EFFECTS OF THE ENVIRONMENTAL REGULATION ON THE INTERNATIONAL TRADE PATTERN FOR AGRICULTURAL PRODUCTS

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1. Introduction

Since the 1970s has seen growing interest on environmental issues. Governments and international organizations are actively engaged in building policies that take into account the links between economic activity and the environment. In this context, a body of theory has emerged, increasingly broad, trying to determine how the business growth and changes in trade regimes affect the environment, and otherwise, how such stricter environmental regulations and their enforcement affect trade.

Despite the growing number of recent studies that performs to elucidate the relationship between national environmental policies and international competitiveness, the debate on the subject follows polarized by two competing visions. On one hand, stand those who defend the traditional view of a trade-off between environmental gains and economic gains. Alternatively, and opposed to this view, those who advocate the revisionist approach, known as "followers of Porter," which highlights the potential synergistic effects between environmental regulations and competitiveness.

As results are ambiguous in the literature that achieved to address both the above-mentioned approaches, it seems necessary to apply more specific tests (case-by-case). In this sense, throughout the 1990s, a series of studies sought to identify the industrial goods that might be classified as environmentally sensitive, and then confronting the revisionist and traditional approaches. During this period, particularly given the scarcity of environmental performance indicators reasonably harmonized to a number of countries, the analysis of the agricultural sector was relegated to a second plane. Only recently, progress has been made in this regard because of advances in production of statistics on the provision of capital, labor and natural resources in rural areas.

Since the middle of this decade, the United Nations Food and Agriculture Organization - FAO has been undertaking efforts aimed at the production and improvement of statistics that reflect the allocation of manpower, land, water, machinery, use of agrochemicals, fertilizers and investment to more than two hundred countries and for major crops. In parallel, since 2005, Yale Center for Environmental Law & Policy, in partnership with the Center for International Earth Science Information Network, began to develop a comprehensive system of Environmental Performance Index - EPI, whose results are published annually in the World Economic Forum Davos.

The recent availability of this data set enabled to a broader application of the main models of international trade to examine the effects of environmental regulations on competitiveness and world trade patterns of agribusiness.

In the current scenario, the mere suspicion that a country is taking a passive position before the adoption of environmentally degrading practices, increasing their competitiveness, has overburdened the use of instruments of trade discrimination. In this sense, it is common the proliferation of diagnoses without proper scientific basis, relating the export growth of agribusiness in developing countries to the increased global environmental problems.

Given this context and the demand for flexibility in WTO law to include provisions allowing trade discrimination motivated by environmental issues, this paper aims at identifying the effects of heterogeneity of environmental regulations among countries on the global patterns of agribusiness trade. The empirical tests are conducted following the model Heckscher-Ohlin-Vanek (HOV) of international trade, traditionally employed to examine the effects of policies and/or variables of government control over trade patterns.

The paper is organized into five sections including this introduction. Initially presents the summary of the main theories, empirical evidence and controversies relating to the environmental regulation, competitiveness and standards of international trade, with special emphasis to agriculture sector. The following section presents the methodological framework and the database used. The following comprises the analysis of the impacts of different environmental regimes on the world trade in agricultural and environmentally sensitive goods of this sector. Finally, considerations were made highlighting the importance of the present work and the context of its findings in relation to the existing literature.

2. Environmental regulation and competitiveness in the agriculture

Huang (2002) believes that the development of standards and environmental regulations and changes in understanding the meaning of the term "competitiveness" are factors that have driven the evolution of literature regarding the relationship between environmental regulation and competitiveness.

According to the Department for Environment, Food and Rural Affairs of United Kingdom - DEFRA (2007), the debate began in the United States in the mid-1960s, when, given the demands of several segments of society, the Environmental Protection Agency – EPA was created and the Clean Air Act was signed. The vast volume and multiple forms of environmental regulations implemented have promoted a broad debate about their economic effects and as a result, since the early 1990s, a theoretical background on the subject had been consolidated.

Early studies, conducted by neoclassical economists, prominently by Baumol and Oates (1975), Pethig (1976) and Siebert (1977) concluded that new environmental regulations have impacted significantly on production costs and competitiveness of the United States. According to these authors, there would be a trade-off between stringency of environmental regulation and competitiveness.

For over a decade the focus of analysis was the measurement of this trade-off through the use of neoclassical approach and tools, until Porter (1991) and Porter and van der Linde (1995) inaugurated a new approach that produced results opposite to those known until then. The new approach proved possible to achieve environmental protection while maintaining, or even increasing, competitiveness.

Almeida (2002) synthesized the polarization of the debate between advocates of the traditional view (trade-off or neoclassical) versus the recent revisionist view. The author notes that, according to proponents of the traditional view, there is an inevitable conflict (trade-off) between environmental gains and economic gains, which derives from the concept of negative externality. Since the microeconomic agent maximizes profits based on the selection of the alternative minimum production cost, the choice does not take into account the environmental damage related to the regulations that aim precisely to induce the agent to internalize environmental externalities, leading him necessarily an extra cost.

On the other side, the advocates of revisionist approach, known as "Porter hypothesis", emphasize the synergistic effects between environmental regulations and competitiveness. According to this view, there is no inevitable conflict between economic and environmental gains. By promoting environmental improvements, companies can save inputs, to streamline the production process, make waste, and differentiate the product and thereby improving competitiveness. Thus, compliance with stricter and increasing environmental regulations on production would not be a zero sum game because it could represent a new source of permanent structural change.

With the establishment of two radically opposed fields of study, Jaffe et al. (1995) entered the debate to occupy an intermediate position, stating "the truth about the relationship between environmental protection and competitiveness lies between the two extremes of the then current discussion." From this moment on, the literature erupted in a number of different lines of exploration.

For Valluru and Peterson (1997), these disputes tend to become the center of the discussion agenda of future international negotiations related to trade, environment and development in the Third World.

Amid the global trends of trade liberalization, environmental crisis and intensification of inequality, agriculture assumes a prominent role. Indeed, one can say that it is the economic activity that has generated the most controversy and resented more heavily on direct and indirect effects of this situation (FEIX; VASCONCELOS, 2005).

The agriculture, while fulfilling a vital role in the eradication of world hunger is directly related to unsustainable demand for natural resources. According to the United Nations Food and Agriculture Organization (FAO, 2003), agricultural production is the main source of anthropogenic greenhouse gases emissions and contributes significantly to other types of air and water contamination. Moreover, according to the study, some methods applied in agriculture, forestry and fishing are the main causes of biodiversity loss worldwide.

For Procópio Filho, Vaz and Tachinardi (1994), there is broad consensus that trade barriers and subsidies in agriculture have caused significant market distortions in developing countries and induced injury to the inefficient techniques of production. There is ample evidence that agricultural protectionism not only may fail to help the environment but also it can be an important source of environmental degradation.

However, these authors make aware that the effects of liberalization can not be identified as responsible for the immediate environmental problems arising from agricultural production. In any case, the subsidy policy adopted by the major countries of the Organization for Economic Cooperation and Development - OECD, to reduce the international prices of agricultural commodities in order to ensure the competitiveness of its products, contributes to economic stagnation of developing countries. In contrast, the developing countries find themselves obliged to intensify the use of pesticides and other environmentally degrading practices in order to stay competitive in international markets.

Given the current trend in developed countries to enhance extra-territorial application of environmental, phytosanitary and zoosanitary standards, within a context of harmonizing them, the risk that developing countries come to confront restrictions on agricultural trade increases. This is so particularly if the environmental laws of the latter are not interpreted as congruent with the production and environmental standards in those countries (PROCÓPIO FILHO; VAZ; TACHINARDI, 1994).

3. Model specification

This section analyzes the role of the factor endowments and environmental regulations in determining patterns of global trade. The modern trade theories explain the comparative advantages in terms of different characteristics of countries. This is the case of the Hecksher-Ohlin model (H-O), which considers that the central hypothesis of the comparative advantages that are influenced by the interaction between the resources of the nation (the relative abundance of production factors) and technology (which influences the relative intensity to which different factors of production are used in the production of different goods). As a result, countries tend to export goods that are intensive in factors of which are abundantly endowed.

3.1 The Heckscher-Ohlin-Vanek model adapted to the environmental analysis[1]

The HOV model incorporates an important modification to the H-O theorem, since it allows working with *n* factors of production and establish a relationship between net exports and factor intensities excess supply of factors. Thus, the generalization of the H-O model of international trade for *n* factors, as specified by Vanek (1968), embodies the idea of ordering factor intensities, so that the intensity of each factor is used as a benchmark for others in defining a range of abundance.

According to Maskus (1985), the relationship established by the HOV model shows that a country can be considered abundant in one factor, compared to a second factor, if its share in world supply of that first factor outweighs its participation in the global supply of the second factor.

In the HOV model equations incorporating measures of internal endowments of production factors are used to explain trade flows observed. To test whether environmental regulations distort trade patterns, variables representing the stringency and enforcement of these regulations are included in the model.

Alternatively to the original HOV model, relations between the internal allocation of factors and trade can also be perceived by applying the simplified theoretical model. Thus, the estimated coefficients show the direct influence of resources on trade for the specific product. However, the coefficients do not indicate the intensity of factors use in production. As shown by Leamer and Bowen (1981), there are not necessarily the relation between the relative intensity factors and the estimated coefficients due to the fact that the complementarities between the sectors are sufficiently severe.

Algebraically, the equation 1 expresses the value of net exports, by country, as a function of internal factors endowments.

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

where W_{ij} is the net export of sector *i* from country *j*, V_{kj} is the endowment of resource *k* of country *j*, b_k are the coefficients to be estimated, Φ_{ij} is the variable representing the environmental regulatory regime *i* in the country *j*, c is the coefficient that indicates the average conditional relationship between environmental regulation and trade balance, and u_{ij} are random disturbances.

The model expressed in equation 1 is based on Leamer (1987) and it is estimated by applying the Ordinary Least Squares - OLS2 method, over the period 2005-2007, for five variables representing the endowments of resources, eight variables representing the environmental regulatory regime, and a dummy variable indicating the patterns of North-South trade. The data cover an universe of 117 countries, classified as developed or developing countries, and according to the model, explain the patterns of trade to four agricultural sectors (maize, soybean, wheat and rice) and to the whole agriculture sector. The definition of agriculture employed in this work follows the methodology proposed by the WTO.

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[1] For details on the structure of the HOV model see Vasconcelos (2001).

[2] The software used for the estimation of econometric models was the Statistics Data Analysis, version 9 (STATA 9).

3.2 Sources of data and econometric procedures

This type of analysis, incorporating environmental variables to the HOV model, was inaugurated by Tobey (1990) and followed by Diakosavvas (1994), Valluru and Peterson (1997), van der Beers and van der Bergh (1997) and Xu (1999).

As mentioned earlier, the measure adopted to represent the accuracy and application of environmental policies for the countries studied is the EPI, whose methodology was revised in 2008, enabling the calculation of indicators more closely aligned to agriculture sector. The EPI is focused on addressing two main environmental objectives: i) reduce wear with environmental effects on human health, ii) to promote the sustainability of the ecosystem and analyze natural resource management. These objectives reflect the policy priorities set by the international community, expressed in goal number seven of the Millennium Development Goals (ensure environmental sustainability). The two objectives mentioned above are calibrated using 25 performance indicators, divided into six categories of policies, which are combined at the end to create a single index (EPI total) (see Figure 1).

The methodology for calculating the EPI generates values expressed in terms of the proximity of the countries regarding the environmental goal established, classifying quantitatively the performances of a set of national goals of environmental policies that governments should pursue. Thus, countries whose environmental performance are in accordance with the present target, will have higher EPI than countries that still need to modify its regulation for sustainability (represented by the goals). By identifying the completion of a specific target and measuring the observed lagging behind the "ideal", the EPI provides a guiding principle for policy analysis over time and allows comparing international compliance to the principles of sustainable development.

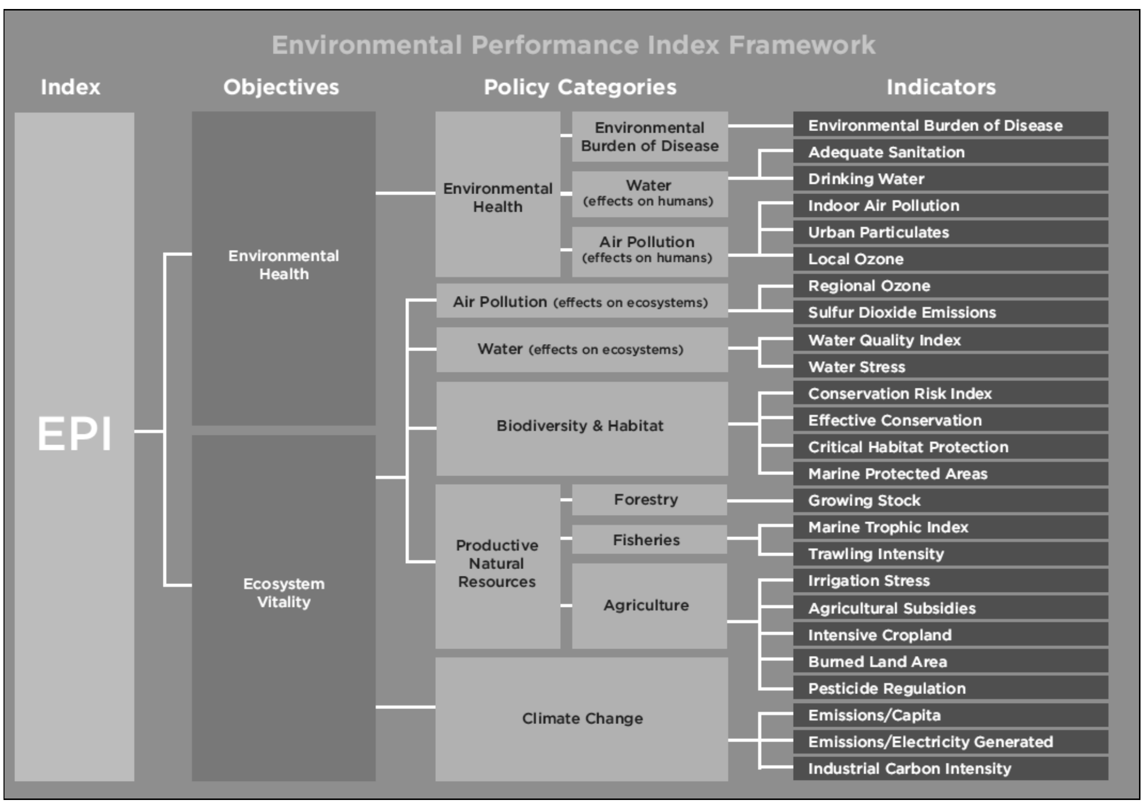

Figure 1 - Structure of the Environmental Performance Index - 2008

The statistics representing factor endowments and net exports were collected from the databases of the World Bank (World Development Indicators), FAO (FAOSTAT), International Labor Organization (LABORSTAT) and International Energy Agency.

The set of EPI 2008 data used as a variable to capture the environmental regulation in the estimated models was correspondent to the highest level of aggregation of indicators (model I). The environmental indicators selected to model II were those for which the potential impacts are assumed to be the highest for agricultural sector (model II). These indicators include: irrigation stress (EPIirrstr), agricultural subsidies (EPIagsub), intensive cropland (EPIagint), burned land area (EPIburn), pesticide regulation (EPIpest), emission of greenhouse gases (EPIghgca), effective conservation by biome (EPIeffcon) and growth of the stock of forest resources (EPIforgro)[3].

The variables of resource allocation in turn comprise the area of agriculture, renewable quantity of water, physical capital, human capital and stock of energy. However, as noted by Diakosavvas (1994), the performance of the agricultural sector also tends to be strongly influenced by government policies. Particularly in the developed countries, the agriculture sector receives a series of government incentives, a different situation from that observed in developing countries. Given this situation, the model is constructed in such a way to evaluate the expected performance for net exports from the perspective of possible differences between North and South, considered here that developed countries alludes to the North and developing countries to the South. Taking into account the fact that government policies relating to the agricultural sector differs categorically in these two regions a dummy variable was introduced.

The hypothesis that environmental regulations affect trade patterns is tested by "t-student" and "F" tests, thus allowing verification of individual and joint significance of estimated coefficients for the environmental indicators.

Obviously, before estimating equation 1, it becomes necessary to build variables representing the factors endowments for each country. The theoretical basis to define these endowment variables was proposed by Leamer (1984).

Due to limitations of data on land endowment, originally used by Leamer (1984) and Tobey (1990), the statistics of land use available in FAOSTAT database were adopted in this study. According to the HOV model, it is expected that the estimated coefficients have the following signs displayed below each variable:

$$W_{ij} = \underset{}{\beta_0} + \underset{(+)}{\beta_1 TRAC_j} + \underset{(+)}{\beta_2 PEA_j} + \underset{(+)}{\beta_3 AREA_j} + \underset{(+)}{\beta_5 ENER_j} + \underset{(+)}{\beta_5 WAT_j} + \underset{(+/-)}{\beta_6 DUM_j} + \underset{(+/-)}{\lambda_i EPI_{kj}} \qquad (4)$$

where:

W_{ij} = average net exports in the period 2005-2007, measured in thousands of current dollars, of product *i* by country *j*. Source: FAO (2010);
TRAC = number of agricultural tractors in use in country *j*. Source: FAO (2010);
PEA = economically active population engaged in agriculture in country *j*, expressed in thousands of people. Source: FAO (2010);
AREA= agricultural area, corresponding to arable land, permanent crops and permanent pastures, in thousands of hectares, in the country *j*. Source: FAO (2010);
ENER = energy production, in million tonnes of oil equivalents (ktoe). Is the sum of the production of energy from the following sources: crude oil, natural gas, nuclear, hidroelectric, geothermal, solar and other renewable fuels. Source: International Energy Agency (2008);

[3] For more details regarding the composition of these indicators, see Esty et al. (2008).

WAT = renewable fresh water available annually for use in irrigation and animal production purposes, in billions of cubic meters. Constitutes a *proxy* of water resources in agriculture. Source: FAO (2008);
DUM = dummy variable of value 0 for developed countries, and 1 for developing countries. Source: United Nations (2008);
EPI_{kj} = Environmental performance index *k*, in the country *j*. Source: Esty et al. (2008).

The choice of environmentally sensitive goods is given based on diagnostic studies conducted by the OECD (2003, 2004 and 2005). From the mid-1990s, this organization produced specific diagnostics for the trade-environment relationship in agriculture. In these studies, the following sectors were emphasized: pork, dairy and arable crops (rice, maize, soybeans and wheat). The arable crops sector products were selected to be analyzed in this study, mainly due to their strong intra-industry relationship with the meat and dairy sectors.

4. Results

Tables 1 and 2 present the results of the models estimated. The first column of the tables presents the explanatory variables, the significance test of overall regression (F) and the coefficient of determination (R^2). The first line comprises the explanatory variables, i.e., the average total net exports of environmentally sensitive agricultural products: maize, rice, soybeans, wheat and agriculture.

For each explanatory variable there is the estimated parameter value and its corresponding standard error (in parentheses). Significant estimates at 1%, 5%, 10% and 15% have their standard deviations labeled by superscripts “a”, “b”, ‘c” and “d”, respectively. The same is true for the calculated value of "F".

It is noteworthy that, for reasons discussed in Branson and Monoyios (1977) and confirmed by Diakosavvas (1994), it is expected to find heteroskedasticity in this kind of analysis. Through the test proposed by Breusch and Pagan (1979), the presence of heteroskedasticity was indeed observed. Aiming to correct this problem and enable more robust statistical inference, where it is necessary, the standard errors were corrected by using the Huber-White or sandwich[4] technique.

4.1. Model I

In general, analyzing the results of regressions for model I, presented in Table 1, and considering the particularity of cross-country data, one realizes that the quality of the adjustment of the regression lines to the data (R^2) is satisfactory, showing variability between 0.18 and 0.59 for the soybeans and rice sectors respectively. The null hypothesis that all coefficients are both equal to zero could be rejected at a significance level of 1% in all regressions estimated.

With regard to the individual analysis of the estimated coefficients, some of them show opposite signs to those expected according to the HOV theory. For instance, this was observed to the coefficients estimated to capture the influence of the economically active population (PEA) on trade balance, for all sectors except rice. These coefficients are statistically significant at 5%, but have a negative sign.

Regarding the maize sector, besides the estimated coefficient for the economically active population in agriculture, the stock of tractors in use, area and energy are also statistically significant (with the signs expected by theory).

[4] For more details on this technique see White (1980).

The regression performed for the rice sector generates statistically significant coefficients only for stock of tractors in use (1%) and economically active population (10%) explanatory variables.

	maize	rice	soybean	wheat	Agriculture
TRAC	0.36	0.25	0.98	0.33	-0.43
	(0.10[a])	(0.06[a])	(0.21[a])	(0.09[a])	(0.98)
PEA	-4.72	1.13	-19.05	-4.93	-22.23
	(1.11[a])	(0.62[c])	(2.36[a])	(1.05[a])	(10.77[b])
AREA	1.55	-0.21	6.93	3.23	39.30
	(0.93[c])	(0.51)	(1.97[a])	(0.87[a])	(8.98[a])
WAT	-82.79	-3.34	631.46	-57.26	1560.10
	(50.61 [c])	(27.90)	(107.09[a])	(47.59)	(488.09[a])
ENER	1.02	-0.27	-1.86	-0.004	-15.17
	(0.35 [a])	(0.19)	(0.74[a])	(0.33)	(3.39[a])
DUM	130555.6	71218.76	521083.8	-170642.9	13241.54
	(98768.18)	(54430.76)	(208961.4[a])	(92868.77[c])	(952351.2)
EPItotal	-1510.03	-698.32	2912.85	6794.76	117.60
	(3621.4)	(1995.74)	(7661.71)	(3405.09[b])	(34918.58)
β_0	-141354.9	-28014.11	-948722.1	-498575	-719597.1
	(273236.7)	(150579.7)	(578080.2[c])	(256916.3[b])	(2634627)
R^2	0.4126	0.1809	0.5947	0.4229	0.6047
F	11.74[a]	3.69[a]	24.53[a]	12.25	13.67[a]

Table 1 - Results of the regressions for the model I - HOV with total (aggregated) EPI

Note: The superscripts “a”, “b”, “c’ and “d” for the standard errors indicate the statistical significance of estimated coefficients at 1%, 5%, 10% and 15% respectively.

The results of coefficients estimated for the soybean sector indicate statistical significance for all the estimated coefficients, except by the environmental explanatory variable, the EPI total. But besides the PEA in agriculture, the energy endowment is found inversely related to trade balance, differing from the expected result according to theory. The inverse relationship between soybean trade balance and PEA in agriculture can be derived from the fact that cultivation of soy, increasingly, has become relatively intensive in capital and land and, and therefore, labor saving.

Wheat is the only sector that shows a significant result for the environmental aggregated variable (EPI total). Its correspondent regression produces a statistically significant coefficient (at 5%) of positive sign, which supports the “Porter hypothesis”, because it indicates that a higher environmental performance, on average, leads to an increase in trade balance for this sector. *Ceteris paribus*, this increase would be around US$ 6.79 million for each percentage point moving closer to the Index goal, e.g., closer to the ideal environmental performance. The regression also shows that the estimated coefficients for stock of tractors (1%), agricultural area (1%), North-South dummy (10%) and PEA in agriculture (1%) are statistically significant, though these two last showed negative signs. Regarding the dummy result, the negative coefficient is compatible with the characteristic of wheat being mostly exported by developed countries.

Concerning the regression performed to agriculture as a whole sector, it is observed that the estimated coefficients for agricultural area (1%), water supply (1%), PEA in agriculture

(5%), and energy endowment (15%) are statistically significant. However, the sign of the estimated coefficient for the last two variables mentioned is contrary to the expected.

4.2 Model II

Model II estimates the equation 1 considering the variables representing the environmental regulatory regime according to its lowest level of aggregation. Among the 25 indicators of environmental performance built by Esty et al. (2008), those with the greatest potential of impact in agriculture were selected to test in the model.

Table 2 identifies that, similarly to model I, the goodness of fit of the regression lines to the data (R^2) is satisfactory, except for rice sector (0.2457). The null hypothesis that all slopes are both equal to zero could be rejected at the significance level of 1% for all sectors.

	maize	rice	soybean	wheat	agriculture
TRAC	0.69 (0.08[a])	0.31 (0.07[a])	1.38 (0.24[a])	0.46 (0.10[a])	2.39 (0.81[a])
PEA	-4.11 (0.85[a])	1.17 (0.67[c])	-18.53 (2.41[a])	-5.14 (1.01[a])	-19.34 (8.17[b])
AREA	0.52 (0.73)	-0.25 (0.57)	5.04 (2.06[b])	2.88 (0.86[a])	35.37 (6.99[a])
WAT	-118.14 (40.18[a])	0.56 (31.53)	546.02 (113.80[a])	-51.35 (47.72)	1439.43 (386.33[a])
ENER	0.77 (0.27[a])	-0.35 (0.21[c])	-1.92 (0.77[b])	-0.08 (0.32)	-18.66 (2.61[a])
DUM	160455.1 (75624.86[b])	61612.76 (59358.57)	563576.6 (214206.8[a])	-202053.3 (89812.82[b])	-105108.9 (727179.2)
$\mathbf{EPI_{forgro}}$	-166.42 (1666.60[a])	-208.32 (1308.13)	-3707.57 (4720.63)	-1299.33 (1979.27)	3686.16 (16025.36)
$\mathbf{EPI_{effcon}}$	746.54 (1066.43)	58.91 (837.05)	1245.28 (3020.65)	625.30 (1266.50)	16052.92 (10254.37)
$\mathbf{EPI_{irrstr}}$	1902.63 (1803.19)	-920.48 (1415.34)	3684.94 (5107.53)	-1651.26 (2141.49)	9594.84 (17338.8)
$\mathbf{EPI_{agint}}$	-1999.65 (1414.37)	718.38 (1110.15)	-2645.32 (4006.19)	-210.44 (1679.72)	-14265.86 (13600.01)
$\mathbf{EPI_{agsub}}$	2483.36 (-1234.92[b])	285.28 (969.30)	7011.81 (3497.89[b])	-2376.66 (1466.60[c])	2412.95 (11874.47)
$\mathbf{EPI_{burn}}$	-1141.80 (1543.93)	801.86 (1211.84)	-2150.54 (4373.17)	-2372.04 (1833.59)	4936.11 (14845.82)
$\mathbf{EPI_{pest}}$	677.31 (954.55[d])	-313.07 (749.23)	3358.90 (2703.76 [d])	1463.62 (1133.63[c])	-416.27 (9178.59)
$\mathbf{EPI_{ghgca}}$	-4511.07 (2243.94[b])	1039.44 (1761.28)	-12015.04 (6355.93[c])	1228.01 (2664.92)	5882.37 (21576.82)
β_0	-24219.91 (415716.9)	-187498 (326299.6)	-125899.6 (1177515)	470923.6 (493709.4)	-2260014 (3997371)
$\mathbf{R^2}$	0.6750	0.2472	0.6683	0.5549	0.5031
F	14.84[a]	2.07[a]	14.39[a]	8.90[a]	7.23[a]

Table 2 - Results of regressions for model II - HOV with EPI selected

Note: The superscripts “a”, “b”, “c’ and “d” for the standard errors indicate the statistical significance of estimated coefficients at 1%, 5%, 10% and 15% respectively.

The separate analysis of the statistical significance of the estimated coefficients reveals, as proposed by the HOV model, that variables representing the allocation of factors influence the patterns of trade in the case of those sectors considered.

As noted in model I, the PEA in agriculture is inversely related to trade, which could mean that more labor-intensive agriculture sectors or countries, in average, tend to show a negative influence, worsening the trade balance. That is the case for the average trade balance of maize, soybean, wheat and agriculture tends that to be more negative according to the increase of population in the rural sector. The variable energy endowment and water endowment also show similar behavior for soybean and rice, and maize, respectively.

The analysis of the estimated coefficients for environmental variables reveals that the expected value of net exports of rice and agriculture (total) are not affected by achieving the environmental sustainability goals included in the model.

Results also show that trade performance in maize sector is positively affected by achieving the environmental goal related to subsidies (index EPI_{agsub}). The patterns of trade for maize are also affected by the partial index related to effective stock of forest resources. The negative estimated coefficient is statistically significant at 1%. This result suggests the existence of an apparent trade-off between conservation of forest resources and gains from trade in maize sector.

However, this indicator is calculated based on the observed changes of stock registered between 2000 and 2005. Thus, the fact that a country did not provide variation in the stock of forest resources for this period, which is to say that it has reached the target, not necessarily imply that the existing stock is equivalent to the minimum necessary to fulfill your sustainable basis. Issues like this have faced intense debate in international discussion forums, since part of developing countries are facing difficulties to convert into productive areas some portions of their forest areas. A commonly used argument that emphasizes environmental injunctions imposed by the North to the South would be justifiable only when implemented in a scenario that reflects each country's historical contribution to the process of environmental degradation and encourage actions to transfer clean technology without endangering the economic sustainability of nations whose social demands remain suppressed.

Another environmental variable, which the estimated coefficient was negative and statistically significant at the 5% level for maize, are the *per capita* emissions of greenhouse gases. This result is also aligned to that expected by neoclassical theory and can be partially explained by a rising share of corn production is being used to produce ethanol rather than to exports. The same feature is observed for the soybean industry regression, which coefficient for greenhouse gases emissions is found also negative and statistically significant at 5%.

Besides the maize sector, soybean and wheat regressions also show a significant effect trade balance of achieving the goal established for granting of subsidies and the elimination of price differences between internal and external influence. According to the estimated coefficients in the regression, the approximation of the target (expressed by the EPI for subsidies) by the soybean-producing countries leads to increased exports. This result is consistent with the advances of countries in this emerging market. In such countries, government support is relatively minor and it has generated negative effects on indicators of competitiveness. Opposite interpretation may be made for the wheat industry.

It should be noted that the estimated coefficient to capture the influence of achieving the goal established for the pesticides use on net exports of sectors of corn, soybeans and wheat are statistically significant at 15%, for the first two, and at 10% for wheat. This result may be related to the increasing adoption of phytosanitary measures to reduce to a minimum the presence of pesticide residues in food. Because such measures become prohibitive to trade, the inadequacy of those standards has significant potential to restrict exports.

5. Conclusions

The trade liberalization in goods and services markets noticed in the last fifty years has coincided with the intensification of environmental problems on a planetary scale. Despite some initial resistance, the need for achieving economic development according to sustainability principles has induced countries to establish more stringent legal frameworks for the management of natural resources. Since the 1970s the proliferation of standards and environmental regulations, observed mainly in the United States and Europe, went to merit the attention of economists because of their possible impacts on international competitiveness.

In spite of agricultural production has always been at the center of discussions relating to economic performance and environmental sustainability, the analysis of the impacts generated by an increased number of more stringent environmental policies on trade pattern has always occupied space in the secondary agenda of research. Alongside this process, the practice of discriminating trade of agricultural products, which profit from environmentally degrading production methods, became widely advocated.
The scarcity of studies focusing on the agricultural sector is probably related to the lack of robust statistics, reconcilable and comparable, for a sufficiently large number of countries regarding the accuracy and application of existing environmental regulations. Applying the Environmental Performance Index (Esty et al., 2008), this study aims to contribute to filling this space, assessing the impact of environmental regulations on trade patterns for products considered environmentally sensitive.

The study adapted the HOV model to allow including variables representatives of the environmental regulations imposed by governments.

Similarly to a significant part of the literature relating to industrial segments, the obtained results for models run are also inconclusive to state unequivocally whether the degree of commitment of countries to sustainability principles and policy tools adversely (neoclassical) or positively (revisionist approach) affects trade patterns in environmentally sensitive agricultural sectors.

The maize net exports were the most impacted by differences in environmental status through countries, pointing to a negative effect of the environmental requirements on the commodity international commerce (particularly related to the greenhouse gas issue). The Porter's hypothesis was confirmed by results obtained for wheat (model I), and maize (model II), regarding specifically the indicator for the subsidies goal.

Moreover results point that the origin of net exports (North or South) is a relevant factor to determine trade pattern in the case of soybean, wheat and maize.

Despite a recent trend of increasing environmental regulation, in general the differences in the compliance level to environmental goals among countries seem to play a secondary role in determining their trade pattern for agricultural products.

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