11.91681$^{d}$) | (2.433064$^{d}$) | (27.82942$^{b}$) |
| **WAT** | 2994.325 | 81.05896 | 127.1235 | -4.341937 | 1030.727 | -110.0709 | 1038.315 |
| | (86867.54) | (71.99232) | (117.5203) | (27.24307) | (284.5605$^{a}$) | (103.8729) | (659.0872$^{d}$) |
| **ENER** | -684.5346 | 0.712502 | 0.5442312 | -0.1194396 | -3.485544 | 0.5174214 | -13.4701 |
| | (542.3645) | (0.767969) | (0.7290226) | (0.1339496) | (1.905497$^{c}$) | (0.5547334) | (8.338934$^{d}$) |
| **MIN** | -0.4449483 | -0.0094481 | -0.0033961 | -0.0016959 | -0.0187253 | -0.0003253 | -0.02229 |
| | (3.264038) | (0.0041822$^{b}$) | (0.0048985) | (0.0008638$^{b}$) | (0.0169312) | (0.0034457) | (0.037538) |
| **DUM** | -31800000000 | -45089.19 | -261949.4 | 78423.19 | 158197.3 | -161987.1 | -961441 |
| | (197000000$^{d}$) | (94697.1) | (200613.9) | (55148.84$^{d}$) | (237952.2) | (95980.56$^{c}$) | (863089.6) |
| **$EPI_{tot}$** | 4224948 | -1286.437 | -4038.574 | -985.1518 | 3519.255 | 7251.601 | -14646 |
| | (5660751) | (4170.659) | (6565.942) | (1507.638) | (10150.38) | (5049.284$^{d}$) | (30485.73) |
| $\alpha$ | -6550000000 | -87919.17 | 478602.3 | -17551.45 | -871424.7 | -541359 | 1240569 |
| | (39600000000) | (296900.6) | (492460.2) | (108065.2) | (724561.8) | (345442.3$^{d}$) | (2284878) |
| **$R^2$** | 0.1709 | 0.6483 | 0.2653 | 0.2257 | 0.6861 | 0.5589 | 0.6047 |
| **F** | 9.90$^{a}$ | 2.84$^{a}$ | 3.11$^{a}$ | 2.90$^{a}$ | 36.3$^{a}$ | 24.81$^{a}$ | 13.67$^{a}$ |

TABLE 2: REGRESSION RESULTS – MODEL II

| | dairy_tot | maize_tot | pigs_tot | rice_tot | soybean_tot | wheat_tot | agri_tot |
|---|---|---|---|---|---|---|---|
| **K** | 0.0000723 | 0.00000042 | 0.00000014 | -0.00000011 | 0.0000008 | -0.00000018 | -0.000002 |
| | (0.00026) | (0.0000001$^{a}$) | (0.0000003) | (0.00000012) | (0.00000038$^{b}$) | (0.0000002) | (0.000001$^{b}$) |
| **TRAC** | -229.7311 | 0.0878269 | -0.106814 | 0.3872621 | 0.4411521 | 0.6248289 | 5.201562 |
| | (349.2289) | (0.1446976) | (0.2757202) | (0.166087$^{b}$) | (0.4426452) | (0.2524212$^{b}$) | (1.468523$^{a}$) |
| **HARV** | 1525.721 | 1.665843 | 1.268156 | 0.723686 | -0.8854191 | 1.015578 | 29.63221 |
| | (1754.637) | (0.95568$^{c}$) | (1.598066) | (1.003623) | (3.153921) | (1.197924) | (9.101139$^{a}$) |
| **MILK** | 1967.845 | - | - | - | - | - | -31.29358 |
| | (2804.911) | - | - | - | - | - | (8.877649$^{a}$) |
| **PEA** | 1175.847 | -1.757816 | 0.7258719 | 0.4818554 | -12.99317 | -6.007637 | -32.3586 |
| | (1773.96) | (0.9838168$^{c}$) | (1.770709) | (0.824306) | (3.631023$^{a}$) | (1.425078$^{a}$) | (10.49166$^{a}$) |
| **AREA** | 1995.123 | 0.6871074 | 0.4325835 | -0.2363232 | 5.53265 | 3.626025 | 50.9693 |
| | (1287.143$^{d}$) | (1.039725) | (0.8157804) | (0.4010535) | (5.18999) | (1.426605$^{a}$) | (8.137067$^{a}$) |
| **WAT** | -24228.87 | -46.84796 | 93.29527 | -30.22954 | 747.4598 | -99.61017 | 721.9334 |
| | (66675.18) | (35.3889) | (65.60314$^{d}$) | (25.21297) | (169.1716$^{a}$) | (115.7571) | (441.5145$^{c}$) |
| **ENER** | -1291.338 | -0.2929765 | -0.9116722 | -0.2340957 | -3.682947 | -0.120168 | -25.53564 |
| | (391.0341$^{a}$) | (0.339330) | (0.6807632) | (0.2580346) | (1.27533$^{a}$) | (0.5221486) | (3.639658$^{a}$) |
| **DUM** | -36100000000 | 156497.5 | -257324.9 | 115211.3 | 572722.1 | -186986.9 | -1234480 |
| | (191000000$^{c}$) | (86245.38$^{c}$) | (246039.5) | (53715.36$^{b}$) | (246396$^{b}$) | (117628.5$^{d}$) | (911176.4) |
| **$EPI_{envh}$** | 1975692 | 149.1112 | -2265.46 | -548.9724 | 2923.823 | 4801.255 | -7722.969 |
| | (3646127) | (1968.527) | (4131.761) | (670.7835) | (5391.447) | (2610.981$^{c}$) | (17451.03) |
| **$EPI_{air}$** | 6402880 | -3404.024 | 7498.21 | -1425.888 | -7252.467 | -413.0177 | 45407.75 |
| | (4991154) | (2369.807$^{d}$) | (4864.453$^{d}$) | (1179.584) | (8666.868) | (2817.256) | (30899.52$^{d}$) |
| **$EPI_{wat}$** | 1453621 | 1579.869 | 4570.757 | -113.9426 | 3941.197 | -1748.967 | 12802.17 |
| | (3057787) | (1644.486) | (3664.605) | (1267.089) | (4415.807) | (1974.627) | (23872.22) |
| **$EPI_{bio}$** | 3275991 | 1212.354 | 1560.599 | 568.482 | 1348.448 | 2517.471 | 15396.52 |
| | (2841363) | (1448.916) | (3585.946) | (672.0879) | (3798.007) | (2053.786) | (14245.82) |
| **$EPI_{agri}$** | 2621919 | 3617.779 | -7508.767 | 1540.533 | 9475.06 | -1230.036 | 693.387 |
| | (8459158) | (3338.588) | (10501.91) | (1843.464) | (9847.56) | (3396.664) | (36077.28) |
| **$EPI_{clim}$** | 85527.24 | -2109.378 | 2080.476 | 686.0449 | -8014.621 | 5991.622 | 16289.55 |
| | (4272862) | (2616.728) | (4388.514) | (3281.047) | (9631.638) | (3959.09$^{d}$) | (27873.22) |
| $\alpha$ | -91000000000 | -213914.4 | -246513.8 | -118192.8 | -773586.8 | -664304.3 | -5710680 |
| | (84600000000) | (346997.4) | (649120.2) | (354817.1) | (1195253) | (467172) | (3951568$^{d}$) |
| **$R^2$** | 0.2079 | 0.7829 | 0.094 | 0.2371 | 0.6897 | 0.5834 | 0.6114 |
| **F** | 5.27$^{a}$ | 8.71$^{a}$ | 2.20$^{a}$ | 2.73$^{a}$ | 23.61$^{a}$ | 14.38$^{a}$ | 7.87$^{a}$ |

Note: The superscripts "a", "b", "c" and "d" to the standard errors indicate the statistical significance of the coefficients estimated, at the level of 1%, 5%, 10% and 15%, respectively.