Impact of agricultural trade openness on the Environment and legitimacy of Non-Tariff Measures: That fine line between protectionism and environmental protection

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ABSTRACT

This study attempts to evaluate the impact of trade openness on the agri-environmental efficiency and to disentangle agricultural protectionism from Non-tariff measures' (NTMs) dispositions justified on the grounds of true environmental concerns. To that end, we measure agri-environmental efficiency (AEE) scores based on DEA method of the primary sector of a panel of 109 countries across the globe during the period 2003-2013. This paper provides the classification of 109 countries into 5 groups according to their agri-environmental growth and stability over time. Their breakdown does not meet any economic or income criteria. Low income and high income countries conducting heterogeneous agricultural and environmental policies may belong to the same group and thus, have similar agri-environmental performances. This finding is even more surprising for the European Union given the considerable variation of the AEE among its member states which may suggest that agri-environmental measures undertaken by the Common Agricultural Policy has impacted differently the EU's countries. Further results highlight the synergy between the agricultural trade openness and the environmental efficiency which confirms the Race-to-the-Top hypothesis concerning the F&Vs sector. Furthermore, our results show that endured Technical Barriers to Trade and Quantitative Restrictions turn out to be levers for enhancing the AEE of exporters. Finally, imposed NTMs impact differently agri-environmental performance of importers. Technical Barriers to Trade as well as Sanitary and Phytosanitary measures confirm their consistency with the WTO's terms and their environmental and food safety "legitimacy" contrary to environmentally-related Export Subsidies and agricultural Special Safeguards which are susceptible to be disguised trade protectionism measures.

1. Introduction

Managing sustainably depletable resources became more challenging for agriculture and critically important whether for ensuring food security (Khan and Hanjra, 2009; Tilman et al., 2002), conserving ecosystem services (Dominati et al., 2010; Ribaudo et al., 2010) while coping with global warming (Battisti and Naylor, 2009). Consequently, enhancing agricultural productivity in an ecologically sustainable manner became an urgent target for several governments for the past years by implementing devices for environmental regulation (Moon, 2011). It is no secret that these issues had a low priority during the first four decades of the GATT until the Doha Round, considered as the first WTO round to deal officially with environmental concerns along with the genesis of the Agreement on Agriculture (AoA hereafter) where environmental measures are eligible to the Green Box. Hence, and after being removed at the end of the Uruguay Round, Non-tariff measures (NTMs) especially Agri-environmental programmes' subsidies, Technical Barriers to Trade (TBT) and Sanitary and Phytosanitary (SPS) measures related to environmental protection and food safety were reintroduced. Consequently, environmental side effects have become increasingly integrated into several agricultural policies whether in developed countries (EU and USA), CAIRNS' group or developing countries.

The debate here started by focusing on what does a good agri-environmental policy imply in the first place and how can we measure its stringency? What is the state of the global agri-environmental regulations over the past years and what are their determinants? Does international trade openness impact the agri-environmental regulations' stringency? If so, has it encouraged a "race to the bottom" in environmental standards, or "a race

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to the top," leading to a convergence of standards at a higher level. At this level, it is crucial to understand and address the environmentally related NTMs that accompanied the escalating trend in agricultural trade and globalization. Do endured NTMs affect positively or negatively the agri-environmental performance of exporters? Are these environmentally-related measures levers for enhancing such performance or barriers against it? Compared with the EU, are less NTMs-demanding countries necessarily the least agri-environmentally efficient ones? If so, do all types of NTMs (SPS, TBT…) have the same impact on the agri-environmental efficiency? Then, the questions have turned into the debate over the "legitimacy" of these NTMs and whether they have been more of a "disguised" form of protectionism or, as stipulated in the WTO's Agreement on Agriculture, are purely implemented for food and environmental protection purposes. In international trade, fruits and vegetables (F&Vs) are closely regulated because of the nature, sensitivity and perishability of these products. They are subject to technical measures imposed by partner countries. At the same time, they are among the most important commodity exports for several developed and developing countries.

This paper belongs to a narrow branch of efficiency literature and is the first to be interested in the agri-environmental efficiency assessment related to fruits and vegetables' production of a large sample of 109 countries during the period 2003-2013. Data Envelopment Analysis (DEA) has gained great popularity in environmental modeling in recent years thanks to its nonparametric Frontier approach which does not assume a particular functional form and relies on the general regularity properties such as free disposability, convexity, and assumptions concerning the returns to scale (Daraio and Simar, 2007). Few cross-country studies had applied this technique in order to compute the environmental efficiency of the agricultural sector and are worth mentioning. Kuosmanen (2013) examines the environmentally oriented efficiency of a panel of 13 OECD countries over the time period 1990 –2004 where the results indicates large differences across countries. Furthermore, Vlontzos et al. (2014) attempted to evaluate the energy and environmental efficiency of the primary sectors of the EU member state countries in the 2001–2008 time period. The main findings of the employed DEA model are that countries with strong environmental protection standards (such as Germany, Sweden, or Austria) appear to be less energy and environmentally efficient, compared with countries like Denmark, Belgium, Spain, France or Ireland. Moreover, a series of eastern European countries achieve low efficiency scores, which can be explained by the low technology level implemented in their primary production process. Finally, Hoang and Rao (2010) evaluated the sustainability efficiency of the agriculture sector of 29 OECD countries. Sustainability efficiency is composed by two sub elements. Nevertheless, and to the best of our knowledge, there is not a previous empirical attempt targeting explicitly the impact of NTMs on Agri-environmental efficiency or other **determinants** of any type whatsoever.

To overcome this lack of information and to answer the previously asked questions, our paper proposes a larger-scaled empirical application in order to measure the Agri-environmental efficiency (AEE) considered as proxy for the domestic agri-environmental regulations' stringency of 109 countries during the period 2003 2013. The evaluation is based on a **2-step** radial super-efficiency **Data Envelopment Analysis** (DEA) Window analysis model which allows as a first step, using **time-varying data** and **undesirable output**, to compute the agri-environmental efficiencies besides ranking countries and identifying their efficiencies' evolution and stability during this period. Throughout this paper, we shall assume some knowledge of DEA on the reader's part. Readers who are not familiar with the technique are referred to Charnes et al. (2013), Cooper et al. (2000) and Färe et al. (1994). Another major concern is with regards to the determinants of the Agri-environmental efficiency, subject of the **second step** where AEE scores are further analyzed using the bootstrap technique suggested by Simar and Wilson (1998) to conduct a sensitivity analysis and test the effect of a wide range of variables on the Agri-environmental **in**efficiency (AEI). Besides identifying the impact of climatic (temperature and precipitation), macroeconomic (environmental and R&D public investment) and agricultural trade openness variables (F&Vs' Revealed Comparative Advantage and Degree of trade openness), we investigate separately the impact of **endured** and **imposed** non-tariff measures whether at aggregated (NTMs) or disaggregated level (SPS, TBT, …) on the inefficiency scores.

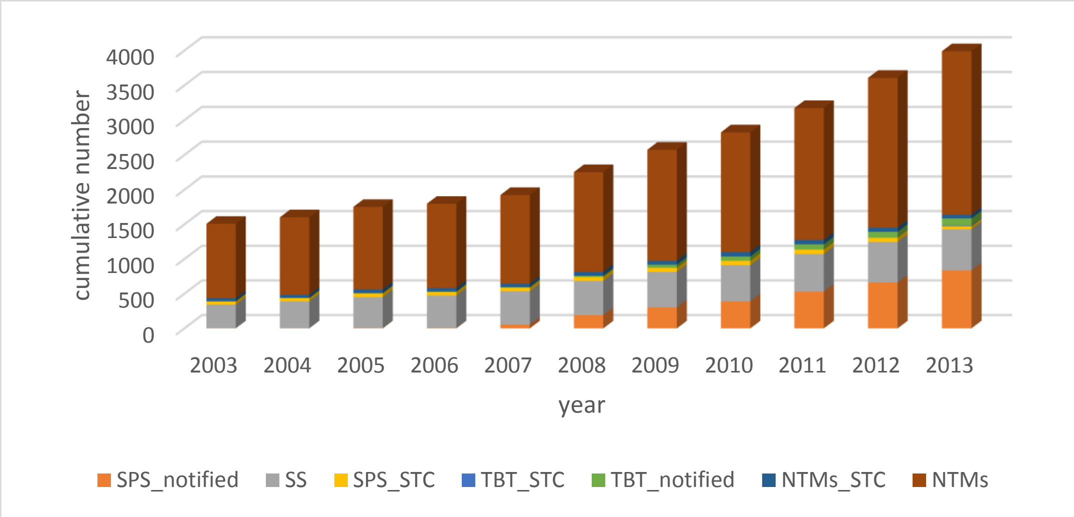
This paper provides a countries' classification into 5 groups according to their agri-environmental growth and stability over time. Their breakdown does not meet any economic or income criteria. Low income and high income countries conducting heterogeneous agricultural and environmental policies may belong to the same group and thus, the same agri-environmental performance. This finding is even more surprising for the EU given the considerable variation of agri-environmental efficiency scores among member states and may suggest that agri-environmental measures undertaken by the CAP has impacted differently the EU's countries. Further results highlight also the synergy between the agricultural trade openness and the environmental efficiency which confirms the Race-to-the-Top hypothesis concerning the F&Vs sector. Furthermore, the paper findings suggest that endured Technical Barriers to Trade and Quantitative Restrictions turn out to be levers for enhancing agri-environmental efficiency of exporters. Finally, imposed NTMs impact differently agri-environmental performance of importers. SPS and TBT measures confirm their consistency with the WTO's terms and their environmental and food safety "legitimacy" contrary to environmentally-related Export Subsidies and agricultural Special Safeguards which are susceptible to be disguised trade protectionism measures. This paper has the following main sections. **In section 2.1** we discuss the current NTMs structure related to F&Vs trade from 2003 to 2013 and look at some theoretical underpinnings and findings on agricultural trade and environment linkage. This is followed by a description of the DEA model in **Section 2.2**, and the second stage truncated model in **section 2.3** as well as the used data. The computed Agri-environmental efficiency scores are reported in **section 3.1**. The effects on the agri-environmental performance of climate variables and domestic investment in environmental and R&D projects are quantified in **Section 3.2**. This is followed by **Section 3.3** in which we analyze the impact of trade openness and the different endured and imposed NTMs on the efficiency scores. We further distinguish among protectionist and effective environmentally-related NTMs in **Section 3.4**. Finally, we draw in **Section 4** clear conclusions on these issues regarding the possibility of "race to the top" hypothesis, the effective role of NTMs and discuss their policy implications.

2. Methodology and data

2.1. Typology of Agri-Environmentally related NTMs and impact of trade openness on environmental regulations: some theoretical foundations

Despite the fact that environmental issues had a low priority during the first four decades of the GATT, they came back with a vengeance in the early 1990s. The starting point of the current debate was a series of contentious environmentally- related trade disputes about agricultural products' trade that has been always a subject of risk of exhaustion of natural resources, biologic and informational risk, and human health. In order to tackle these risks, environmentally related Non-Tariff Measures were reintroduced without imposing barriers to trade. Since its formation in 1995, the Doha Round was the first WTO round to deal with environmental concerns as an official issue and following which, several decisions related to the Agreement on Agriculture (AoA) were made namely i/ the GATT's Article 20 which stipulates that policies affecting trade in goods for protecting human, animal or plant life or health are exempt from normal GATT disciplines under certain conditions ; ii/ Technical Barriers to Trade and Sanitary and Phytosanitary Measures were explicitly recognized as tools for environmental objectives and iii/ Agri-environmental programmes are exempted from cuts in subsidies. Consequently, NTMs became prevalent and tend to be more widespread in agriculture, a sector of greatest interest for exporters in developing countries. Under the agreement on the application of Sanitary and Phyto-Sanitary standards (SPS) adopted in 1995 by WTO members', countries may protect themselves against imports of toxic or contaminating goods. Nevertheless, notified measures must not be of a protectionist nature and must be based on scientific evidence or international sanitary standards such as the Codex Alimentarius. The same motivations and logic apply for the agreement on Technical Barriers to Trade (TBT) that recognizes countries' rights to adopt the standards they consider appropriate whether for human, animal and plant life or health, for the protection of the environment or to meet other consumer interests. Countries can thus impose criteria regarding the way products are produced, subject to (contingent on) the presence of a trace of the production method in the final product (e.g. pesticides).

Figure 2.1. Evolution of imposed NTMs in the World from 2003 to 2013



NTMs data is gathered under the WTO's integrated trade intelligence portal (i-tip) project that has the largest country coverage of the detailed NTMs cumulative number at section 02 corresponding to fruits and vegetables products. Unfortunately, this database does not inform on the likely NTMs' harmonization between countries. In this framework, two categories of NTMs must be distinguished as reported in Appendix 1:

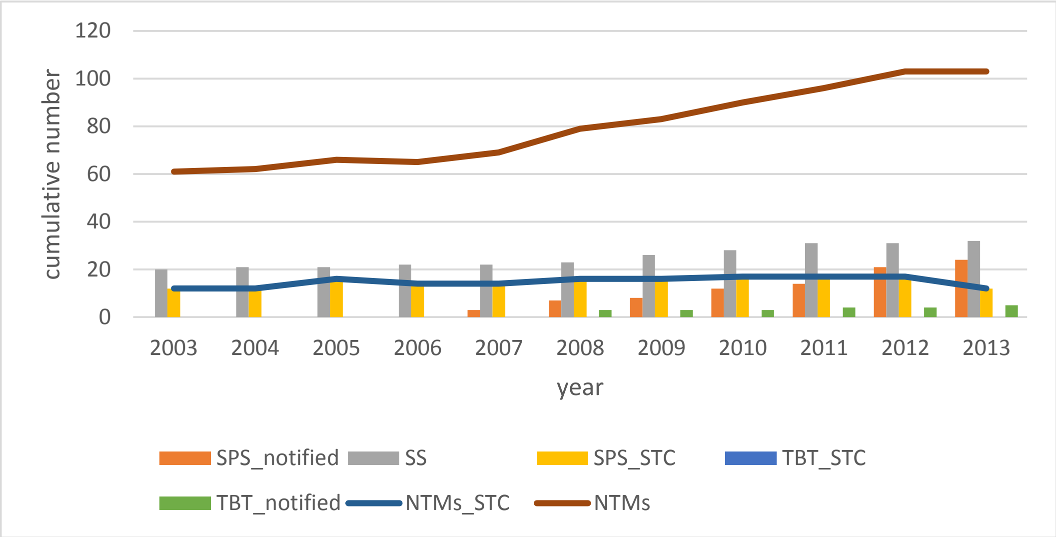
- First category is related to the **Imposed NTMs (NTM-I)**: a country can impose several NTMs including Anti-dumping (AD) duties, countervailing duties (C) , Safeguards (S) measures, Technical Barriers to Trade (TBT), Sanitary and Phytosanitary (SPS) measures, Quantitative Restrictions (QR) as well as State Trading Enterprises (STE), Special Safeguard(SS), Tariff-rate Quotas (TRQ) and Export subsidies (ES) measures from the Agreement on Agriculture (*c.f.* Appendix 2) . Nevertheless, A bare list of imposed NTMs' notifications **(NTM-I-N)** is not a good indicator of the existence of non-tariff barriers[2] and need to be complemented with Specific Trade Concerns **(NTM-I-STC)** i.e. measures that have been imposed by an importer without being notified to the WTO. They are consequently raised by the affected country (exporter).
- Second, the **Endured NTMs (NTM-E)**: a county can be affected by several types of NTMs including Anti-dumping and countervailing duties, Safeguards measures, Technical Barriers to Trade, Sanitary and Phytosanitary measures, Quantitative Restrictions as well as Special Safeguard, Tariff-rate Quotas and Export subsidies measures. As explained earlier, an Endured NTM can be whether notified **(NTM-E-N)** by the imposing member or raised **(NTM-E-STC)** by the affected country.
In this paper, each NTM is distinguished by its category (endured or imposed) and whether is notified (-N) by the imposing country to WTO or raised by the affected country (-STC).

As illustrated in Figure 2.1, and before 2008, imposed SPS measures were mainly not notified to the WTO. For instance, a total of 57 SPS norms were imposed in 2006 among which, only 6 norms were notified under the SPS agreement and the rest were raised by affected countries. The pace of notifications under the SPS agreement has quadrupled over the period 2007-2008. In its World Trade Report, the WTO (2012) highlighted the fact that non-tariff measures increased after the "trade collapse" that followed the 2008 financial crisis. This exponential growth will continue until 2013 where the share of SPS notifications has reached 838 measures. However, unnotified imposed SPS measure recorded stable level during the same period ranging between 46 and 62 non-notified (STC) measures. Imposed TBT measures were mostly notified and went from one norm in 2003 to 104 norms in 2013 among which, only 9 imposed TBT measures were unnotified and

[2] While some WTO members notify all measures, some other members may choose to notify measures which do not follow international standards or only those having trade effects. In search of a better indicator of Technical Barriers to Trade, Sanitary and Phytosanitary measures impact, a complementary source of information is used in I-TIP: Specific Trade Concerns (STC) raised by members. In these STCs, members make complaints about measures taken by other members. Those concerns are recorded by the Secretariat in the minutes of the meetings. STCs may also be raised on non-notified measures.

raised by exporters. Overall, this decade has witnessed a dramatic extent of imposed NTMs going from 1073 in 2003 to 2351 norms in 2013 where the relative share of special trade concerns related to F&Vs did not exceed 63 measures by year.

Figure 2.2. Evolution of NTMs imposed by the EU from 2003 to 2013

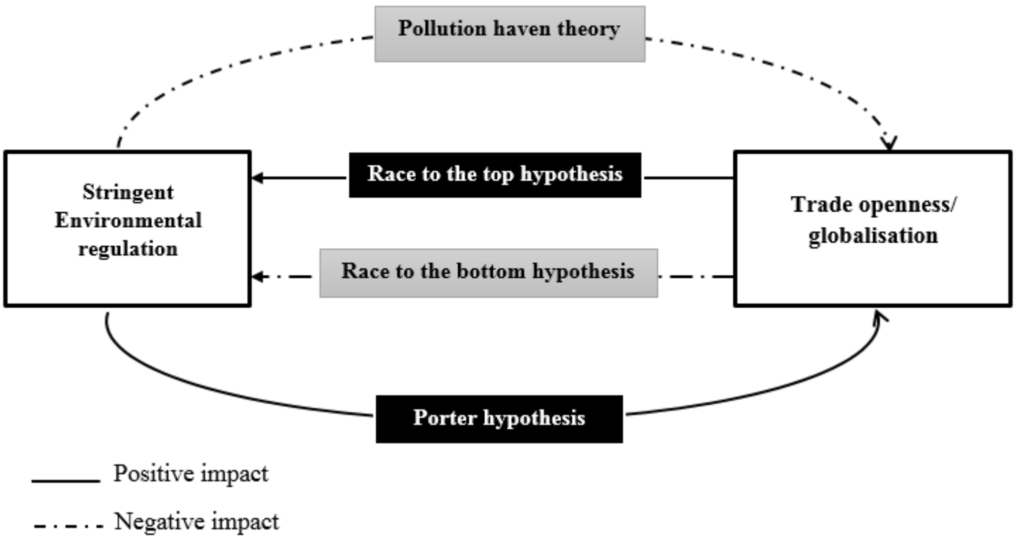


In this framework, we suggest to take a special look at the positioning of the EU, considered as one of the most users of NTMs and the least affected by these norms (Beestermöller et al., 2018a; Fontagné et al., 2005; UNCTAD, 2018) according to whom, access to the European market remains difficult due to its complex and demanding regulatory standards. According to Figure 2.2, the EU follows the global trend where imposed NTMs had considerably increased by 2007-2008. The relative share of total imposed TBT and SPS measures doubled within 10 years and went from 20% of the total imposed NTMs in 2003 up to 40% in 2013. Up to 2006, imposed NTMs were mostly unnotified and raised by F&Vs exporters. Starting from 2008, unnotified measures continued to increase simultaneously with the notified ones until 2005 where NTMs_STC decreased by 5 measures. The introduction of border measures (SPS, TBT…) by importing countries is often the first-best instruments to pursue non-economic to prevent biological risks and inappropriate use of traded products. At the same time, abuse of environmental arguments for protectionist reasons is likely for agricultural products. The environment could be the channel through which non-tariff protection measures, removed at the end of the Uruguay Round, could be reintroduced and following which, several agricultural policies have been reformed to re-introduce environmental measures especially the Common Agricultural Policy of the EU (Fontagné et al., 2005; UNCTAD, 2018).

According to the WTO's Agricultural agreement, **we assume that all the previously cited NTMs are environmentally-related. This assumption implies that the greatest NTMs imposers are the most agri-environmentally efficient ones. Furthermore, the more a country endures NTMs, the less agri-environmentally efficient it is.** In this paper, we will examine the accuracy of these assumptions by exploring the impact of such NTMs on domestic **Agri-Environmental inefficiency** (AEI hereafter). **This article aims also to draw the distinction between legitimate environmental NTMs and protectionism.** If NTMs are "loyal" to their original environmental and food safety purposes as stipulated by the Agreement on Agriculture, there should be a synergy between imposed measures and the quality of agri-environmental policies. In other words, high number of NTMs should be imposed by countries characterized by good (stringent) environmental policy. On the other hand, the more a country endures NTMs, the less agri-environmentally efficient it should be, otherwise, one may conclude that NTMs are not fulfilling their environmental role and thus representing protectionist measures.

This paper aims also at exploring how international trade openness can steer domestic agri-environmental policies. To that end, it is essential to appeal to the Environmental Economics' theories in order to draw the desirable conclusions. The impact of environmental regulation (ER) on the competitiveness of an industry has been a hot topic for economists for some years now as illustrated in Figure 2.3. According to the traditional assumption known as the "Pollution haven hypothesis", an environmental regulation, by adding additional constraints on the possible actions of the companies, increases the production costs of the latter negatively affecting their competitive position on the international markets. This theory implies a deliberate strategy on the part of host governments to purposely "undervalue" the environment in order to attract new investment. However, in recent years, this negative link between ER and competitiveness has been questioned first by Porter (1991), then Porter and Van der Linde (1995). Based on what is now known as "Porter's hypothesis", the introduction of well-designed environmental regulations will, in most cases, lead to innovation that will ultimately be able to generate a rent to cover the costs of compliance and reach new markets. **Another school of thought relates less to environmental regulations' impact on competitiveness and more to environmental outcomes of trade openness.**

Figure 2.3. Main Environmental Economics' theories



The Race-to-the-Bottom hypothesis was initially formulated in the context of local competition for investments and jobs within federal states with decentralized responsibilities for the environment and argue that increased competition for trade and foreign direct investment could lead to lowering of environmental standards and regulations (World Bank, 2000; World Trade Organization, 1999). On the other hand, few previous studies countered this negative link and used the **terms "Race to the Top"** to address the positive impact of globalization on environmental regulation by arguing that increased trade could eventually lead to better environmental protection (Dong et al., 2012; Yao and Zhang, 2008).

In this paper, we borrow the terms to simply refer to the positive impact of the specialization in agricultural exports on tightening Agri-environmental regulation. Will Fruits and Vegetables'(F&Vs) trade openness support the "Race to the Bottom" or "Race to the Top" hypothesis? In order to answer this question, we shall first compute the agri-environmental efficiency (AEE hereafter) scores.

2.2.First stage: DEA

Based on the earlier work of Farrell (1957), **Super-Efficiency Data Envelopment Analysis** (DEA-SE hereafter) models were developed by Andersen and Petersen (1993) to evaluate the relative efficiencies of a set of comparable entities called decision making unit (DMUs) by some specific "output-maximization" programming called **output-oriented** model and rank the DEA efficient ones. Agricultural production process including F&Vs produced by n countries denoted DMUs: $DMU_1, DMU_2 \dots DMU_j \dots DMU_n$ $(j = 1 \dots n)$ can be modelled as transformation of m input items denoted by vector x_{ij} $(i = 1, \dots, m)$ (e.g., land, capital, labour, feed, fertilizers, etc.) into s output items denoted by vector y_{rj} $(r = 1, \dots, s)$ that may contain economic outputs (e.g. fruits, vegetables), environmental services (e.g., landscape management) as well as undesirable outputs (e.g., pollution). The production possibility set which represents the set of observed feasible activities (x, y), denoted P, is written as follows:

$$P = \{(x, y) \mid x \geq X\lambda, y \leq Y\lambda, \lambda \geq 0\} \quad \textbf{(2.1)}$$

where λ is a semipositive vector in $\mathbb{R}^n$. This approach takes the form of a radial CCR-DEA model in order to avoid the possibility of non-solution that is usually associated with the convexity constraint in the Variable Returns to Scale **(VRS)** models (e.g., BCC model[3]). In this section, we aim at estimating the agri-environmental efficiencies related to the fruits and vegetables production in the 109 countries listed in Table 2.4 and address their changes over the period 2003-2013. As described in Table 2.1, all inputs and outputs data is extracted from the FAOSTAT database except for agricultural labour provided by the World Bank. The desirable output of our model ($y^d = y_{1jt}$) is an aggregate variable of fruits and vegetables' production quantity expressed in tonnes at a country-level that is associated with the production undesirable outputs denoted ($y^{ud} = y_{2jt}$). If inefficiency exists in the production, the undesirable pollutants should be reduced to improve the efficiency, i.e., the undesirable and desirable outputs should be treated differently when we evaluate the production performance of agriculture. According to Baumert (2005) and Viard et al. (2013), Nitrous oxide (N_2O) is a greenhouse gas (GHG) that mainly originates from soils and agricultural activities and therefore, is closely tied to the fruits and vegetables production process. Thus the undesirable output (y_{2jt}) is represented by the Emissions (CO_{2eq}) from N_2O in gigagrams. This second output is an aggregated GHG emissions for the N_2O greenhouse gas expressed in CO_2 equivalents. Total agricultural N_2O emissions include sub-domains such as: manure management, synthetic fertilizers, manure applied to soils and pastures, crop residues, burning-crop residues and burning-savanna. Many methods have been proposed to incorporate undesirable outputs into DEA models (Scheel, 2001). Generally, these methods are mainly based on data translation and the utilization of traditional DEA models (Seiford and Zhu, 2002). Given the presence of desirable and undesirable outputs and that all inputs and outputs selected in our model are positive elements, the weaker conditions remain satisfied which allows us to adopt the CCR Radial SE model of Andersen and Petersen (1993). A second advantage of this model is that the use of CCR model avoids the possibility of non-solution that is associated with the convexity constraint in the variable returns to scale models (e.g., BCC model). By introducing the undesirable outputs, P can be written as follows :

$$P' = \{(x, y^d, y^{ud}) : x \text{ produces } (y^d, y^{ud}) \mid x \geq X\lambda, y^d \leq Y\lambda, \frac{1}{y^{ud}} \leq Y\lambda, \lambda \geq 0\} \quad \textbf{(2.2)}$$

that undergoes the following assumptions according to Färe et al. (1989):

- First, **Weak disposability** which requires that reduction of the undesirable output y^{ud} is costly in terms of the proportional reduction of desirable output y^d, i.e. if $(x, y^d, y^{ud}) \in P'$ and $0 \leq \theta \leq 1$ then $(x, \theta y^d, \theta y^{ud}) \in P'$
- and **null-jointness**: if $(x, y^d, y^{ud}) \in P'$ and $y^d = 0$ then $y^{ud} = 0$. The only way to produce zero amount of undesirable output is by stopping the production of y^d

Following the method of Seiford and Zhu (2002), and in order to simultaneously increase the desirable output while decreasing y^{ud}, we apply a **monotone decreasing transformation** (e.g., **$1/y_{2it}$**) to the undesirable output which represents in our case **the pollution abatement** related to the Nitrous oxide (N_2O) emissions associated with the F&Vs production and then to use the adapted variable as output. Moreover, this method preserves the convexity and linearity relations of DEA model. Therefore, the adopted DEA output-oriented model assumes an increase in the desirable output and a reduction in the undesirable output given constant quantities of inputs.

[3] Which refers to the DEA-model of Banker, Charnes and Cooper (Banker et al., 1984).

Table 2.1. Inputs-Outputs description for empirical application

		Label	Variable	Source	Mean	SD	Min	Max
Outputs	y^d	$\mathbf{y_{1jt}}$	fruits and vegetables production	FAO	1.34e+09	6.15e+09	14879	7.40e+10
	y^{ud}	$\mathbf{y_{2jt}}$	Emissions (CO_{2eq}) from N_2O	FAO	17925.3	44871.09	25.0303	375673
Inputs	**Economic**	$\mathbf{x_{1jt}}$	Agricultural land	FAO	13011.95	28796.95	9.2	174364
		$\mathbf{x_{2jt}}$	Agricultural labour	WB	8183.709	35069.67	1.669	334976
	Chemical	$\mathbf{x_{3jt}}$	Pesticides **imports'**	FAO	5941833	3.11e+07	2.483	3.00e+08
		$\mathbf{x_{4jt}}$	Fertilizers	FAO	174.8553	281.8457	.000427	2718.69

As for the selected inputs, they contain two economic production factors such as agricultural land (x_{1jt}) expressed in 1000 hectares of arable lands and permanent crops area in each country. Arable land refers to land under temporary crops (double cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). Land under permanent crops is cultivated with crops that need to be replanted after each harvest. This category includes land under flowering shrubs, fruit trees, nut trees and vines but excludes land under trees grown for wood or timber. The second economic input is Labour (x_{2jt}) and measures the economically-active population in agriculture defined as the number of persons engaged in or seeking employment in the operation of a family farm or business, whether as employers, own-account workers, salaried employees or unpaid workers according the World Bank database.

Our model includes also two chemical inputs namely Pesticides imports' quantity used as a proxy for pesticides' consumption per cultivated hectare (unavailable for all the studied countries). This input is an aggregated variable of all the pesticide items such as insecticides, fungicides, herbicides, disinfectants, etc. expressed in tonnes. Fertilizers (x_{4jt}) are the last inputs used in this model which provide information on the average use per unit area of chemical or mineral fertilizers of each of the following primary plant nutrients: Nitrogen (N), Phosphate (P_2O_5) and Potash (K_2O) expressed in kilogrammes per hectare of cropland. Even if **DEA Super-Efficiency** approach is widely applied in several research fields such as development economics (Martić and Savić, 2001), energy studies (Khodabakhshi et al., 2010), papers related to agricultural economics are not that numerous to our best knowledge and are mainly conducted on micro-level. Han et al. (2014) are among the authors who used a Super-efficiency DEA Model in order to analyze the efficiency of agricultural informatization in Hunan province in China from 2009 to 2013. Super efficiency model was also used by Mathur and Ramnath (2018) in order to measure the efficiency of food grains production in India for the two time periods 1960-1990 and 1991-2014. and identify the years in which food grains production was most efficient.

We recall that the aim of this paper is to evaluate the agri-environmental efficiency (AEE) change over time. To that end, we employ the DEA Window Analysis Approach originally introduced by Klopp (1985) and then developed by Charnes et al. (1984) based on radial approach. The main idea is to capture the temporal impact on agri-environmental efficiency and see its short-run evolution from one window to another (Yue, 1992).

Table 2.2. Windows Breakdown

window 1	~~2002~~[5]	**2003**	2004										
window 2		2003	**2004**	2005									
window 3			2004	**2005**	2006								
window 4				2005	**2006**	2007							
window 5					2006	**2007**	2008						
window 6						2007	**2008**	2009					
window 7							2008	**2009**	2010				
window 8								2009	**2010**	2011			
window 9									2010	**2011**	2012		
window 10										2011	**2012**	2013	
window 11											2012	**2013**	~~2014~~

2002 & 2004: Unavailable data

This analysis provides **trends** of efficiency and the **rank** of each country evaluated in terms of its effectiveness. Thus, the obtained results allow for analyses of trends of the overall agri-environmental efficiency related to the F&Vs sector (Tulkens and Vanden Eeckaut, 1995) during the time period 2003-2013. By this approach, the super efficiency is analyzed sequentially with a certain window width (i.e. the number of years in a window) using time-varying data. The DEA-SE model is applied for every window to estimate the AEE for each DMU or country. The windows are made on the basis of moving average method, that is one DMU is coming and one DMU leaves the system. Following the work of Charnes et al. (2013), Halkos and Tzeremes (2009), Wang et al. (2013) as well as Zhang et al. (2011), we choose a narrow window with the width of three $(w = 3)$ in this study since it tend to yield the best balance of informativeness and stability of the efficiency measure and thus allows to compute credible agri-environmental efficiency results. According to Table 2.2, the second window incorporates years 2003, 2004 and 2005. From the 3rd to the 10th window, when a new period is introduced into the window, the earliest period is dropped. Thus, in window 3, year 2003 will be dropped and year 2006 will be added to the window. Subsequently in window 4, years 2005, 2006 and 2007 will be assessed. This analysis is performed until window 10 that incorporates years 2011, 2012 and 2013. Due to the lack of data in years 2002 and 2014, we apply a two-year window size for both of the first (2003 and 2004) and last (2012 and 2013) windows. As DEA window analysis treats a DMU as different entity in each year, a three-year window width with 11 time periods and 109 DMUs would considerably increase the number of observations of the sample providing a greater degree of freedom.

In the rest of this paper, we donote by $\mathbf{DEA\_SE_{jt}}$ the computed super-efficiency scores, proxy for the Agri-environmental efficiency **(AEE_{jt})** of the jth country in year t. Consequently, we assume that the inverse of these efficiency scores $\mathbf{1/DEA\_SE_{jt}}$ represent the estimated relative inefficiency level of the jth country and tth year relative to the estimated best-practice technology frontier.

2.3.Second stage: Truncated regression

In this section, and once the DEA-SE scores are computed, the paper assumes and test the following regression specification:

$$\begin{cases} AEI_{jt} = \beta_0 + \beta Z_{jt} + \varepsilon_{jt} & \text{j: 1 ... n} \quad ; \quad \text{t: 1 ... T} \\ s.t AEI_{jt} = \frac{1}{DEA\_SE_{jt}} & if \quad DEA\_SE_{jt} < 1 \\ AEI_{jt} = 1 & if \quad DEA\_SE_{jt} \geq 1 \end{cases} \quad \textbf{(2.3)}$$

Where the regressand is the DEA inefficiency scores $(\frac{1}{DEA\_SE_{jt}})$, β_0 is the constant term and β represents the corresponding estimators of the variables Z_{jt}. Z_{jt} is a vector of observation and time-specific variables for DMU_{jt} that are expected to be related to the DMU's inefficiency $\frac{1}{DEA\_SE_{jt}}$ and thus its efficiency score, i.e, DEA_SE_{jt}. ε_{jt} is the statistical noise which distribution is restricted by the condition $\varepsilon_{jt} \geq 1 - \beta_0 - \beta Z_{jt}$ and, following Simar and Wilson (2007) method, assume that this distribution is truncated normal with zero mean (before truncation), unknown variance $\varepsilon_{jt} \approx N(0, \sigma_\varepsilon^2)$, and (left) truncation point determined by this very condition. The employment of the Tobit-estimator to regress **model (2.3)** has been a common practice in the DEA literature until Simar and Wilson (2007, 1999) demonstrated that the results of such approach could be biased for two reasons. First, the endogenous variable (AEI_{jt}) is not an observed one and inefficiency scores are replaced by their estimated values $1/\text{DEA\_SE}_{\text{jt}}$. Second, the first-stage input-output variables can potentially be correlated with the second-stage controls. Therefore, we employ the procedure of Simar and Wilson (2007) to further analyze the determinants of the agri-environmental **(in)**efficiency using the global model **(2.3)**. The usefulness of such technique in energy and environmental DEA-modeling has been empirically demonstrated by Hawdon (2003) and Sanhueza et al. (2004). In their estimation algorithm, Simar and Wilson (2007) use the parametric bootstrap for regression to construct the confidence intervals for the estimates of parameters ($\beta, \sigma_\varepsilon^2$), which incorporates information on the parametric structure and distributional assumption. The selected Z_{jt} variables are developed in **equations 2.4, 2.5 and 2.6** and detailed in Table 2.3.

$$AEI_{jt} = \beta_0 + \beta_1 \text{Precip}_{jt} + \beta_2 Precip^2{}_{jt} + \beta_3 Temp_{jt} + \beta_4 Temp^2{}_{jt} + \beta_5 IG_{jt} + \beta_6 RCA_{jt} + \beta_7 OD_{jt} + \beta_8\ I\_Env_{jt} + \beta_9\ I\_R\&D_{jt} + \sum_{m=1}^{109} \delta_{1\,m} country_j + \sum_{t=2009}^{2013} \gamma_{1\,t}\ year_t + \varepsilon_{jt} \qquad \textbf{(2.4)}$$

$$AEI_{jt} = \beta_0 + \beta_1 \text{Precip}_{jt} + \beta_2 Temp_{jt} + \beta_3 Temp^2{}_{jt} + \beta_4 RCA_{jt} + \beta_5 OD_{jt} + \beta_6 NTM\_E_{jt} + \beta_7\ NTM\_E\_STC_{jt} + \beta_8\ SPS\_E_{jt} + \beta_9\ QR\_E\_N_{jt} + \beta_{10} TBT\_E\_N_{jt} + \sum_{m=1}^{109} \delta_{2\,m} country_j + \sum_{t=2009}^{2013} \gamma_{2\,t}\ year_t + \mu_{jt} \qquad \textbf{(2.5)}$$

$$AEI_{jt} = \beta_0 + \beta_1 \text{Precip}_{jt} + \beta_2 Temp_{jt} + \beta_3 RCA_{jt} + \beta_4 \left| GAP_{EU/NTM\,jt} \right| + \beta_5\ Sign\_GAP_{EU/NTM\,jt} + \beta_6 \left| GAP_{EU/SPS\,jt} \right| + \beta_7\ Sign\_GAP_{EU/SPS\,jt} + \beta_8 \left| GAP_{EU/SPS\_STC\,jt} \right| + \beta_9\ Sign\_GAP_{EU/SPS\_STC\,jt} + \beta_{10} \left| GAP_{EU/TBT\,jt} \right| + \beta_{11}\ Sign\_GAP_{EU/TBT\,jt} + \beta_{12} \left| GAP_{EU/ES\,jt} \right| + \beta_{13}\ Sign\_GAP_{EU/ES\,jt} + \beta_{14} \left| GAP_{EU/SS\,jt} \right| + \beta_{15}\ Sign\_GAP_{EU/SS\,jt} + \sum_{m=1}^{109} \delta_{3\,m} country_j + \sum_{t=2009}^{2013} \gamma_{3\,t}\ year_t + \vartheta_{it} \qquad \textbf{(2.6)}$$

$\varepsilon_{jt}, \mu_{jt}\ and\ \vartheta_{it}$ are error terms and β are parameters and β_0 refers to the constant term.

Model 2.4 allows for the isolation of the causal influences of climatic and some macro-economic factors on agri-environmental inefficiencies **(AEI).** To that end, we introduce three categories of variables as described in Table 2.3. **First, Climate variables** namely Precip and Tempr extracted from FAOSTAT and World Bank databases which reflect annual mean of precipitation and temperature change in each of the studied countries for the period of 2003 through 2013. Climate plays an important role in shaping agricultural systems and a change or variation in the climate directly or indirectly affects the AEI. In low income countries, economies are tied with the primary sector and climate variability is expected to have a major impact on the AEI. In this model, quadratic terms of precipitation $Precip^2$ and temperature $Tempr^2$ are meant to reflect the nonlinearity of the response function between the AEI and climate variables where the function will have either a convex (when the quadratic term is positive) or a concave shape (when the quadratic term is negative). **The second type of variables is macroeconomic** including the country's Revealed Comparative Advantage indicator **(RCA)** related to the F&Vs sector, the Degree of Openness to Trade **(OD)**, the Environmental **(I-Envt)** and Research & development (**I-R&D)** investment share in total agricultural investment.

OD and RCA reflect respectively the importance of international trade linkages for a country and its specialization index of F&Vs exports. The revealed comparative advantage (RCA) indicator was first introduced by Balassa (1965) and employed in our regression model as a specialization index of F&Vs exports from country *j* to different world markets in year t. **RCA** reports the share of exports of sector k which is F&Vs in our case study ($X_{j,F\&Vs}$) in total exports of country j (X_j) on the share of world exports of the same sector ($X_{w,F\&Vs}$) in total world exports (X_w). If the ratio is greater than one, e.g. if the country exports more F&Vs than the world average, then it has a comparative advantage for this good. RCA variable is extracted from Data *World Integrated Trade Solution* and trade openness variable is computed based on FAOSTAT data. A positive impact of trade openness variable on Agri-environmental inefficiency means that trade can directly and negatively influence domestic Agri-environmental policies and norms. However, a negative impact of the OD variable on AEI means that agricultural exports enhance the stringency of environmental policies.

As for the variable RCA, two hypotheses are present: at one hand a positive sign of the estimator suggests that the specialization in F&Vs exports is taking place in the most polluting countries where environmental regulations are not applied or simply absent. On the other hand, a negative impact suggests that countries specialized in F&V are the ones with the highest environmental standards and thus the most stringent environmental policies.

Both of **I-Envt** and **I-R&D** variables are calculated based on FAOSTAT data using to the following equations:

$$\text{I-Envt} = \frac{Environmental\ protection\ expenditure\ in US\$,2005\ prices}{government\ expenditure\ in\ agriculture\ in\ US\$,2005\ prices} \quad \textbf{(2.7)}$$

$$\text{I-R\&D} = \frac{R\&D\ in\ Agriculture, forestry\ and\ fishing\ expenditure\ in US\$,2005\ prices}{government\ expenditure\ in\ agriculture\ in\ US\$,2005\ prices} \quad \textbf{(2.8)}$$

An increasing share of Environmental protection and R&D expenditures are supposed to decrease the Agri-environmental inefficiency of the country.

The third type of variables are the cumulative numbers of endured and imposed NTMs previously described in **section 2.1** and are introduced in equations **2.5** and **2.6**.

Model 2.5 allows to estimate the impacts of all types of endured NTMs on the agri-environmental inefficiency. According to our basic assumptions, effective environmentally-related NTMs imply that cumulative number of endured measures should be positively correlated with the Agri-Environmental inefficiency. In this case, the more an exporter endures NTMs, the less agri-environmentally efficient it is. On the other hand, a negative impact would mean that increasing endured NTMs by an exporter would enhance it to upgrade its Agri-environmental performance. At this point, we shall point out the high potential of **endogeinity problem** between regressors (endured NTMs) and the regressand (AEI).

In an attempt to remedy this, we introduce **model 2.6** where we estimate the impact of imposed NTMs on the AEI in terms of Gap that measures the disparity of norms against the EU**.** We consider in this case the **EU as the reference** and we measure the impact of the gap of imposed NTMs between the EU and each country j on its AEI_{jt} score. To that end, we measure six gap terms (as shown in model 2.6) by country against the different types of NTMs imposed by the EU. **These gaps' variables are proxies for environmental norms' divergence (e.g. alienation if the Gap $\ll 0\ or\ \gg 00 \leftrightarrow |Gap| \gg 0$) or proximity (if Gap$\sim$0) towards the EU norms.** The first gap measures the difference between the total imposed NTMs of the EU and those imposed by the country j. As for the second and third gap terms, we pay a special attention to the impact of the imposed SPS norms and compute $GAP_{EU/SPS\text{-}i,t}$ and $GAP_{EU/SPS\_STC\text{-}i,t}$ that represent respectively the total imposed and unnotified SPS measures' differentials. As for the fourth, fifth and last gap terms, they are respectively related to Imposed TBT, export subsidies and agricultural special safeguards' gap terms.

The **absolute value** of these variables are introduced in model **2.6** to capture the effects of NTMs gap on countries' AEI, e.g its domestic agri-environmental policy. To control for their signs, we introduce also a set of discrete variables denoted $sign\_GAP_{EU/...}$ that take value 1 if $GAP_{EU/..} < 0$; 2 if $GAP_{EU/..} = 0$ and 3 if $GAP_{EU/..} > 0$. EU member states are excluded from the regression of this model.

Table 2.3. Second-stage regression variables & descriptive statistics

	Variable	Mean	Std. Dev.	Min	Max
Climate variables					
Precip $_{j,t}$	Annual mean precipitations	87.07046	61.26019	1.965213	316.2
Temp $_{j,t}$	Annual mean temperatures	.8899708	.4721198	-.447	2.98
Macro-economic variables					
RCA $_{j,t}$	Revealed Comparative Advantage indicator	3.094924	4.589938	0	35.78
OD $_{j,t}$	Degree of Openness to Trade	295.2539	163.6328	37.32342	1011.3
I-Env $_{j,t}$	Environmental Investment‘s share in total agricultural investment	1.427605	1.623965	0	7.35
I-R&D $_{j,t}$	Research & development Investment’s share in total agricultural investment	1.682897	17.25074	0	214.6
NTMs (Non-Tariff Measures) variables					
	Endured NTMs				
NTM-E $_{j,t}$	The sum of endured NTMs including Anti-dumping, technical barriers to trade, Sanitary and Phytosanitary measures …	1417.707	327.7736	999	1988
NTM-E-STC $_{j,t}$	The sum of endured & raised NTMs	4.547123	13.02524	0	56
SPS-E $_{j,t}$	endured Sanitary and Phytosanitary measures	215.8482	201.7614	2	541
QR-E-N $_{j,t}$	endured quantitative restrictions	59.47289	32.52528	40	132
TBT-E-N $_{j,t}$	endured technical barriers to trade	37.45455	36.90679	1	104
	Imposed NTMs’ Gaps between EU and each country j				
$GAP_{EU/NTM\ j,t}$	imposed NTMs’ Gap term	46.86572	46.40517	-207	103
$GAP_{EU/SPS\ j,t}$	imposed SPS measures’ Gap term	3.413678	19.20839	-289	12
$GAP_{EU/SPS\text{-}STC\ j,t}$	Imposed & unnotified SPS measures’ Gap term	18.79316	10.91715	-2	38
$GAP_{EU/TBT\ j,t}$	Imposed TBTs’ Gap term	.8924	2.479	-27	5
$GAP_{EU/ES\ j,t}$	Imposed export subsidies’ Gap term	3.174	6.397	-50	6
$GAP_{EU/SS\ j,t}$	Imposed agricultural special safeguards’ gap term	14.838	21.757	-154	32
sign_$GAP_{EU/\ldots}$	A set of discrete variables that take value 1 if $GAP_{EU/..} < 0$; 2 if $GAP_{EU/..} = 0$ and 3 if $GAP_{EU/..} > 0$			1	3

To refine these models' results, we further differentiate the studied countries with respect to their income group based on the Economies' income groupings of the World Bank[4]and according to which, countries are divided into low, lower-middle, upper-middle, and high income countries. In this paper, we regrouped lower-middle and upper-middle in one group called middle income and we added a fourth category related to the BRICS as shown in table below.

Table 2.4. Country List

Income Group	Countries
High income countries & BRICS	Argentina, Australia, Austria, Belgium, Canada, Chile, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Oman, Poland, Portugal, Republic of Korea, Saudi Arabia, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States of America, Uruguay, Bolivarian Republic of Venezuela, Brazil, China, India, Russian Federation and South Africa.
Middle income countries	Albania, Algeria, Armenia, Azerbaijan, Bangladesh, Belarus, Belize, Bolivia, Bosnia and Herzegovina, Bulgaria, Cameroon, Colombia, Costa Rica, Côte d'Ivoire, Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Ghana, Guatemala, Honduras, Indonesia, Jamaica, Jordan, Kazakhstan, Kenya, Lebanon, Libya, Malaysia, Mexico, Morocco, Namibia, Nigeria, Pakistan, Panama, Paraguay, Peru, Philippines, Romania, Senegal, Sri Lanka, Syrian Arab Republic, Thailand, Tunisia, Turkey, Ukraine, Viet Nam, Yemen, Zambia
Low income countries	Benin, Burkina Faso, Burundi, Cambodia, Ethiopia, Gambia, Madagascar, Mozambique, Niger, United Republic of Tanzania, Togo, Uganda, Zimbabwe

Regressions of model **2.6** are conducted according to the three countries' samples previously defined in order to disentangle agricultural protectionism from dispositions justified on the grounds of true environmental concerns. Let's take the example of the total SPS gap terms. A simultaneous positive sign of β_6 and β_7 would suggest that the gap variable is positively correlated with the AEI scores. In this case, importers that are considerably less SPS-demanding compared to the EU are agri-environmentally inefficient. Consequently, one may conclude that SPS measures are used (imposed) for environmental concerns. However, a simultaneous negative sign of β_6 and positive sign β_7 would suggest the opposite and that less SPS-demanding importers are agri-environmentally efficient.

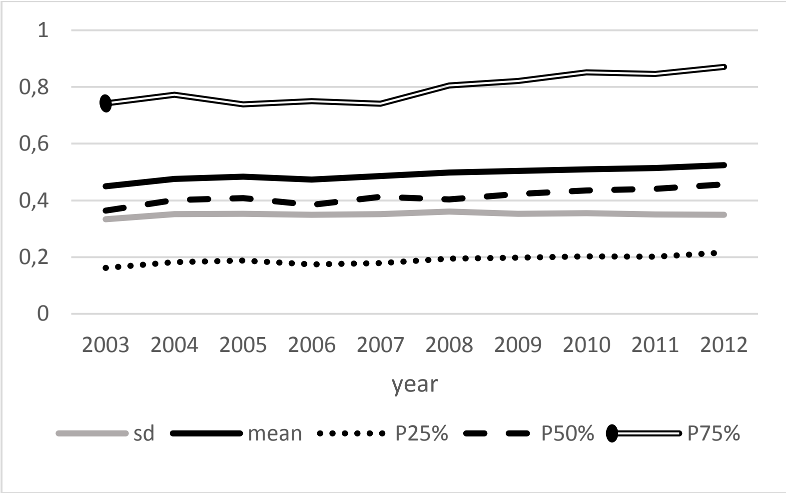
3. Results and discussion

3.1. And the Oscar for Best Agri-Environmental Policy goes to...

According to Table 2.1, F&Vs production ranges from 14879 (Luxembourg) to 74 billion tonnes (China) during the period 2003-3013, an activity associated with Nitrous Oxide emissions which varies from 25 (Malta) to 375 673 gigagrams (China). The used inputs to produce $\mathbf{y_{1jt}}$ and $\mathbf{y_{2jt}}$ also vary considerably from country to another. For instance, agricultural land $\mathbf{x_{1jt}}$ and labour $\mathbf{x_{2jt}}$ are respectively less than 100000 ha and 5000 workers in countries like Malta, Luxembourg and Oman contrary to Canada, Brazil, China India and Russia that represent large agricultural land (over 50 million ha) and intensive agricultural employment (more than 5 million workers per year). In addition, our sample include small chemical products' users like Niger, Benin, and Togo where their fertilizers consumption does not exceed 1 kg per ha against big fertilizers consumers (>1000 kg/ha) namely USA, India and China. The United States also happens also to be, along with the EU member states, an important pesticides importer (>100 million tonnes per year). However, pesticide imports in countries like Benin, Mozambique and Gambia are no more than 1000 tonnes per year.

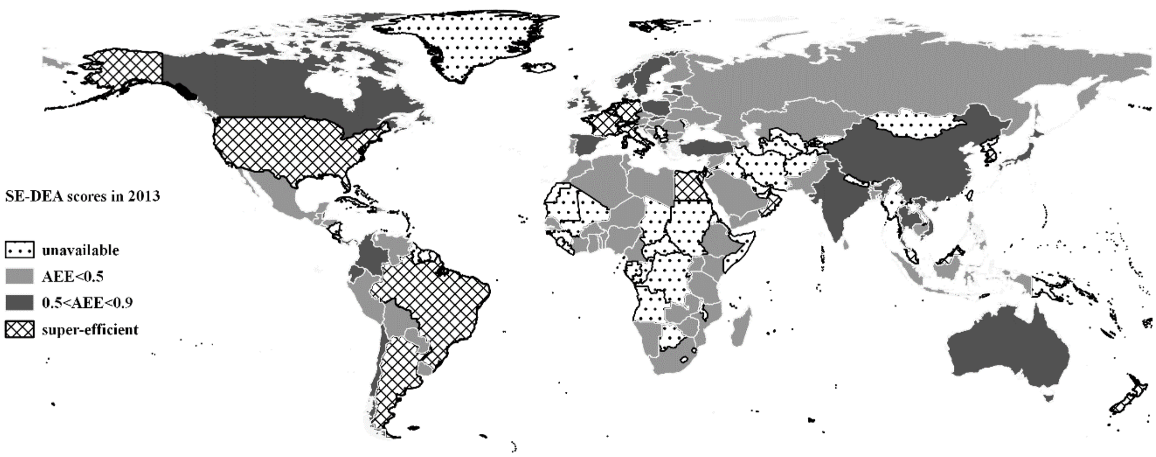
[4] https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries

Figure 3.1. Overall evolution of DEA-SE scores over the period 2003-2013



The computed super-efficiency scores related to the Agri-Environmental performance and the corresponding ranking for each country given the use of these inputs during the period 2003-2013 are reported in Appendix 3. The efficiency values calculated with DEA were the relative values ranging from 0,021 to 1,49. At an aggregated level, we notice an overall improvement in **Agri-Environmental Efficiency (AEE)** scores between 2003 and 2013. According to Figure 3.1, one may notice that the yearly average is in a constant increase during this period. However, this overall average hides an individual heterogeneity as highlighted in Figure 3.2. The geographical breakdown of the AEE scores in 2013 represented by this map stress out the significant AEE gap between **agri-economically** similar countries and in some cases **under the same agricultural policy**. During this period, AEE scores rage from 0.023 to 1.31. Besides, 50% of our sample are agri-environmentally inefficient with DEA scores under 0.45 and only 10% of the studied countries namely Germany, Luxembourg, Israel, Switzerland, Costa Rica, France, Netherlands, Belgium, Argentina… are qualified as super-efficient.

Figure 3.2. DEA-Super Efficiency scores by country in 2013



At this point, analyzing the AEE scores' change over time will most likely be more straightforward to establish relevant findings. Nonetheless, AAGR[5]-based classification is not determinant for drawing any conclusions on the overall agri-environmental regulations of the studied 109 countries. To this end, we introduce the standard deviation over time and by country (sd) of the computed DEA-SE scores as an indicator of the stability

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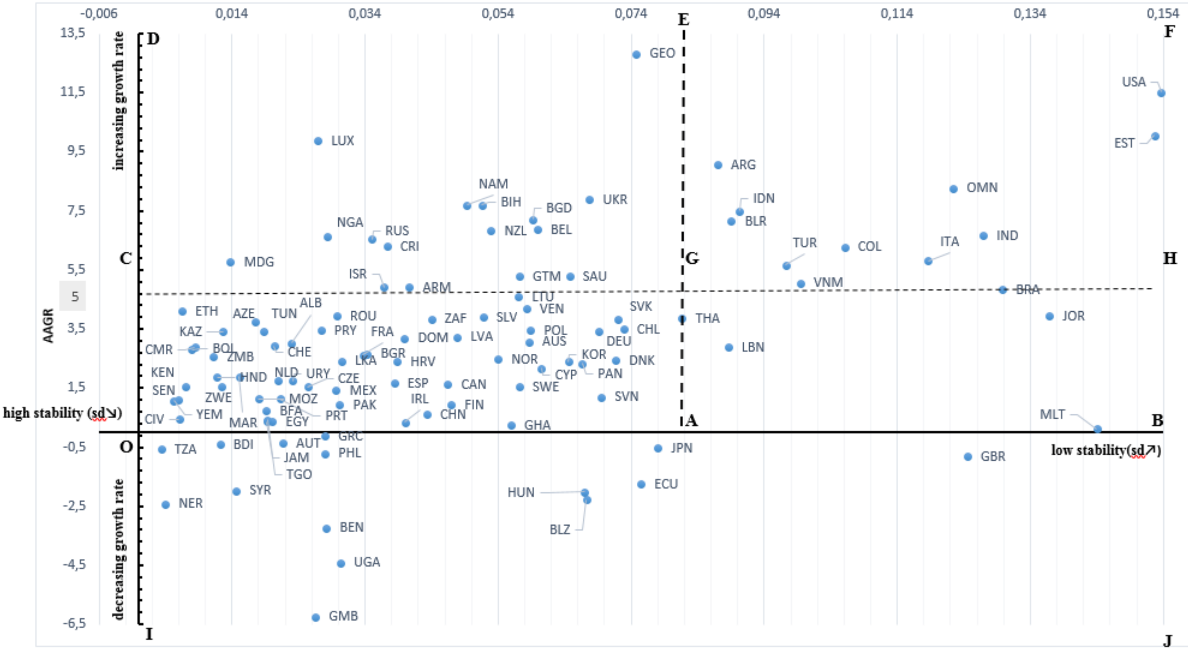
[5] Average Annual Growth Rate (AAGR) = $\left(\sqrt[11]{\frac{AEE_{2013}}{AEE_{2003}}} - 1\right) \times 100$

of the AEE scores. **In other terms, we assume that two conditions must be fulfilled to considered an implemented agri-environmental policy as stringent**: i) Increasing values of AEE scores and thus positive AAGR; and ii) Low standard deviation of the DEA-SE scores i.e. high stability of efficiency scores over time. Given the reported results in Appendix 3 and as shown in the figure below, five group of countries may be distinguished according to the computed AEE scores' average annual growth rate and standard deviation from 2003 to 2013.

Figure 3.3. Classification scheme



<u>Best Agri-environmental practice countries</u> defined by the **area CGED (Group 1)** in Figure 3.3 and includes some CAIRNS'[6] members namely New Zealand, Costa Rica, Guatemala and some high income countries such as Belgium Luxembourg, Israel and Russian Federation. Furthermore, we found some developing countries like Algeria, Bosnia and Herzegovina, Armenia, Bangladesh, Cambodia, Georgia, Madagascar, Nigeria and Saudi Arabia. What these countries have in common is that their AEE score are characterized by sustainably (low sd) high Average Annual Growth Rate over time.

On the other hand, **<u>the worst agri-environmentally practice countries (Group 5)</u>** which recorded decreasing AEE scores (AAGR<0) belong to the area OBIJ where we may find both developed and overly protectionist countries like Austria, Greece, Hungary, United Kingdom (under the CAP) and Japan accompanied solely by two CAIRNS members namely Peru and Philippines as well as the following developing countries: Belize, Benin, Burundi, Gambia, Niger, United Republic of Tanzania, Uganda and Ecuador.

Between these two extremes are situated two country groups that made a trade-off between their agri-environmental efficiencies' stability and growth over this period. **Countries belonging to the area EFGH (Group 2) had recorded obviously the highest yet volatile AEE** scores over this time period. This group includes mostly net food exporters such as the United States of America, Argentina, Belarus, India, Indonesia, Malaysia, Viet Nam and Turkey. Besides Colombia, this country group includes two EU members namely Estonia and Italy.

[6]is an interest group composed of the following 19 agricultural exporting countries: Argentina, Australia, Brazil, Canada, Chile, Colombia, Costa Rica, Guatemala, Indonesia, Malaysia, New Zealand, Pakistan, Paraguay, Peru, the Philippines, South Africa, Thailand, Uruguay, and Vietnam that seek to liberalize global trade in agricultural products.

On the other hand, countries bounded by **the area OACG (Group 3) have "privileged" their AEEs' stability over their growth rate**. This group includes over 52 % of our countries' sample namely seven CAIRNS' members (Pakistan, Australia, Canada, Chile, Paraguay, South Africa and Uruguay), 19 EU member states (Romania, Spain, Sweden, Slovakia, Slovenia, Poland, Portugal, Netherlands, Latvia, Lithuania, Ireland, Finland, France, Germany, Croatia, Cyprus, Czechia, Denmark and Bulgaria), seven net food exporters (Norway, Morocco, Bolivia, Honduras, Ethiopia, Panama and Zambia), nine African countries (Zimbabwe, Togo, Senegal, Mozambique, Kenya, Ghana, Côte d'Ivoire, Burkina Faso and Cameroon), few Mediterranean (Albania, Tunisia, Egypt) and central and southern American countries (Mexico, Venezuela, Dominican Republic, El Salvador and Jamaica) as well as China, Switzerland, Republic of Korea Sri Lanka, Kazakhstan and Azerbaijan. Last but not least, the moderately satisfactory rating countries are defined by the **area GHBA (Group 4)** including Brazil, Thailand (two CAIRNS' members) as well as Malta, Jordan and Lebanon. These countries are characterized by lower growth rates compared to the first and second groups and barely stable AEE scores over time.

Contrary to our expectations, this classification does not meet any economic or income criteria. One may notice the **heterogeneous composition** of each group especially the third and fifth ones. In other words, low income and high income countries conducting heterogeneous agricultural and environmental policies may belong to the same group and thus, the same Agri-environmental performance. This finding is even more surprising for **the EU** given the considerable variation of AEE scores among its member states and may suggest that the agri-environmental measures undertaken by the CAP has impacted differently the EU's countries. As a matter of fact, Agri-environment schemes including environmentally favourable extensification of farming; management of low-intensity pasture systems; integrated farm management and organic agriculture; preservation of landscape…were first introduced into the CAP during the late 1980s and are co-financed by member States. During the period 2007 – 2013, EU's expenditure on agri-environment measures reached nearly 20 billion euros, the equivalent 22 % of the expenditure for rural development. Since 1992, the application of agri-environment programmes has been compulsory for member States in the framework of their rural development plans, whereas they remain optional for farmers and may be designed at the national, regional, or local level so that they can be adapted to particular farming systems and specific environmental conditions. The paper's findings suggest that the CAP's "decoupling" subsidies reform impacted disproportionately its member states and had the expected results in Belgium, Luxembourg and Italy contrary to Austria, Greece and the United Kingdom. A third sub-group of EU's members composed of Romania, Spain, Sweden, Switzerland, Slovakia, Slovenia, Poland, Portugal, Netherlands, Latvia, Lithuania, Ireland, Finland, France, Germany, Croatia, Cyprus, Czechia, Denmark and Bulgaria recorded increasing and relatively stable AEE scores over time. These countries are considered also among the net food exporters in which, the CAP's "decoupling" subsidies effects are being much more noticeable.

Besides the EU, countries like **the United States, Japan, Norway, South Korea and Switzerland** maintain high level of agricultural protection on grounds of public policy. Nevertheless, they present mixed results. **USA** recorded increasing yet volatile DEA scores. Note that this country spent around 5.4 billion US$ on agricultural conservation programs. Its Farm Act of 2008 provided an additional 8 billion for US$ conservation programs and changed the amount of land that may be brought into reserve programs. The country signed also several cooperation agreements on trade and the environment with ASEAN members and other bilateral trade agreements, such as the United States-Bahrain, Chile, Jordan, Morocco, Oman, Peru and Singapore Free Trade Agreements (FTA) in order to uphold the environmental key commitments. Moreover, the United States maintains export restrictions and controls for national security and foreign policy reasons, including international agreements (such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Under the National Environmental Policy Act (NEPA), all genetically engineered animals must undergo an environmental assessment. The outcomes of **Norway, South Korea and Switzerland** highlighted a better stability despite their lower AAGR compared to the USA. For instance, **Switzerland** established the Ecological direct payments as incentives for voluntary environmental contributions beyond minimum environmental eligibility criteria for direct payments like extensive use of pastures and meadows, payments under the Environmental Quality Ordinance, extensive cereal and rapeseed farming, incentive payments to encourage organic farming methods, water protection and sustainable use of natural resources. Moreover, the categories of the revised scheme of direct payments in 2014 are linked to the achievement of specific policy objectives and the provision of public goods such as payments for ensuring food supplies, bio-diversity payments and payments for landscape quality. **As for Japan,** it recorded decreasing agri-environmental performance during this period calling into question its agri-environmental policies. The “basic policy and action plan for the revitalization of its food, agriculture, forestry and fisheries” was introduced in October 2011 and has been driven by several factors such as the environment. Furthermore, the Organic Agricultural Standards (JAS law) was established in accordance with the Codex "Guidelines for Production, Processing, Labelling and Marketing of Organically Produced Foods”. On 27 August 2009, mandatory technical regulations for organic plants were revised and a total of 54 technical regulations are in force based on the JAS law.

Another important point to consider is the distribution of **CAIRNS’ members** in Figure 3.3. Besides Peru and the Philippines, they had recorded increasing AEE scores over time with relatively different levels of stability. As a matter of fact, environmental side effects have become increasingly integrated into several agricultural policies starting by **Brazil** that had implemented the Low Carbon Agriculture Program in 2010 which was set up to finance agricultural practices to reduce greenhouse gas emissions and to encompass investment programs to support the recovery of forests and sustainable agricultural production. Furthermore, Brazilian Government launched the Plan for Low Carbon Emissions in Agriculture which comprises a credit line organized under the Low Carbon Agriculture Program where the disbursements were worth 3.4 billion US$ in harvest year 2012/2013. Brazil’s level of support to its agricultural producers is relatively low compared with other like OECD countries, but it maintains several domestic support measures, including preferential credit lines and price support mechanisms. For example, the Federal Government agricultural credit programs administered by the Brazilian Development Bank initiated in 2012 a Program to Strengthen Household Agriculture that provided credit to small-scale producers with annual income up to 160,000 us$ per family according to many criteria like organic and agri- ecological production systems; environmental technologies. On its part, the **Costa Rican** government had enacted in 2013 numerous laws and decrees concerning various aspects of agricultural activity. They include the Law on the Development, Promotion and Fostering of Organic Farming (Law No. 8591 of 28 June 2007) and its regulations that govern and promote organic farming activities by means of fiscal and financial incentives. The incentives include exemptions from tariffs and other levies on imports of equipment, machinery, inputs and work vehicles, income tax and the tax on the sale of organic products. Moreover, the Law No. 8631 applies to varieties of all plant genera and species and contains provisions on protection, procedures and enforcement. The Costa Rican Ministry of Agriculture and Livestock had also initiated the State Phytosanitary Service (SFE), which is in charge of the sanitary protection of all products of plant origin, including biotechnology organisms or products for agricultural use, and the National Animal Health Service (SENASA).

Furthermore, several developing countries had recorded increasingly stable AEE scores over the time period of 2003-2013 including China, India, Indonesia, Nigeria Côte d'Ivoire and Mexico to cite only a few. As a matter of fact, **China** had introduced the Green for Grain program on a pilot basis in 1999 with the objective of encouraging afforestation, reversing ecological degradation and soil erosion, and reducing over-cultivation of sensitive land. This has been followed by a series of tax policies implemented to promote energy conservation and environmental protection as well as harmless-input subsidies. In **India**, state trading of exports has the claimed purpose of ensuring better marketing and prices of agricultural products, grown by small-scale farmers. The country imposes also export taxes in order to preserve and promote further processing of natural resources. In 2010, **Indonesia** enacted a new Law on Horticulture (Law No. 13/2010) that requires importers of horticultural products to ensure the safety aspect of the imported food. The country has also implemented an export licensing system to ensure natural resources and endangered species’ protection. Furthermore, agricultural products like crude palm oil and raw cocoa are subject to export taxes to minimize environmental damage caused by uncontrolled agricultural production and prevent illegal exports. For its part, the **Mexican** agricultural policy was reorganized between 2007 and 2012 and has introduced environmental goals in order to reverse the deterioration of the ecosystems and manage the harmonious development of the rural market. In the area of bioenergy and alternative sources, the Natural Resources Sustainability program seeks to promote the production of biofuels, bio-fertilizers and organic manures and the use of renewable energy. Besides, Mexico had implemented the “Direct Support to Farmers Program (PROCAMPO)” in 1994 considered as one of the most important means of providing domestic support for agriculture. PROCAMPO provides for direct payments per hectare to producers who plant any legal crop, on condition that the land continues to be used for agricultural production or for an environmental protection program authorized by the Secretariat of the Environment and Natural Resources (SEMARNAT). Support is linked to productivity, namely, $160 per quintal, up to 10 quintals per hectare and up to 20 hectares per producer, for conventional coffee, and $410/hectare for producers with recorded marketing in one of the two previous cycles and the current cycle, up to 20 hectares per producer, for sustainable coffee.

Most of the **Southern and Eastern Mediterranean countries** had recorded increasing yet more or less stable AEE sores except for Syria which recorded negative AAGR. Most of these countries had signed and ratified many Multilateral Environmental Agreement as mentioned in Appendix 4. Computed agri-environmental performances of Morocco, Tunisia, Albania and Egypt are similarly higher and more stable than those of Lebanon. Nonetheless, Israel and Turkey are **ranked among the best Agri-environmental performing countries**. **Israel**'s accession to the OECD was a catalyst for important reforms, for instance, in the area of chemicals management and environmental protection, including cooperation in the fields of green growth strategy and eco-innovation. Its government has a strong regulatory role in agriculture in order to ensure food security, export expansion, rural development and preservation of the environment. **In Turkey**, the Agricultural Law specifies complementary instrument to support agriculture, including environmental payments, particularly soil erosion and overuse of water resources. The country has also adopted a Biosafety Law and a related Genetic Modified Organisms Regulation in 2010 regulating all aspects of agricultural biotechnology. Agri-environmental regulations have been also implemented by several African countries. For instance, **Central African Economic and Monetary Community** (CEMAC) countries have harmonized their pesticide registration procedures in March 2006. Since being established in 2007, Pesticides Committee of Central Africa (CPAC) has been taking stock of the use of pesticides and developing the tools required for registration. Moreover, the CEMAC countries are signatories to the Convention on International Trade in Endangered species of Wild Fauna and Flora (CITES). On their side, **Benin, Burkina Faso and Mali** adopted in January 2008 a Common Environmental Improvement Policy (PCAE) whose objectives are to reverse the trends of deterioration and reduction of natural resources, improving life environments and maintaining biodiversity and with commitment to harmonize and standardize their environmental standards and technical regulations, and to promote the sustainable management of natural resources, renewable energy sources and management of environmental problems.

The few studies (Hoang and Alauddin, 2011; Hoang and Coelli, 2011; Hoang and Rao, 2010; Kuosmanen, 2013; Vlontzos et al., 2014) having assessed the energy and environmental efficiency of the agricultural sector had confined their research to the EU or OECD countries without addressing its determinants. At this level, one question arises: How can we explain the Agri-environmental inefficiency variability within countries and their volatility over time? Is it due to climatic variables? Does agricultural trade openness and the Non-tariff measures from the WTO Agreement on Agriculture have an impact on Agri-environmental inefficiency (AEI) and thus the stringency of the domestic environmental policies?

3.2. Impact of climate, agricultural investment on agri-environmental inefficiency

After estimating the DEA-SE scores, the conducted two-stage allows the isolation of the causal influences of contextual factors on agri-environmental inefficiencies (AEI) of each country j (j=1…109) in year t. In a panel data framework, the three models **2.4, 2.5 and 2.6** previously describes in **section 2.3** are estimated.

In model 2.4, we look for estimating the impact of climate on the agri-environmental inefficiency (AEI) performance of the studied countries. According to the results reported in Table 3.1, the overall sample shows that inefficiency is more sensitive to temperature (β=1.39) than precipitation changes ($\beta=3.10^{-3}$) except for the BRICS and high-income countries where rainfall ($\beta=-4.10^{-3}$) decreases significantly but slightly the inefficiency. Results show that further temperature (β=1.4) has positive affect on AEI which means that hot climate countries are more agri-environmentally inefficient. However, increasing temperature have a negative effect ($\beta_4<0$) on inefficiency beyond a certain threshold equal to 1.55 ($\frac{\delta AEI}{\delta Tempr} = 0$). Furthermore, and despite the non-significance of Precipitation estimators (β_1) in models **I.1** and **I.4** (Table 3.1), they are positive which means that more abundant rainfall increases the inefficiency. This may be explained by the excessive use of pesticides and fungicides in wetlands. As for the $Precip^2$, it has almost zero impact on the inefficiency ($\beta_4 \sim 0$). Thus, the non-linearity of the relationship between rainfall and AEI is not be verified in our case.

Environmental protection estimators in overall sample (β_8=-1.14) as well as for middle and low income sample (β_8=-1.358) are relevant and decreases the inefficiency. Furthermore, R&D expenditures' estimator decreases significantly and highly the agri-environmental inefficiency in low and middle income countries (β_9 = -21.05).

However, climatic conditions are not relevant in low-income countries and do not have a significant impact on the AEE scores.

Table 3.1. Climate variables and some macro-indicators' impacts on Agri-environmental Inefficiency

Variables	M1.1	Model 1.2	Model I.3	Model 1.4	Model 1.5
Precip		0.00299	-0.00476***	0.000725	0.0544***
		(0.0194)	(0.00170)	(0.00750)	(0.0206)
(Precip)²		-1.40e-05			
		(5.67e-05)			
Temp		1.390**	0.122	0.409	0.847
		(0.664)	(0.116)	(0.359)	(0.747)
(Temp)²		-0.451*	-0.0493		
		(0.256)	(0.0563)		
RCA	-.61**		-0.0159	-0.139**	0.216
	(.33)		(0.0701)	(0.0697)	(0.411)
OD	-.0018		-0.000591*	-0.0116***	-0.0965**
	(.0136)		(0.00047)	(0.00312)	(0.0408)
I-Env	-1.147**				-1.358**
	(.5613)				(0.600)
I-R&D	1.38				-21.73**
	(3.15)				(8.707)
Constant	.9381***	5.896***	3.151***	11.70***	29.53***
Observations	435	435	152	283	283
	(0.104)	(1.062)	(0.180)	(1.577)	(9.211)
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Selected countries	All	All	HI[7]&BRICS	LI[8]&MI	LI&MI[9]

Bootstrap standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

3.3.Is agricultural trading good for the environment?

Throughout the whole sample, estimators showed negative impact of agricultural Trade openness (β_6= -0.61; β_7=-0.0018) on AEI which means, by deduction that they influence positively the agri-environmental efficiency scores. Trade openness estimators are more significant for low and middle income countries (models I.4 and I.5) than the BRICS and High-income countries (β_7= -6.10^{-4}). A negative impact of OD on Agri-environmental inefficiency means that trade can directly and positively influence domestic Agri-environmental policies and norms. This means that trade openness enhances the stringency of environmental policies especially in low and middle-income countries. According to Table 3.1, higher revealed comparative advantage index (RCA) for fruits and vegetables exports decreases the inefficiency. RCA variable estimator back up these findings with negative and significant estimated parameters for both BRICS/HI (β_8= -0.016) and MI/LI groups (β_8= -0.14). However, the weight of the Fruits and vegetables' revealed comparative advantage indicator is higher than the Degree of Openness to Trade in this model. These results suggest that the specialization in F&Vs exports is enhancing countries to upgrade their agri-environmental regulations, i.e. the stringency of their environmental policies. This finding confirm the previously stated hypothesis which suggests that Fruits and Vegetables-exporting countries are the ones with the highest environmental standards and thus the most stringent environmental policies. This finding backs up the **"Race to the Top"** hypothesis, according to which globalization stimulates innovations and environmental regulations. Bilateral, multilateral and International agricultural trade agreements appear as an opportunity to beneficially reorient national and regional agricultural policies towards green technologies and F&Vs products.

[7] High income countries
[8] Low income countries
[9] Middle income countries

3.4.Distinguishing among environmentally-related and protectionist NTMs

Table 3.2. Impact of the endured Non-tariff measures on Agri-environmental Inefficiency

Variable	Model 2.1	Model 2.2	Model 2.3	Model 2.4	Model 2.5
RCA	-0.127***	-0.125**	-0.24**	-0.045	-0.048
	(0.0487)	(0.0547)	(0.109)	(0.068)	(0.055)
OD	-0.009***				-0.0022***
	(0.00247)				(6.10^{-4})
Precip	-0.00251				
	(0.00687)				
Temp	0.283	0.339	2.41**	0.0309	0.0111
	(0.779)	(0.225)	(1.42)	(0.05)	(0.19)
$(Temp)^2$	-0.389				0.0137
	(0.296)				(0.072)
NTM-E	0.207**				
	(0.108)				
NTM-E-STC		-0.727	2.59	-0.201	
		(1.53)	(1.86)	(0.27)	
SPS-E		0.234**	3.43***	0.024**	0.028
		(0.105)	(0.89)	(0.014)	(0.020)
QR-E-N		-0.0811**	-1.12***	-0.008**	-0.01
		(0.0343)	(0.29)	(0.005)	(0.006)
TBT-E-N		-0.563**	-7.72***	-0.064**	-0.077*
		(0.236)	(1.92)	(0.033)	(0.047)
Constant	-415.3**	-46.01*	-816,64***	-2.223	1.776
	(210.4)	(25.49)	(218,24)	(3.54)	(5.07)
Observations	435	435	65	152	218
Country FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Selected countries	All	All	LI	HI&BRICS	MI

Bootstrap standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Both of models 2.5 and 2.6 allow us to extend the analysis of the impact of international trade rules on domestic agri-environmental efficiency and to conclude whether the environmentally-related NTMs applied to imports of F&Vs could be a major factor affecting the agri-environmental performance of the studied countries or not.

Table 3.2 presents the estimations of **equation 2.5** and the impact of the **Endured NTMs** by each country on its own agri-environmental inefficiency. Overall (models II.1 and II.2), the endured NTMs estimator is significant and additional endured norms increase the inefficiency (β= 0.207) which means that the more a country is affected by non-tariff measures when exporting fruits and vegetables, the less agri-environmentally inefficient it is. As for the endured but not notified NTMs variable **(NTM-E-STC),** it is not relevant in this model but are of negative sign (β = -0.727) meaning that efficiency increases when these measures are more numerous as well, especially for the BRICS and High income countries (β = -0.201). The rest of the table allows us to uncover the impact of endured NTMs in details and examine the relevance of measures like quantitative restrictions, technical barriers to trade and SPS norms. **Endured SPS (SPS-E)** variable is positive and significant for the entire sample (β = 0.234) as well as for all the clusters except for the middle-income group. This result suggests that less agri-environmentally efficient countries are the most affected by SPS norms. We note also that the agri-environmental performance in low income countries is more sensitive to endured SPS (β = 3.43) than the BRICS and High income economies (β = 0.024). The vulnerability of agri-environmental efficiency scores of LI countries toward endured SPS norms may be explained by the weight as well as the position that the primary sector still occupies in their economies. The more they are affected by SPS, the less they export agricultural products and the less they will be able to promote their primary sector (public and private investment in environment and R&D). This explains the low scores recorded by some African (Benin Burkina Faso Burundi Cameroon Cote d'Ivoire Ethiopia Gambia Ghana Kenya Madagascar

Mozambique Namibia Niger Nigeria Senegal Zambia Zimbabwe) and Asian (Azerbaijan Bangladesh Cambodia Georgia Kazakhstan) countries during the period 2003-2013. These countries had set up and ratified several environmental policies whether at national or international scale to meet the Sustainable Development Goals set up by the united nations dealing with the fight against poverty, food security and climate change.

We note also that endured QR variables have significant and negative effects on environmental inefficiency. This effect is higher in LI countries (β =-1.12) than in BRICS & HI ones (β =-8.10-3). Accordingly, and averall, the more a country endures TBT, the less agri-environmentally inefficient it is (β =-0.56). The same result is confirmed for LI countries (β =-7.72) and HI ones (β =-0.064). These findings suggest that the more a country is affected by TBT and QR measures, the better its agri-environmental performance will be. Among these countries, we find several Mediterranean, BRICS and CAIRN's countries. **Unlike endured SPS measures, TBT and QR turn out to be levers for enhancing agri-environmental efficiency of exporters.**

Estimations of **model 2.6** allow us to determine the impact of aggregated and disaggregated of NTMs' EU-gap variables on the AEI. The results are reported in both of Table 3.3 and Table 3.4 and allow us to draw the following conclusions. **Imposed NTMs' gap** do not have any impact on the inefficiency scores of the sample as a whole nor on Low and Middle income countries. However, its absolute value **$|GAP_{EU/NTM}|$** is significant, and slightly decreases (β =-0.0135) the inefficiency of High income countries and the BRICS (M3.2). Moreover, the estimator of the variable (**$sign\_GAP_{EU/NTM}$)** is in turn significant and positive (β =1.84) which means that HI & BRICS countries that are imposing more NTMs than the EU such as China, Norway, Republic of Korea, USA and Venezuela are necessarily characterized by high agri-environmentally performance. So far, environmentally related imposed NTMs are in line with the WTO terms'. However, is there a disparity between the different types of these norms?

Start with **SPS measures' gap variable** which is, once again, only significant in case of High income & BRICS countries (M3.5). The estimator is around 0.03 which implies that countries that aren't as SPS-demanding as the EU are agri-environmentally inefficient. This implies that HI & BRICS countries that impose less SPS norms than the EU on their food imports are most likely to be less agri-environmentally efficient. The same conclusion emerges from the **imposed and unnotified SPS** imposed norms' gap variable $|GAP_{EU/SPS\_STC}|$ which is significant and positively correlated with HI &BRICS (β =0.036) and low income (β =1.258) inefficiency scores'. This suggest that BRICS as well as high and low income countries that are imposing considerably lower number of SPS measures, whether notified or not, than the EU are more likely to be agri-environmentally inefficient. **SPS measures confirm therefore their consistency with the WTO's terms and, consequently, their environmental and food safety legitimacy. Is it the same case for TBT, export subsidies and agricultural special safeguards?**

Simultaneous significant and negative estimators of both **$|GAP_{EU/ES}|$ and $sign\_GAP_{EU/ES}$** variables in model M4.4 (β_{12} =-0.0075; β_{13} =-0.336) and M4.6 (β_{12} =-0.038; β_{13} =-2.88) would suggest that the BRICS as well as high and low income countries imposing significantly less Export Subsidies measures than the EU are agri-environmentally efficient ones.

The same finding is maintained for Agricultural special safeguards (SS) measures. HI & BRICS (β_{14} =-.0357) and Low income (β_{14} =-1.72) importers that aren't as SS-imposing as the EU are not necessarily agri-environmentally inefficient. **Thus, using ES and SS measures by importers do not necessarily imply environmental concerns.**

Nonetheless, different conclusions may be drown concerning **TBT measures**. Results of models M4.1, M4.2 and M4.3 in Table 3.4 show that the higher the EU-TBT Gap, the more agri-environmentally inefficient are BRICS & HI (β_{10} =.0055; β_{11} =0.612), LI (β_{10} =.0055; β_{11} =0. 612) as well as MI (β_{10} =.114; β_{11} =3.09) countries. In other words, less TBT imposing importers (compared to the EU) are characterized by low agri-environmental efficiency scores. **Along with SPS measures, TBT norms confirm their consistency with the WTO's terms and, consequently, their environmental concerns.**

Table 3.3. Impact of EU-NTMs' Gap on Agri-environmental Inefficiency (Part 1)

	OVERALL NTMs				SPS MEASURES			UNNOTIFIED SPS MEASURES		
VAR	**M 3.1**	**M 3.2**	**M 3.3**	**M 3.4**	**M 3.5**	**M 3.6**	**M 3.7**	**M 3.8**	**M 3.9**	**M 3.10**
RCA	-.11**	0.0327	-0.279**	-0.057	0.0617	-.279**	-0.0474	-.00023	-0.279**	-.063
	(.054)	(0.0663)	(0.133)	(0.057)	(0.0654)	(.113)	(0.0644)	(0.0631)	(0.128)	(.051)
Precip	-.001	-0.00362**	0.0521	0.00045	-0.00278	.051	0.000505	-0.004***	0.0518	.00042
	(.006)	(0.00158)	(0.0386)	(0.0012)	(0.00172)	(.036)	(0.00138)	(0.00156)	(0.0364)	(.0013)
Temp	.33	0.0102	3.145*	.056	0.00977	3.47**	0.0554	0.0218	3.479**	.056
	(.24)	(0.0439)	(1.758)	(0.069)	(0.0387)	(1.83)	(0.0699)	(0.0469)	(1.720)	(.070)
$\|GAP_{EU/NTM}\|$	-.0018	-0.0135***	-0.685	0.0002						
	(.013)	(0.00442)	(0.441)	(0.003)						
$sign\_GAP_{EU/NTM}$	-.309	1.849***	-	-0.155						
	(2.99)	(0.255)	0	(0.26)						
$\|GAP_{EU/SPS}\|$					0.0293***	-1.34	0.0001			
					(0.00611)	(1.06)	(0.00209)			
$sign\_GAP_{EU/SPS}$					-.0505	0	-0.168			
					(0.079)	(0)	(0.124)			
$\|GAP_{EU/SPS\_STC}\|$								0.036*	1.258***	-.020
								(0.0198)	(0.477)	(.054)
$sign\_GAP_{EU/SPS\_STC}$								0	0	0
								(0)	(0)	(0)
Constant	7.55	-0.0583	26.23	6.243***	2.533***	16.11	6.714***	1.606**	-29.18	7.164***
	(5.73)	(0.318)	(51.01)	(1.465)	(0.232)	(12.49)	(0.297)	(0.778)	(22.30)	(1.97)
Observations	435	156	65	218	156	65	218	156	65	218
Year & Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Selected countries	All	HI& BRICS	LI	MI	HI & BRICS	LI	MI	HI & BRICS	LI	MI

Bootstrap standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.4. Impact of EU-NTMs' Gap on Agri-environmental Inefficiency (Part 2)

VAR	TECHNICAL BARRIERS TO TRADE			EXPORT SUBSIDIES			AGRICULTURAL SPECIAL SAFEGUARD		
	M 4.1	M 4.2	M 4.3	M 4.4	M 4.5	M 4.6	M 4.7	M 4.8	M 4.9
OD	-.0001*	-.0219 ***	-.0023***	-.00041	-.0236**	-.002**		-.022***	-.0021**
	(.0003)	(.0074)	(.0006)	(.00052)	(.0078)	(.0007)		(.008)	(.0007)
Precip					.0505				
					(.0364)				
Temp					3.362*			2.773	.044
					(1.63)			(1.731)	(.064)
$\lvert GAP_{EU/TBT} \rvert$	.0055*	.888*	.114*						
	(.0431)	(.64)	(.0491)						
$sign\_GAP_{EU/TBT}$	.612***	.052*	3.092 ***						
	(.115)	(1.349)	(.2552)						
$\lvert GAP_{EU/ES} \rvert$				-.0075**	0	-.038*			
				(.0026)		(.024)			
$sign\_GAP_{EU/ES}$				-.336***	0	-2.88***			
				(.0569)		(.118)			
$\lvert GAP_{EU/SS} \rvert$							-.0357***	-1.872*	-.0285
							(.0093)	(.934)	(.047)
$sign\_GAP_{EU/SS}$							2.265	0	1.84
							(.283)	(0)	(1.43)
Constant	.167***	11.641*	.315 ***	.1947***	11.00*	.32***	.19 ***	73.63 ***	.7495 ***
	(.01)	(5.746)	(0.015)	(.0118)	(4.449)	(.015)	(.012)	(28.64)	(2.730)
Observations	156	65	218	156	65	218	156	65	218
Year & Country FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Selected countries	HI& BRICS	LI	MI	HI & BRICS	LI	MI	HI & BRICS	LI	MI

Bootstrap standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

These findings highlight the fact that environmentally-related NTMs impact differently the measured agri-environmental inefficiency and allow us to decouple protectionism from justified environmental and food safety measures. Two categories of norms are distinguished: First SPS and TBT measures which are positively correlated with AEI scores despite the country's income group confirming thus their environmental protection "legitimacy". However, environmentally-related export subsidies and agricultural special safeguards gap variables are negatively correlated with the agri-environmental inefficiency scores and mostly significant in case of high income and BRICS group of countries. Consequently, they are susceptible to be disguised trade protectionism measures.

4. Conclusions and implications

This paper aims to shed light on some of the key questions arising from agricultural policies reforms, trade and environmental issues by providing additional empirical evidence. To that end, we estimate the agri-environmental efficiency related to the Fruits and Vegetables production in 109 countries during the period 2003-2013. The yearly average of the DEA scores is in a constant increase from 2003 to 2013. However, it hides an individual heterogeneity. Countries like Belgium, Argentina, Costa Rica, France, Germany, Israel, Italy, Luxembourg, Malta, Netherlands, New Zealand, Oman or China are among the **best 20** Agri-Environmentally efficient countries in 2013. Moreover, two conditions must be fulfilled to considered an implemented agri-environmental policy as stringent: i) Increasing values of AEE scores and thus positive annual growth rate; and ii) Low standard deviation of the DEA-SE scores i.e. high stability of efficiency scores over time. Our findings provide a countries classification into 5 groups according to their agri-environmental growth and stability over time. Their breakdown does not meet any economic or income criteria. Low income and high income countries conducting heterogeneous agricultural and environmental policies may belong to the same group and thus, the same Agri-environmental performance. This finding is even more surprising for the EU given the considerable variation of agri-environmental efficiency scores among member states and may suggest that the agri-environmental measures undertaken by the CAP has impacted differently the EU's countries. Overall, net food exporters and several CAIRNS' member are well ranked.

In order to explain the determinants of the agri-environmental performance, we introduced c**limate and macroeconomic** variables including the Revealed Comparative Advantage indicator (RCA) related to the F&Vs sector, the Degree of Openness to Trade (OD), the Environmental **(I-Envt)** and Research & development (**I-R&D)** Investment share in total agricultural investment. In international trade, fruits and vegetables are closely regulated because of the nature, sensitivity and perishability of these products and are subject to non-tariff measures imposed by partner countries.

The results highlight also the synergy between the environmental efficiency and the agricultural trade openness which confirms the Race-to-the-Top hypothesis concerning F&Vs sector. Furthermore, the paper findings suggest that endured Technical Barriers to Trade and Quantitative Restrictions turn out to be levers for enhancing agri-environmental efficiency of exporters. Finally, imposed NTMs impact differently agri-environmental performance of importers. SPS and TBT measures confirm their consistency with the WTO's terms and their environmental and food safety "legitimacy" contrary to environmentally-related Export Subsidies and agricultural Special Safeguards which are susceptible to be disguised trade protectionism measures

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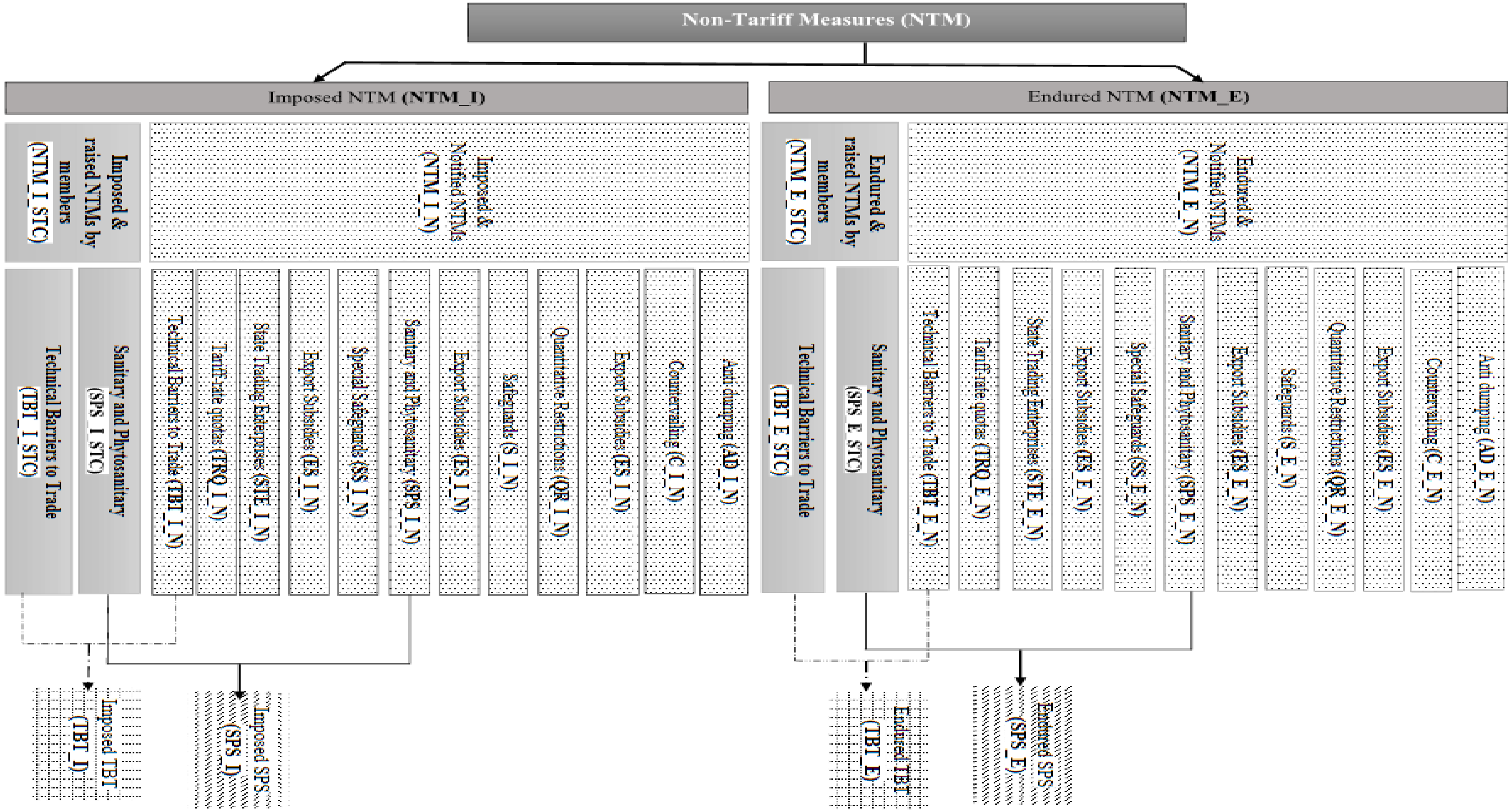
6. Appendix

Appendix 1. NTMs' classification



Appendix 2. NTMs' Classification in 2012 (WTO[10], 2012)

LEV	CODE	NAME	DESCRIPTION	EXAMPLE & NOTES
1	A	SANITARY AND PHYTOSANITARY MEASURES	Measures that are applied: to protect human or animal life from risks arising from additives, contaminants, toxins or disease-causing organisms in their food; to protect human life from plant- or animal-carried diseases; to protect animal or plant life from pests, diseases, or disease-causing organisms; to prevent or limit other damage to a country from the entry, establishment or spread of pests; and to protect bio-diversity. These include measures taken to protect the health of fish and wild fauna, as well as of forests and wild flora.	Measures classified under A1 through A6 are Technical Regulations while those in A8 are their Conformity Assessment Procedures. Note that measures for environmental protection (other than as defined above), to protect consumer interests, or for the welfare of animals are not covered by SPS.
1	B	TECHNICAL BARRIERS TO TRADE	Measures referring to technical regulations, and procedures for assessment of conformity with technical regulations and standards, excluding measures covered by the SPS Agreement.	A "technical regulation" is a document which lays down product characteristics or their related processes and production methods, including the applicable administrative provisions, with which compliance is mandatory. It may also include or deal exclusively with terminology, symbols, packaging, marking or labelling requirements as they apply to a product, process or production method. A "conformity assessment procedure" is any procedure used, directly or indirectly, to determine that relevant requirements in technical regulations or standards are fulfilled; it may include, inter alia, procedures for sampling, testing and inspection; evaluation, verification and assurance of conformity; registration, accreditation and approval as well as their combinations. Measures classified under B1 through B7 are Technical Regulations while those under B8 are their Conformity Assessment Procedures. Among the Technical Regulations, those in B4 are related to production processes, while others are applied directly on products.
3	D12	Antidumping duty	A duty levied on imports of a particular good originating from a specific trading partner to offset injurious dumping found to exist via an investigation. Duty rates are generally enterprise-specific.	Example: An antidumping duty of between 8.5 to 36.2% has been imposed on imports of “biodiesel products” from Country A.
3	D22	Countervailing duty	A duty levied on imports of a particular product to offset the subsidies granted by the exporting country on the production or trade of that product, where an investigation has found that the subsidized imports are causing injury to of the domestic industry producing the like product.	Example: A countervailing duty of 44.71% has been imposed by Mexico on imports of “dynamic random access memory (DRAM) semiconductors” from Country A.
2	D3	Safeguard measures		

[10] http://i-tip.wto.org/goods/Forms/Methodology.aspx

3	D32		Agricultural special safeguard	Agricultural special safeguard allows the imposition of an additional tariff in response to a surge in imports or a fall in import prices. The specific trigger levels for volume or price of imports are defined at the country level. In the case of the volume trigger, the additional duties only apply until the end of the year in question. In the case of price triggers, the additional duty is imposed on a shipment by shipment basis.	
2	E2		Quantitative restrictions (Quotas)	Restriction of importation of specified products through the setting of a maximum quantity or value that is authorized for import. No imports are allowed beyond those maximums:	
2	E6		Tariff Rate Quotas	A system of multiple tariff rates applicable to a same product: the lower rates apply up to a certain value or volume of imports, and the higher rates are charged on imports which exceed this amount.	Example: Rice may be imported free of duty up to the first 100,000 tons, after which it is subject to a tariff rate of $1.5 per kg.
2	H1	**State trading enterprises**	State trading enterprises,	for importing; other selective import channels	
3	H11		State trading enterprises, for importing	Enterprises (whether or not state-owned or –controlled) with special rights and privileges not available to other entities, which influence through their purchases and sales the level or direction of imports of particular products.	Examples: A statutory marketing board with exclusive rights to control imports of certain grains; a canalizing agency with exclusive right to distribute petroleum; a sole importing agency; or importation reserved for specific importers regarding certain categories of goods.
2	P2		State trading enterprises	for exporting; other selective export channels.	
3	P21		State trading enterprises, for exporting	Enterprises (whether or not state-owned or –controlled) with special rights and privileges not available to other entities, which influence through their purchases and sales the level or direction of exports of particular products.	Example: An export monopoly board, to take advantage of terms of sale abroad; a marketing board, to promote for export on behalf of a large number of small farmers
2	P7		Export subsidies	Financial contribution by a government or public body, or via government entrustment or direction of a private body (direct or potential direct transfer of funds: e.g., grant, loan, equity infusion, guarantee; government revenue foregone; provision of goods or services or purchase of goods; payments to a funding mechanism), or income or price support, which confers a benefit and is contingent in law or in fact upon export performance (whether solely or as one of several conditions), including measures illustrated in Annex I of the Agreement on Subsidies and Countervailing Measures and measures described in the Agreement on Agriculture.	Example: All manufacturers in Country A are exempt from income tax on their export profits.

Appendix 3. DEA Super-Efficiency scores and ranks of the studied countries

COUNTRY (C)	YEAR											MEAN/C	RANK										
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013		R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13
Albania	0,16	0,17	0,17	0,18	0,18	0,20	0,21	0,21	0,22	0,22	0,22	0,19	83	85	85	80	81	79	78	81	81	82	84
Algeria	0,16	0,20	0,20	0,19	0,19	0,20	0,23	0,26	0,28	0,31	0,35	0,23	84	80	79	77	78	77	77	76	75	72	69
Argentina	0,91	1,04	1,05	1,15	1,18	1,06	1,03	1,01	0,90	1,06	2,37	1,16	19	11	9	4	2	15	16	18	24	6	4
Armenia	0,19	0,23	0,24	0,28	0,29	0,31	0,31	0,30	0,29	0,31	0,32	0,28	73	70	70	66	67	65	66	71	72	71	72
Australia	0,41	0,48	0,50	0,41	0,41	0,39	0,44	0,47	0,55	0,55	0,58	0,47	53	45	44	52	56	59	53	49	43	42	44
Austria	0,54	0,50	0,49	0,48	0,50	0,52	0,52	0,49	0,48	0,49	0,52	0,50	36	41	45	45	44	42	44	47	48	50	49
Azerbaijan	0,11	0,12	0,11	0,12	0,12	0,13	0,13	0,14	0,15	0,16	0,17	0,13	97	94	94	94	94	94	94	91	91	88	89
Bangladesh	0,18	0,22	0,24	0,21	0,23	0,26	0,29	0,33	0,33	0,35	0,38	0,27	77	74	71	74	74	71	68	64	67	67	66
Belarus	0,24	0,30	0,38	0,41	0,43	0,45	0,48	0,50	0,49	0,49	0,51	0,42	66	64	57	53	54	50	49	46	47	47	54
Belgium	1,20	1,09	1,04	1,17	1,05	1,11	1,13	1,04	1,02	1,06	2,49	1,22	1	4	10	3	13	7	3	10	14	8	3
Belize	0,92	0,79	0,72	0,75	0,72	0,74	0,72	0,71	0,69	0,71	0,72	0,75	17	26	30	28	31	30	30	31	34	34	36
Benin	0,12	0,08	0,05	0,04	0,04	0,06	0,08	0,10	0,10	0,09	0,08	0,08	92	102	107	108	108	106	102	98	97	102	104
Bolivia	0,16	0,18	0,19	0,18	0,18	0,18	0,18	0,18	0,18	0,19	0,22	0,18	81	83	82	81	83	83	84	86	86	86	83
Bosnia&Herz	0,13	0,21	0,23	0,24	0,24	0,28	0,29	0,29	0,29	0,29	0,29	0,25	88	75	72	69	70	69	69	73	73	75	76
Brazil	0,74	0,72	0,68	0,67	0,73	0,80	0,86	0,89	0,98	1,06	1,25	0,85	28	30	32	30	29	29	25	25	18	7	15
Bulgaria	0,30	0,26	0,27	0,28	0,30	0,31	0,32	0,33	0,34	0,37	0,40	0,32	61	69	69	65	66	66	65	65	66	66	65
Burkina Faso	0,07	0,09	0,10	0,10	0,09	0,06	0,05	0,05	0,07	0,07	0,08	0,07	105	101	100	99	101	105	107	106	104	105	105
Burundi	0,16	0,16	0,15	0,15	0,15	0,16	0,17	0,17	0,14	0,14	0,16	0,16	82	86	88	86	86	87	87	87	92	93	92
Cote d'Ivoire	0,12	0,12	0,11	0,10	0,10	0,10	0,11	0,11	0,11	0,11	0,13	0,11	92	94	98	99	99	98	97	96	96	96	96
Cambodia	0,03	0,04	0,04	0,05	0,06	0,06	0,07	0,08	0,09	0,10	0,11	0,07	108	108	108	106	105	104	104	103	102	99	98
Cameroon	0,11	0,12	0,12	0,12	0,12	0,13	0,13	0,13	0,13	0,14	0,16	0,13	95	93	93	95	93	92	93	94	94	92	91
Canada	0,83	0,90	0,96	0,82	0,80	0,87	0,90	0,85	0,86	0,88	0,99	0,88	25	21	20	25	26	22	23	28	27	27	26
Chile	0,69	0,77	0,82	0,77	0,84	0,89	0,92	0,91	0,85	0,89	1,01	0,85	31	28	24	26	23	21	22	22	28	26	23
China	0,94	0,97	0,95	0,95	0,94	1,09	0,97	0,96	0,98	0,97	1,00	0,97	15	18	21	17	18	10	19	19	19	20	24
Colombia	0,59	0,65	0,73	0,64	0,68	0,67	0,70	0,79	0,83	0,94	1,15	0,76	34	33	29	33	34	32	32	29	29	24	19
Costa Rica	0,97	1,05	1,12	1,06	1,05	1,06	1,08	1,07	1,04	1,03	1,90	1,13	11	9	2	10	14	13	9	7	11	14	7

Croatia	0,44	0,44	0,45	0,48	0,53	0,53	0,52	0,50	0,52	0,53	0,57	0,50	49	50	48	44	41	41	45	45	45	45	46
Cyprus	0,59	0,59	0,57	0,56	0,60	0,65	0,70	0,69	0,71	0,71	0,75	0,65	33	35	39	37	37	35	34	34	32	33	34
Czechia	0,36	0,40	0,43	0,43	0,45	0,40	0,40	0,38	0,37	0,39	0,43	0,40	55	55	52	49	50	55	56	60	63	61	62
Denmark	0,64	0,70	0,83	0,83	0,89	0,81	0,82	0,79	0,75	0,75	0,84	0,79	32	32	23	23	21	28	28	30	31	31	31
Dominican Rep.	0,31	0,32	0,32	0,34	0,36	0,37	0,39	0,40	0,41	0,42	0,44	0,37	59	61	64	61	61	61	61	59	59	60	61
Ecuador	0,72	0,71	0,63	0,56	0,52	0,49	0,53	0,58	0,56	0,55	0,59	0,59	29	31	34	39	42	44	42	41	41	43	42
Egypt	1,05	1,03	1,08	1,05	1,06	1,07	1,06	1,04	1,03	1,02	1,09	1,05	4	14	5	11	10	12	12	11	12	17	21
El Salvador	0,30	0,33	0,35	0,38	0,40	0,40	0,42	0,44	0,45	0,46	0,46	0,40	60	59	59	55	57	57	54	55	52	55	59
Estonia	0,27	0,31	0,33	0,35	0,43	0,53	0,58	0,59	0,63	0,70	0,78	0,50	64	63	61	60	53	40	40	39	39	36	33
Ethiopia	0,04	0,05	0,05	0,05	0,05	0,05	0,06	0,06	0,06	0,06	0,07	0,06	107	107	106	107	106	107	105	105	105	107	108
Finland	0,47	0,49	0,56	0,56	0,57	0,51	0,49	0,46	0,44	0,45	0,52	0,50	41	44	40	40	40	43	48	51	55	56	51
France	1,01	1,05	1,04	0,99	1,07	1,11	1,05	1,02	1,01	1,04	1,34	1,07	6	8	12	16	7	8	15	17	16	12	11
Gambia	0,14	0,11	0,11	0,12	0,11	0,09	0,09	0,07	0,06	0,06	0,07	0,09	86	96	97	93	97	100	101	104	107	106	107
Georgia	0,12	0,20	0,21	0,20	0,19	0,24	0,26	0,30	0,32	0,38	0,44	0,26	94	79	78	76	79	76	74	70	70	65	60
Germany	0,84	0,92	0,97	0,92	0,98	1,04	1,06	1,02	1,02	1,01	1,21	1,00	24	20	19	18	17	16	14	15	15	19	18
Ghana	0,21	0,22	0,19	0,14	0,14	0,16	0,20	0,26	0,31	0,28	0,22	0,21	72	73	80	89	88	88	82	78	71	76	85
Greece	0,52	0,55	0,55	0,51	0,51	0,49	0,49	0,48	0,48	0,49	0,52	0,51	37	37	41	43	43	45	47	48	50	49	53
Guatemala	0,33	0,35	0,33	0,32	0,34	0,38	0,40	0,43	0,45	0,48	0,57	0,40	56	57	60	63	62	60	57	56	54	51	45
Honduras	0,29	0,32	0,32	0,33	0,33	0,33	0,33	0,32	0,33	0,34	0,36	0,33	63	60	63	62	63	63	63	66	68	70	68
Hungary	0,47	0,50	0,51	0,45	0,48	0,43	0,40	0,36	0,32	0,34	0,37	0,42	43	42	43	46	45	53	58	63	69	68	67
India	0,30	0,36	0,38	0,35	0,37	0,45	0,55	0,60	0,64	0,60	0,61	0,47	61	56	56	59	60	52	41	38	38	40	41
Indonesia	0,23	0,27	0,31	0,26	0,30	0,33	0,37	0,44	0,48	0,48	0,52	0,36	68	66	65	68	65	62	62	54	49	52	52
Ireland	0,85	0,82	0,82	0,82	0,82	0,86	0,94	0,89	0,89	0,87	0,88	0,86	23	23	25	24	25	23	21	24	26	28	30
Israel	1,00	1,06	1,06	1,03	1,07	1,14	1,08	1,06	1,05	1,03	1,69	1,11	7	7	7	12	9	5	8	9	8	16	9
Italy	0,90	0,99	1,03	1,23	1,16	1,29	1,20	1,17	1,06	1,15	1,68	1,17	20	17	13	2	4	1	1	3	6	2	10
Jamaica	0,47	0,45	0,42	0,43	0,43	0,47	0,47	0,47	0,47	0,47	0,48	0,46	44	48	53	48	52	48	51	50	51	53	56
Japan	0,93	0,96	0,98	0,76	0,78	0,81	0,80	0,87	0,83	0,82	0,88	0,86	16	19	17	27	27	27	29	27	30	30	29
Jordan	1,11	1,03	0,99	1,03	1,07	1,24	1,11	1,46	1,11	1,08	1,70	1,18	2	13	16	14	8	2	4	1	3	4	8
Kazakhstan	0,07	0,10	0,11	0,09	0,10	0,11	0,12	0,10	0,10	0,10	0,11	0,10	104	99	94	101	100	96	95	97	98	101	102

Kenya	0,15	0,15	0,16	0,15	0,16	0,17	0,17	0,16	0,15	0,15	0,17	0,16	85	87	86	85	85	85	88	89	89	91	87
Latvia	0,45	0,42	0,41	0,42	0,47	0,49	0,51	0,50	0,52	0,55	0,64	0,49	48	54	55	50	47	47	46	44	46	41	40
Lebanon	0,77	0,78	0,72	0,73	0,74	0,82	0,84	0,88	0,93	0,97	1,05	0,84	27	27	31	29	28	25	26	26	21	22	22
Libya	0,10	0,15	0,17	0,16	0,15	0,16	0,16	0,16	0,16	0,17	0,17	0,15	100	88	84	84	87	89	89	88	88	87	88
Lithuania	0,32	0,34	0,36	0,36	0,45	0,45	0,47	0,45	0,43	0,45	0,52	0,42	57	58	58	58	51	51	50	52	56	57	50
Luxembourg	1,02	1,07	1,10	1,08	1,06	1,11	1,10	1,08	1,07	1,05	2,87	1,24	5	6	3	9	11	9	7	6	5	10	2
Madagascar	0,06	0,06	0,07	0,08	0,08	0,08	0,09	0,09	0,09	0,10	0,11	0,08	106	106	104	102	102	101	100	101	101	100	98
Malaysia	0,50	0,58	0,62	0,85	0,94	1,03	1,06	1,03	1,05	1,03	1,23	0,90	38	36	36	21	19	18	13	13	9	15	16
Malta	0,99	1,02	1,09	1,10	1,20	1,19	1,08	1,03	1,44	1,31	1,00	1,13	9	15	4	6	1	3	10	14	1	1	24
Mexico	0,44	0,45	0,46	0,38	0,39	0,40	0,42	0,43	0,45	0,46	0,51	0,44	50	47	47	57	59	56	55	57	53	54	54
Morocco	0,18	0,21	0,21	0,17	0,17	0,18	0,18	0,19	0,20	0,20	0,23	0,19	75	76	77	83	84	84	86	84	83	84	82
Mozambique	0,08	0,08	0,08	0,08	0,08	0,07	0,05	0,03	0,03	0,05	0,09	0,06	103	104	102	103	104	103	106	108	108	108	103
Namibia	0,08	0,10	0,11	0,12	0,12	0,16	0,18	0,21	0,20	0,20	0,17	0,15	102	99	94	96	95	86	85	80	82	85	86
Netherlands	1,08	1,05	1,02	1,03	1,01	1,04	1,02	1,06	1,05	1,05	1,31	1,07	3	10	15	12	15	17	17	8	7	10	13
New Zealand	0,98	1,12	1,04	1,08	1,09	1,15	1,10	1,10	1,01	1,03	2,02	1,16	10	3	11	7	6	4	6	4	17	13	6
Niger	0,03	0,03	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,03	0,02	108	109	109	109	109	109	109	109	109	109	109
Nigeria	0,11	0,12	0,13	0,13	0,13	0,14	0,13	0,15	0,18	0,20	0,23	0,15	96	92	92	91	92	90	90	90	87	83	81
Norway	0,57	0,60	0,64	0,67	0,72	0,74	0,72	0,69	0,69	0,71	0,75	0,68	35	34	33	31	30	31	31	33	35	35	35
Oman	0,89	1,38	1,06	1,12	1,17	1,07	1,14	1,09	1,17	1,07	2,13	1,21	21	1	8	5	3	11	2	5	2	5	5
Pakistan	0,24	0,29	0,30	0,23	0,22	0,25	0,27	0,31	0,28	0,26	0,27	0,27	65	65	66	70	75	75	72	68	77	79	78
Panama	0,42	0,43	0,47	0,52	0,58	0,60	0,61	0,56	0,55	0,54	0,54	0,53	52	51	46	42	39	37	38	42	42	44	48
Paraguay	0,22	0,22	0,22	0,23	0,25	0,25	0,25	0,27	0,28	0,30	0,32	0,26	71	72	74	71	69	73	76	75	76	73	73
Peru	0,85	0,80	0,74	0,60	0,48	0,32	0,26	0,26	0,26	0,27	0,32	0,47	22	25	28	36	46	64	75	77	78	77	74
Philippines	0,46	0,45	0,45	0,38	0,39	0,40	0,40	0,42	0,40	0,39	0,42	0,41	45	49	49	56	58	58	59	58	60	62	63
Poland	0,48	0,53	0,58	0,56	0,58	0,59	0,61	0,64	0,66	0,67	0,70	0,60	40	38	38	38	38	39	37	37	36	37	38
Portugal	0,42	0,46	0,42	0,41	0,41	0,46	0,46	0,44	0,42	0,43	0,48	0,44	51	46	54	54	55	49	52	53	57	58	58
Rep. of Korea	0,99	1,08	1,08	1,24	1,05	1,06	1,07	1,02	1,09	1,09	1,28	1,10	8	5	6	1	12	13	11	16	4	3	14
Romania	0,19	0,20	0,21	0,17	0,18	0,19	0,21	0,22	0,25	0,27	0,29	0,22	74	78	76	82	80	81	80	79	79	78	77
Russia	0,13	0,13	0,14	0,15	0,18	0,20	0,20	0,18	0,20	0,23	0,25	0,18	89	90	90	88	82	80	83	85	84	81	79

Saudi Arabia	0,32	0,31	0,32	0,31	0,30	0,29	0,27	0,30	0,40	0,49	0,56	0,35	57	62	62	64	64	68	73	69	61	48	47
Senegal	0,10	0,11	0,11	0,11	0,10	0,10	0,09	0,09	0,10	0,11	0,12	0,10	99	97	98	97	98	99	99	100	100	97	97
Slovakia	0,47	0,52	0,62	0,63	0,68	0,66	0,69	0,66	0,65	0,65	0,71	0,63	41	40	37	35	33	34	35	36	37	38	37
Slovenia	0,83	0,81	0,81	0,89	0,93	0,98	0,95	0,95	0,97	0,97	0,95	0,91	26	24	26	19	20	20	20	20	20	21	27
South Africa	0,23	0,26	0,27	0,22	0,24	0,26	0,29	0,32	0,34	0,34	0,35	0,28	69	68	68	72	71	72	67	67	65	68	71
Spain	0,92	0,87	0,85	0,84	0,87	0,84	0,87	0,90	0,93	0,95	1,10	0,90	18	22	22	22	22	24	24	23	22	23	20
Sri Lanka	0,24	0,22	0,21	0,22	0,24	0,26	0,28	0,29	0,28	0,29	0,31	0,26	67	71	75	73	71	70	70	74	74	74	75
Sweden	0,49	0,52	0,62	0,63	0,67	0,59	0,58	0,55	0,53	0,53	0,58	0,57	39	39	35	34	35	38	39	43	44	46	43
Switzerland	0,97	1,04	1,03	1,01	1,00	1,01	1,01	1,03	1,02	1,01	1,33	1,04	12	12	14	15	16	19	18	12	13	18	12
Syria	0,17	0,19	0,18	0,19	0,20	0,20	0,21	0,20	0,18	0,16	0,14	0,18	79	81	83	78	76	77	79	83	85	89	95
Tanzania UR	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,08	0,07	0,08	0,08	101	103	103	104	103	102	103	102	103	104	105
Thailand	0,45	0,43	0,44	0,41	0,45	0,49	0,53	0,58	0,62	0,63	0,69	0,52	46	52	51	51	49	45	43	40	40	39	39
Togo	0,10	0,08	0,06	0,05	0,05	0,05	0,04	0,05	0,06	0,08	0,11	0,07	98	105	105	105	107	108	108	107	106	103	100
Tunisia	0,17	0,18	0,19	0,19	0,19	0,19	0,20	0,20	0,22	0,23	0,24	0,20	80	82	80	79	77	81	81	82	80	80	80
Turkey	0,45	0,50	0,52	0,55	0,63	0,65	0,68	0,71	0,69	0,72	0,83	0,63	46	43	42	41	36	36	36	32	33	32	32
Uganda	0,18	0,17	0,15	0,15	0,14	0,12	0,10	0,10	0,10	0,10	0,11	0,13	76	84	87	87	89	95	98	99	99	98	100
Ukraine	0,18	0,20	0,23	0,21	0,23	0,25	0,28	0,29	0,36	0,39	0,41	0,28	77	77	73	75	73	74	71	72	64	63	64
United Kingdom	0,96	1,00	0,98	0,85	0,82	0,66	0,70	0,68	0,89	0,87	0,88	0,84	13	16	18	20	24	33	33	35	25	29	28
USA	0,94	1,26	1,50	1,08	1,14	1,13	1,10	1,22	1,04	1,06	3,12	1,33	14	2	1	8	5	6	5	2	10	9	1
Uruguay	0,40	0,42	0,44	0,45	0,45	0,42	0,40	0,38	0,41	0,43	0,48	0,42	54	53	50	47	48	54	60	61	58	59	57
Venezuela	0,22	0,27	0,28	0,26	0,27	0,30	0,32	0,37	0,39	0,39	0,35	0,31	70	67	67	67	68	67	64	62	62	64	70
Viet Nam	0,71	0,76	0,79	0,66	0,72	0,81	0,84	0,93	0,91	0,94	1,21	0,84	30	29	27	32	32	26	27	21	23	25	17
Yemen	0,14	0,14	0,14	0,14	0,13	0,13	0,13	0,13	0,13	0,13	0,15	0,14	87	89	89	90	91	91	92	93	95	94	93
Zambia	0,13	0,13	0,13	0,13	0,13	0,13	0,13	0,13	0,15	0,16	0,17	0,14	90	91	91	92	90	93	91	92	90	90	89
Zimbabwe	0,12	0,10	0,10	0,10	0,11	0,11	0,11	0,12	0,13	0,13	0,14	0,12	91	98	101	98	96	96	96	95	93	95	94
mean/year	0,45	0,48	0,48	0,47	0,49	0,50	0,50	0,51	0,51	0,52	0,67	_	_	_	_	_	_	_	_	_	_	_	_

Appendix 4. Signature and ratification of Multilateral Environmental Agreement (MEAs) by some SEMCs

Multilateral Environmental Agreement and adoption year	Algeria	Egypt	Jordan	Lebanon	Libya	Morocco	Palestine	Syria	Tunisia	Turkey
Convention on Biological Diversity (1982)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification
Cartagena Protocol (2000)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification
Nagoya Protocol (2010)	Signature	Ratification	Ratification	Signature	Unsigned	Signature	Unsigned	Ratification	Signature	Unsigned
International Treaty on Plant Genetic Resources for Food and Agriculture (2001)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification
Convention on Wetlands (1971)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification
World Heritage Convention (1972)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification
Convention on the International Trade in Endangered Species of Wild Fauna and Flora (1975)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification
Convention on the Conservation of Migratory Species of Wild Animals (1979)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Unsigned
Agreement on the Conservation of African-Eurasian Migratory Waterbirds (1996)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Unsigned
Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (1996)	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Unsigned
United Nations Convention on the Law of the Sea (1982)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Unsigned
United Nations Framework Convention on Climate Change (1992)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification
United Nations Convention to Combat Desertification (1992)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification
Kyoto Protocol (1997)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification
Vienna Convention for the Protection of the Ozone Layer (1985)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification
Montreal Protocol (1985)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification
Basel Convention (1989) [11]	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification
Stockholm Convention on Persistent Organic Pollutants (2001)	Ratification	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Ratification
Rotterdam Convention (1998) [12]	Unsigned	Ratification	Ratification	Ratification	Ratification	Ratification	Unsigned	Ratification	Ratification	Signature
Minamata Convention on Mercury (2013)	Unsigned	Unsigned	Signature	Unsigned	Signature	Signature	Unsigned	Signature	Signature	Signature

Key : Ratification, Acceptance, Approval, Accession — Signature — Unsigned

Source: adapted from (Vernin, 2016)

[11] on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
[12] on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade