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Abstract

This paper presents the first empirical test of coherence (i.e., consistency of policies within a framework), efficiency (i.e., ability of policies to meet their objectives), and independence (i.e., logical priority of objectives over policies) of the overall EU environmental policy system. To do so, I applied statistical (cross-sectional and time series) and econometric (dynamic tri-probit) analyses to an original panel dataset, based on addressed issues rather than on implemented policies. In contrast with previous studies of single EU environmental policies, characteristics of the EU environmental policy, or EU environmental objectives, I found that the overall EU environmental policy system is coherent, efficient, and independent. Moreover, the evidence suggests that many issues are correlated: trans-boundary issues became more relevant in 2012, pollution production was more significant than resource use, and flow issues were more important than stock issues from 1995 to 2010. Finally, I show that few objectives overlapped: a "safe environment" objective (1987 to 1997) was preferred to a "greenhouse gas (GHG) reduction" objective (2003 to 2012, but pursued with a 2-year lag), although the latter has recently become preferred to the former. In addition, a "GHG reduction" objective was preferred to "a sustainable development" objective (1998 to 2002).

Keywords

European Union environmental policy; statistical analyses; cross-sections; time-series, dynamic tri-probit

JEL classification

Q28, Q38, Q48, Q58

1. Introduction

Many single EU environmental policies have been criticized. For instance, Clò et al. (2013) critiqued the Emission Trading System; Balana et al. (2011), Kampagrou et al. (2011), and Bourblanc et al. (2013) critiqued the Water Framework Directive; Hiedampää & Bromley (2011) critiqued the biodiversity policies; Tol (2012) critiqued the energy policies; and Zagonari (2013) critiqued the Flood Directive. Moreover, many single characteristics of EU environmental policy have been criticized. For instance, Steurer et al. (2010) and Jackson (2011) highlighted the *incoherence* of legislation on sustainable development, and of biodiversity vs. renewable energy; Spencer & Fazekas (2013) stressed a lack of *equity* by analyzing legislation on adaptation to climate change; and Aakre & Rübbelke (2010) and Swinbank & Daugbjerg (2013) highlighted *inefficiency* by considering legislation on climate change and biofuels, respectively. Finally, many single EU environmental objectives have been criticized. For instance, Spangenberg (2010) and Steurer & Berger (2011) critiqued *sustainable development*; McLauchlan & João (2012) and Sheate (2012) critiqued the *safe environment objective*; and Haug et al. (2010), Capros et al. (2011), and Brouwer et al. (2013) critiqued *greenhouse gas (GHG) reduction*.

In contrast, few studies have scrutinized the overall EU environmental policy system in terms of its coherence (i.e., consistency of policies within a framework), efficiency (i.e., ability of policies to meet their objectives), and independence (i.e., logical priority of objectives over policies). For example, Nillson et al. (2012) stated that the EU environmental policy was *incoherent*. However, their analysis relied on a dataset in which 28 of the 53 items referred to the period before 1987. Moreover, Halpern (2010) concluded that EU environmental policy is *dependent on and structured by* its instruments, and that apart from the Environmental Impact Assessment and Emission Trading System, it was rarely innovative. However, the analysis was problematic because it relied exclusively on expert judgments, without verification from quantitative data, about legislation on biodiversity, waste treatment, water protection, and renewable energy. Finally, Aakre & Rübbelke (2010) stated that EU environmental policy was often *inefficient* and that, from a geographical perspective, was always unequal. However, their analysis relied on simplistic parameters based on EU spending programs for adaptation to climate change.

The purpose of the present paper was to test the coherence, efficiency, and independence of the overall EU environmental policy system by applying statistical and econometric analyses to an original panel dataset. In addition, insights were obtained about the implicit relative importance attached by the EU to (possibly correlated) issues as well as the relative preferences for stated (possibly overlapping) objectives.

To support this analysis, I created a list of all EU environmental policies from the official EU Web site (http://www.eu/environment/legislation/summary) by focusing on the three legal hierarchies for policies with horizontal or vertical direct or indirect impacts: directives (DIR), regulations (REG), and decisions (DEC). I did not include opinions (e.g., guidelines, proposals, papers), recommendations, and communications, whether or not they were published in official EU journals. I also do not discuss cases or councils by the EU Court of Justice on environmental issues, since my purpose was not to assess the degree of implementation of or compliance with EU environmental policies.

Within this context, I identified four main groups of EU environmental policies that relate to optimal levels of pollution (i.e., TAX = taxes, STA = standards, PER = permits, SUB = subsidies) and three main groups of policies that relate to optimal uses (i.e., GRO = growth rate, TEC = prices of substitutive technology, COS = marginal costs). I then introduced additional policies based on their relevance to the assumptions behind the competitive general equilibrium model (Cardenete et al., 2012): complete information (INF = policies to share information, i.e., to reduce information asymmetries), perfect information (UNC = policies to reduce uncertainty, i.e., to tackle risk), perfect liability (RIG = policies to enforce rights), and a lack of interdependencies (COO = policies to improve cooperation). I will disregard policy measures in favor of competitiveness. This allowed me to test for *coherence*. Note that I classified policies according to their impact on the optimal

production of pollution or the optimal use of resources; for example, policies for water quality relate to pollution production (POL).

Finally, I classified EU environmental policies into renewable (STO, stock) and non-renewable (FLO, flow) resource uses (RES), as well as stock (STO) and flow (FLO) pollution production (POL) and domestic (DOM) and trans-boundary (TRA) issues, by creating a combined category (BOT) for cases in which both sub-categories were plausible (i.e. BOT1 for both domestic or trans-boundary, BOT2 for both resource and pollution, and BOT3 for both stock and flow). For example, surface water is depicted as a domestic or trans-boundary (BOT1) renewable resource (RES) with a fixed natural growth rate (FLO). I then identified four EU environmental objectives: Objective 1, which was pursued from 1987 to 1997, was based on the Unique Environmental Act (1987) and was defined as "a safe environment". Objective 1 was related to DOM, POL, and FLO. Objective 2, which was pursued from 1998 to 2002, was based on the Amsterdam Treaty (1997) and was defined as "sustainable development". Objective 2 was related to BOT1, BOT2, and BOT3. Objective 3, which was pursued from 2003 to 2012, was based on the VI Environmental Action Programme (2001), and was defined as "GHG reduction". Objective 3 was related to TRA, POL, and STO. This allowed me to test for *efficiency* and *independence*. However, I disregarded Objective 4, which will be pursued after 2012 and was based on the Lisbon Treaty (2007). This objective refers to "a dematerialized economy", and should be studied in future research.

Table S1, Table S2 and Table S3 in the Online Supplementary Material summarize the classifications for DEC, DIR, and REG, respectively. Note that I will not consider the implementation (Ivanov & Dobreva, 2011; Newig & Koontz, 2013; Wolkinger et al., 2012), or the degrees of effectiveness or integration (Atkinson & Klausen, 2011; Biesbroek et al., 2010; Dupont & Oberthür, 2012; Jordan et al. 2012; Rietig, 2013; Steurer et al., 2010), of the EU environmental policy system, due to lack of reliable and comprehensive data.

2. Methodology

In the analysis presented in this paper, I first categorized the EU policies into groups to provide an overall statistical cross-section. Next, I performed a time-series analysis to determine how the various policy measures evolved over time. Finally, I developed econometric models for the issues and the three objectives. Based on the results of these analyses, I provide an overall assessment of the EU environmental policy system.

The first three categories refer to the problem directly tackled. For example, gaseous pollutants from mobile machines can be classified as DOM, POL, and FLO, even though this relates to GHG. It is then possible to account for both the first and second most relevant policies. For example, DIR for gaseous pollutants from mobile machines is STA, even though an emission trading system has been introduced to cope with CO_2 emissions.

I used the following simplifying assumptions to determine how laws fit within the overall categories:

- All conventions and protocols are classified as COO (first policy).
- All committees and frameworks are classified as INF and COO (first and second policies, respectively).
- All programs are DOM, BOT2, BOT3, COO, and INF (3 categories, first and second policies, respectively).
- All laws related to implementation and financing are classified as RIG (I policy).
- Public participation is included in DOM, BOT2, BOT3, INF, and RIG (3 categories, first and second policies, respectively).
- Genetically modified organisms (GMOs) are labeled TRA, RES, STO, and STA to identify them (3 categories and first policy, respectively).
- Wastewater is FLO, wastes are STO, surface or fresh water are FLO, and groundwater is STO (third category).

- Climate change (CO_2 emission) issues are TRA, POL, STO, and PER (3 categories and first policy, respectively).
- Renewable (green) energy issues are DOM, RES, FLO, and TEC (3 categories and first policy, respectively).
- Bio-fuels are DOM, RES, FLO, and STA (3 categories and first policy, respectively).
- Regional policies on resources are BOT1 (e.g., the Arctic Ocean; first category).

Note that EU policies towards other countries are not considered, unless they are specifically mentioned in DEC, DIR, or REG.

3. Results

3.1. Statistical cross-section analysis

If STA (mostly DIR) for pollution production and GRO (mostly REG) for resource uses are disregarded in Table 1, some EU policies can be identified:
- DIR-POL-PER identifies the GHG emission allowance trading scheme (i.e., the EU Emissions Trading System DIR2003/87).
- DIR-RES-UNC identifies the flood management and evaluation directive (DIR2007/60).
- DIR-POL-TAX identifies the taxation of heavy goods vehicles (i.e., the Euro-vignette directive DIR1999/62).
- DIR-BOT2-TAX identifies the EU framework for the taxation of energy products and electricity (DIR2003/96)
- DIR-RES-INF includes water protection and management (i.e., the Water Framework Directive DIR2000/60) as the only item with both domestic and trans-boundary (BOT1) and both stock and flow (BOT3) categories, and the strategy for the marine environment (i.e., the Marine Strategy Framework DIR2008/56) as the only item with both domestic and trans-boundary (BOT1) and stock (STO) categories.
- DIR-RES-STA includes motor vehicles and the use of biofuels (DIR2003/30) with the FLO category, and GMO legislation with the STO category.
- DIR-RES-TEC refers to promotion of the use of energy from renewable sources (DIR2009/28).
- DIR-BOT2-RIG refers to Strategic Environmental Assessment (DIR2001/42) with the STO category, and liability and criminality legislation with the FLO category.
- DIR-BOT2-INF refers to Environmental Impact Assessment (DIR1985/337) with the DOM category, and the information access legislation with the domestic and trans-boundary (BOT1) categories.
- REG-BOT2-GRO identifies Integrated Coastal Management (REG2002/413).
- REG-RES-RIG refers to LIFE+ (REG2007/614) with the BOT1 and BOT3 categories, and legislation on fur trade and illegal logging with the FLO and STO categories, respectively.
- REG-BOT2-INF refers to the Eco-Management and Audit Schemes (REG2001/761, REG2009/1221) with the BOT1 and BOT3 categories, and to minimum inspection criteria in the FLO category.

Out of 79 complementary policies (i.e., those that fall within the COO, INF, RIG, UNC classifications), 28 aim at improving cooperation (COO), versus 36 that aim at sharing information (INF); the remaining 15 aim at tackling risks (UNC) and enforcing rights (RIG). My analysis of the second relevant policy, neglected in Table 1, shows that DIR disappears, while REG and DEC relate mainly to GRO (15 out of 28) and STA (11 out of 28). Note that the only 2 TAX in DIR can be explained by the lack of a common EU fiscal policy.

Table 1. Legislation categories for all issues. SUB was never suggested as a POL policy, and COS was never suggested as an RES policy.

	COO	GRO	INF	PER	RIG	STA	TAX	TEC	UNC	TOT
DEC	25	1	7		4	2				39
BOT2	1		3		1					5
POL	8		4		2	2				16
RES	16	1			1					18
DIR		4	16	1	5	60	2	1	2	91
BOT2			3		3		1			7
POL			11	1		55	1		1	69
RES		4	2		2	5		1	1	15
REG	3	7	13		3	17			1	44
BOT2	2	1	3							6
POL	1		10			14			1	26
RES		6			3	3				12
TOT (DEC+DIR+REG)	28	12	36	1	12	79	2	1	3	174

Table 2. Legislation on trans-boundary issues only. Compared with Table 1, COS and TEC disappear from the RES policies, TAX disappears as a POL policy, and UNC disappears as a context policy.

	COO	GRO	INF	PER	RIG	STA	TOT
DEC	8		1			2	11
POL	3		1			2	6
RES	5						5
DIR		4	1	1		6	12
POL			1	1		2	4
RES		4				4	8
REG	1	4	1		1	9	16
POL	1		1			6	8
RES		4			1	3	8
TOT (DEC+DIR+REG)	9	8	3	1	1	17	39

Table 3. Legislation on stock issues only. Compared with Table 1, COS and TEC disappear as RES policies.

	COO	GRO	INF	PER	RIG	STA	UNC	TOT
DEC	17	1	1		1	1		21
POL	4		1			1		6
RES	13	1			1			15
DIR		4	3	1		24	1	33
POL			2	1		20	1	24
RES		4	1			4		9
REG		6	2		1	9	1	19
POL			2			6	1	9
RES		6			1	3		10
TOT (DEC+DIR+REG)	17	11	6	1	2	34	2	73

Comparing GRO with STA in Table 1, the overall summary, and in Table 2, the trans-boundary category, shows a reduction of GRO from 12 to 8 and of STA from 79 to 17, which suggests that resource uses are considered a trans-boundary issue whereas pollution production is considered a domestic issue. Comparing COO with INF in Table 1 and Table 2 shows a reduction of COO from 28 to 9 and of INF from 36 to 3, which suggests that sharing of information is considered a domestic goal, whereas improving cooperation is considered a trans-boundary goal.

Comparing GRO with STA in Table 1and in Table 3, which focuses on stocks, shows a reduction of GRO from 12 to 11 and of STA from 79 to 34, which suggests that resource uses are considered a stock issue (i.e., renewable resources), whereas pollution production is considered a flow issue (i.e., short-run pollution). Comparing COO with INF in Table 1 and Table 3 shows a reduction of COO from 28 to 17 and of INF from 36 to 6, which suggests that sharing information is considered to be a goal related to stock problems, whereas improving cooperation is considered to be a goal related to flow problems.

These results suggest that the proposed classification (by rows) is sufficiently fine-grained to identify single EU environmental policies (by columns), and it is consistent with the competitive general equilibrium set of assumptions, which is implicitly confirmed by the EU brochure on environmental policies (EC, 2013).

3.2. Statistical time-series analysis

In this section I use the competitive general equilibrium set of assumptions (complete information, perfect information, perfect liability, and a lack of interdependencies) to test for coherence (i.e., consistency of the policies within a framework). To do so, I will use the classification suggested in section 3.1 (by rows in the tables) to test for the efficiency (i.e., the ability of the policies to meet their objectives) of the EU environmental policy system.

Figure 1 shows that DIR were used before DEC, which were implemented before REG, and that REG was constantly increasing, whereas DIR and DEC decreased greatly and slightly, respectively. This suggests that once principles have been stated as DIR, the EU perceived the need to implement current environmental policies through direct impacts, and that they did so first by DEC and second by REG.

Figure 2 shows only 2 cases of TAX (1999 and 2003) and only 1 case of PER (2003), whereas the number of STA increased, although the increase slowed towards the end of the study period. Figure 3 shows only 1 case of TEC (2009), whereas GRO increased, though at a decreasing rate. Figure 4 shows only 3 cases of UNC (1993, 2007, and 2011), whereas INF increased, though at a decreasing rate, COO initially increased and then decreased, and RIG increased at an increasing rate.

Figure 1. Changes in the numbers of directives (DIR), regulations (REG), and decisions (DEC) from 1970 to 2011. Lines represent the results of polynomial regressions.
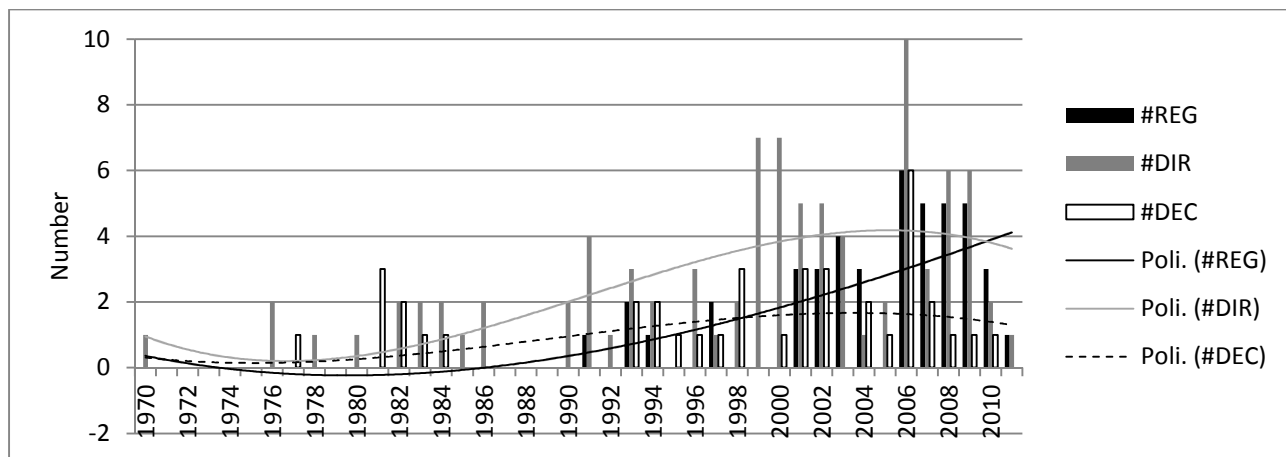
Figure 2. Changes in the number of pollution policies from 1970 to 2011. Policies: STA, standards; TAX, taxes; PER, permits. Lines represent the results of polynomial regressions.
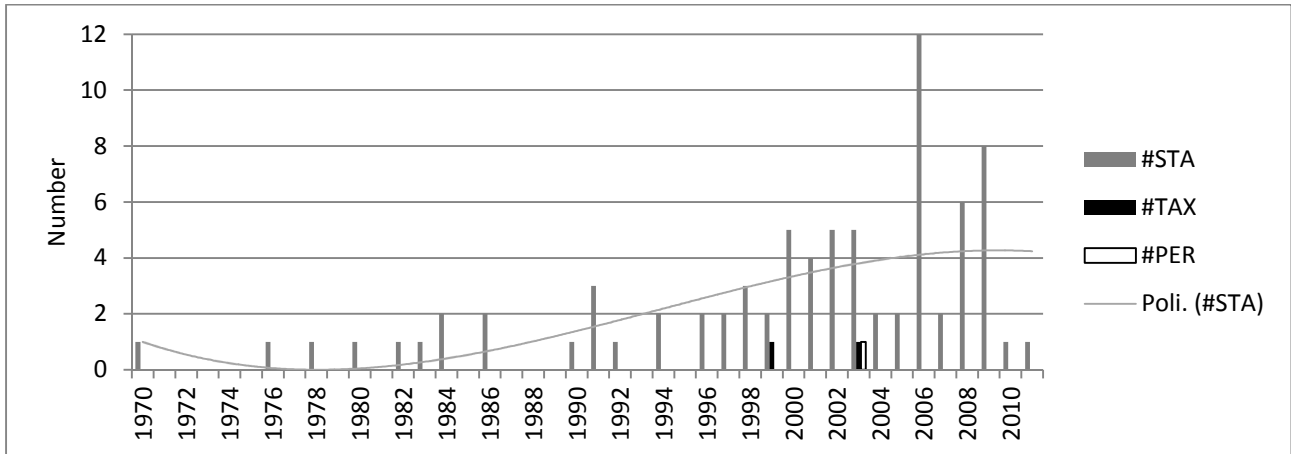
Figure 3. Changes in the number of resource policies from 1970 to 2011. Policies: GRO, growth rates; TEC, prices of substitutive technology. Lines represent the results of polynomial regressions.
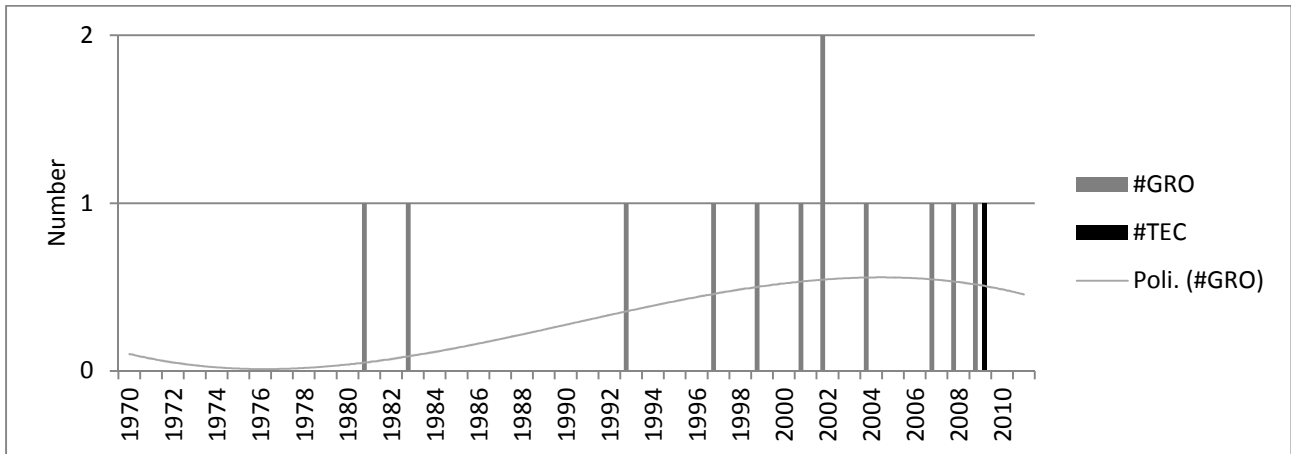
Figure 4. Changes in context policies from 1970 to 2011. Policies: COO, cooperation; INF, sharing of information, RIG, enforcement of rights; UNC, reduction of uncertainty. Lines represent the results of polynomial regressions.
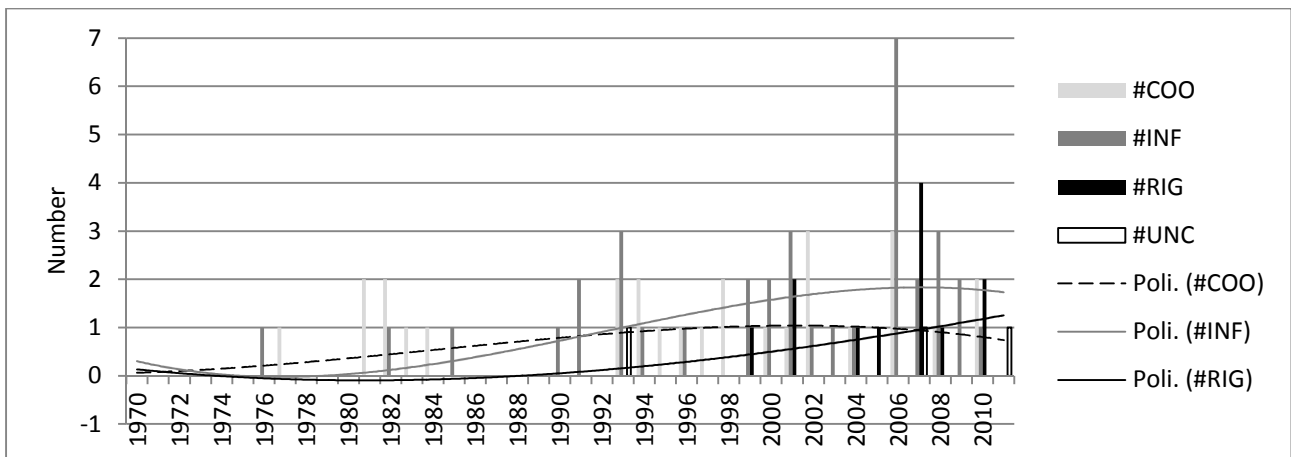
All policies can be assumed to be equivalent in terms of their ability to achieve all objectives within the competitive general equilibrium set of assumptions. Since EU policies are consistent with these assumptions, and since some EU environmental policies are implemented only a few times (e.g., PER and TEC with only 1 record each, TAX with only 2 records), the sample is unacceptably unbalanced, and it was necessary to use the classification of EU environmental policies by rows in Table 1 to test for efficiency.

Figure 5, Figure 6, and Figure 7 show the recent (1990 to 2011) evolution of the proportion of policies characterized by each feature over time (t); in these graphs, 1 means that 100% of the policies introduced in year t possessed the specified feature).

Figure 5. Changes in the relative importance of domestic (DOM), pollution (POL), and flow (FLO) issues from 1990 to 2011 (Objective 1). Lines represent the results of polynomial regressions.
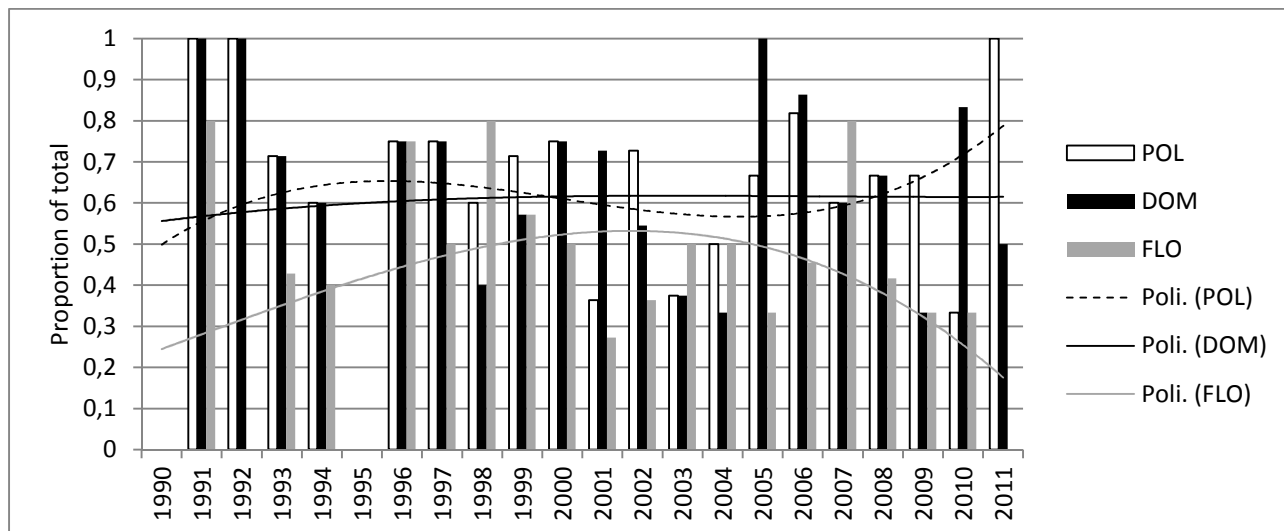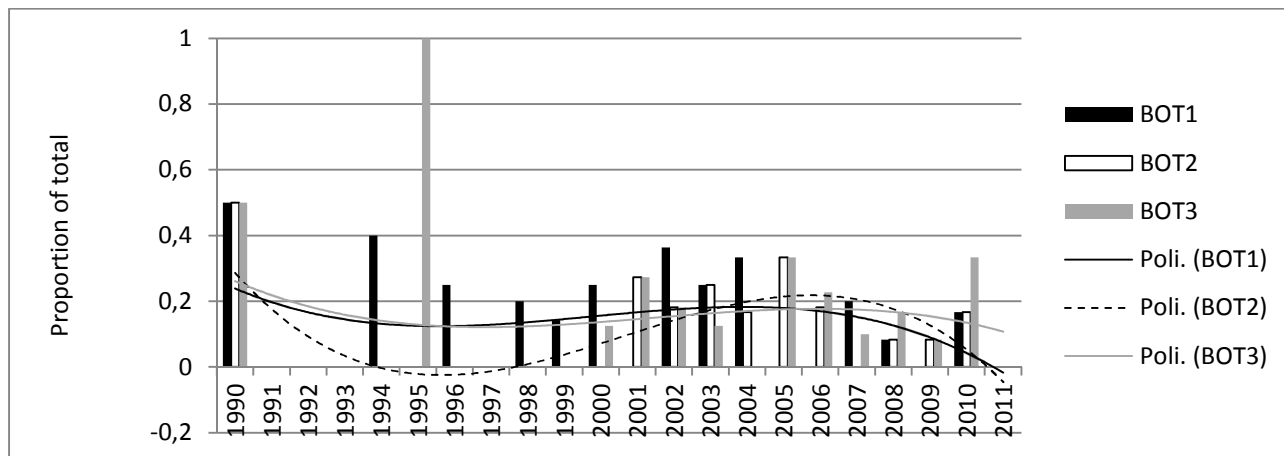

Figure 6. Changes in the relative importance of BOT1 (trans-boundary and domestic issues, TRA and DOM), BOT2 (pollution and resource issues, POL and RES), and BOT3 (stock and flow issues, STO and FLO) issues from 1990 to 2011 (Objective 2). Lines represent the results of polynomial regressions.

Figure 7. Changes in the relative importance of trans-boundary (TRA), pollution (POL), and stock (STO) issues from 1990 to 2011 (Objective 3). Lines represent the results of polynomial regressions.
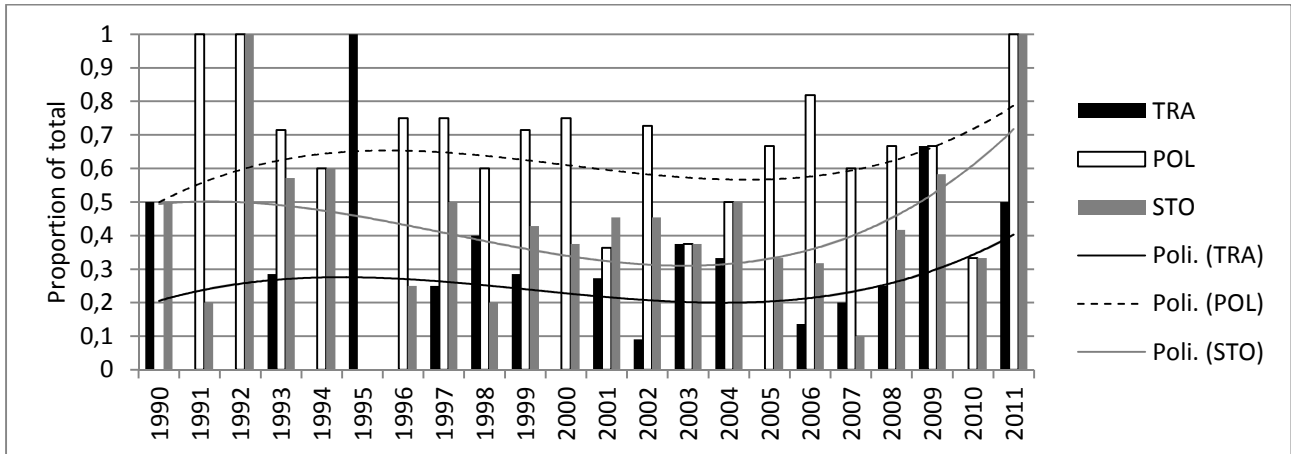
Based on this analysis, I obtained the following interpolation functions for each feature attached to each objective:

Objective 1:   DOM (t) = 0.00002t3 - 0.0008t2 + 0.0139t + 0.5428
                   POL $(t) = 0.0003t^3 - 0.0085t^2 + 0.0792t + 0.4286$
                   FLO $(t) = -0.0001t^3 + 0.0005t^2 + 0.035t + 0.2094$
Objective 2:   BOT1 $(t) = -0.0002t^3 + 0.0066t^2 - 0.0599t + 0.2923$
                   BOT2 $(t) = -0.0005t^3 + 0.0165t^2 - 0.1567t + 0.4271$
                   BOT3 $(t) = -0.0001t^3 + 0.0054t^2 - 0.0583t + 0.3143$
Objective 3:   TRA $(t) = 0.0002t^3 - 0.0057t^2 + 0.046t + 0.1649$
                   POL $(t) = 0.0003t^3 - 0.0085t^2 + 0.0792t + 0.4286$
                   STO $(t) = 0.0002t^3 - 0.0059t^2 + 0.0233t + 0.4763$

Note that I have only considered the dynamics between 1990 and 2011, due to the lack of records in 2012 and because of the distortions in the interpolations that would result from the few records before 1990, while I have estimated third-degree polynomials to describe the three objective periods. Based on this analysis, the EU environmental policy appear to be *efficient*. Indeed, issues related to Objective 1 were mainly tackled before 1997; issues related to Objective 2 were increasingly tackled from 1997 to 2003, with no delay; and issues related to Objective 3 were increasingly tackled since 2005, with a 2-year lag.

Figure 8. Implicit EU relative preferences for domestic versus trans-boundary issues (DOM/TRA) (thick), pollution versus resource issues (POL/RES) (dashed), and flow versus stock issues (FLO/STO) (thin) from 1990 to 2012.
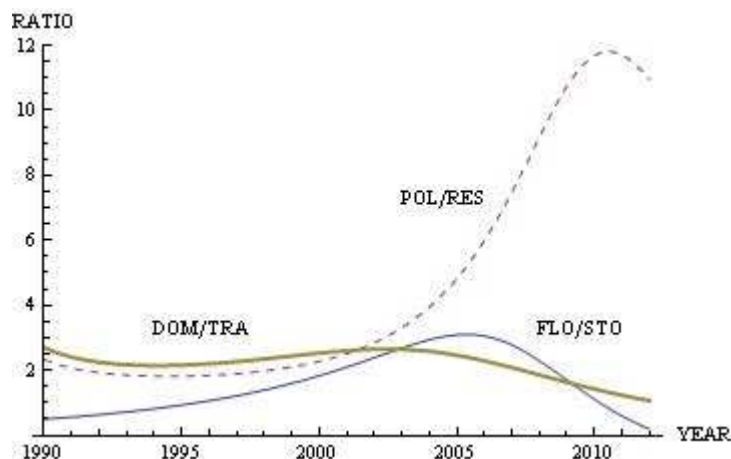
Figure 8 shows changes in the implicit relative preferences (i.e., importance) attached to the main issues from 1990 to 2012: DOM/TRA is initially larger than 1, then smaller; POL/RES is always larger than 1 and increases rapidly towards the end of the period; and FLO/STO is initially smaller than 1, increases gradually, then decreases again to values smaller than 1. Thus, trans-boundary issues became more relevant in 2012; pollution production was always considered to be more significant than resource uses, and became increasingly important over time; and flow issues were more important than stock issues from 1995 to 2010.

3.3. Econometric analysis

Although the statistical analysis performed in section 3.2 suggested that the EU environmental policy has been efficient in pursuing the stated objectives, it does not reveal the possibility of *overlapping* objectives, as suggested by the Lisbon Treaty (Steurer & Berger, 2011). In addition, the analysis did not look for potential *correlations* between issues, and such correlations are to be expected in the implemented policies; for example, climate change policies such as the emission trading system should refer to both TRA and STO issues. In this section, I will develop and estimate an econometric model to test for these problems and to test the assumptions I made in section 3.2.

Since some features are part of two or more objectives (e.g., POL belongs to both Objective 1 and Objective 3) and since all objectives can be assumed to be uncorrelated, even if they could potentially be combined, I will not estimate a nine-equation model. Instead, I will use a Taylor-type (backward-looking; Wang & Handa, 2007) reaction function, which I estimated using a probit model (Huang & Shen, 2002) for all three features related to an objective and for each stated objective ($j = 1, 2, 3$). In particular, I will obtain the maximum-likelihood estimation for the following 3 equation probit model of the three features:

$$\text{FEA}_{1j}(t) = \text{probit} [\text{OBJ}_1(t) \text{ v } \text{LOBJ}_1(t) \text{ v } \text{COBJ}_{12}(t) \text{ v } \text{LCOBJ}_{12}(t) \text{ v } \text{COBJ}_{123}(t) \text{ v } \text{LCOBJ}_{123}(t),$$
$$\text{OBJ}_2(t) \text{ v } \text{LOBJ}_2(t) \text{ v } \text{COBJ}_{23}(t) \text{ v } \text{LCOBJ}_{23}(t), \text{OBJ}_3(t) \text{ v } \text{LOBJ}_3(t)]$$

$$\text{FEA}_{2j}(t) = \text{probit} [\text{OBJ}_1(t) \text{ v } \text{LOBJ}_1(t) \text{ v } \text{COBJ}_{12}(t) \text{ v } \text{LCOBJ}_{12}(t) \text{ v } \text{COBJ}_{123}(t) \text{ v } \text{LCOBJ}_{123}(t),$$
$$\text{OBJ}_2(t) \text{ v } \text{LOBJ}_2(t) \text{ v } \text{COBJ}_{23}(t) \text{ v } \text{LCOBJ}_{23}(t), \text{OBJ}_3(t) \text{ v } \text{LOBJ}_3(t)]$$

$$\text{FEA}_{3j}(t) = \text{probit} [\text{OBJ}_1(t) \text{ v } \text{LOBJ}_1(t) \text{ v } \text{COBJ}_{12}(t) \text{ v } \text{LCOBJ}_{12}(t) \text{ v } \text{COBJ}_{123}(t) \text{ v } \text{LCOBJ}_{123}(t),$$
$$\text{OBJ}_2(t) \text{ v } \text{LOBJ}_2(t) \text{ v } \text{COBJ}_{23}(t) \text{ v } \text{LCOBJ}_{23}(t), \text{OBJ}_3(t) \text{ v } \text{LOBJ}_3(t)]$$

where $\text{FEA}_{1j}(t) = 1$ if the first issue (e.g., DOM) characterizing objective j (e.g., OBJ_1) is observed in a policy suggested at time t, and equals 0 otherwise; $\text{OBJ}_1(t) = 1$ from 1990 to 1997 and 0 otherwise when there is no lag; $\text{LOBJ}_1(t) = 1$ from 1991 to 1998 and 0 otherwise if there is a 1-year lag; $\text{COBJ}_{12}(t) = 1$ from 1990 to 2002 if there is no lag, but combined objectives 1 and 2; $\text{LCOBJ}_1(t) = 1$ from 1991 to 2002 and 0 otherwise if there is a 1-year lag, but combined objectives 1 and 2; $\text{COBJ}_{123}(t) = 1$ from 1990 to 2011 if there is no lag, but combined objectives 1, 2, and 3; and $\text{LCOBJ}_{123}(t) = 1$ from 1991 to 2011 and 0 otherwise if there is a 1-year lag, but combined objectives 1, 2, and 3. The other independent variables are defined similarly for $\text{OBJ}_2(t)$ and $\text{OBJ}_3(t)$.

Table 4 summarizes these values for the feasible and meaningful independent variables. Note that COBJ_{123} amounts to a constant, whereas some independent variables can be obtained as a linear combination of other independent variables.

This three-equation dynamic probit model can depict crucial aspects such as lags, combinations of objectives, and coefficients that vary over time (Huang & Lin, 2006), although it disregards irrelevant facets such as partial adjustments to a target (Clarida et al., 2000), smoothing (Huang & Lin, 2006) or inertia (Melecky, 2012) in policies, changes in forecasts (Kishor & Newiak, 2013), weak instruments (Shibamoto, 2008), and maximization of a specified objective function (Clarida et al., 1998).

Table 4. Summary of all feasible and meaningful independent variables.

Time	OBJ$_1$	LOBJ$_1$	COBJ$_{12}$	LCOBJ$_{12}$	COBJ$_{123}$	LCOBJ$_{123}$	OBJ$_2$	LOBJ$_2$	COBJ$_{23}$	LCOBJ$_{23}$	OBJ$_3$	LOBJ$_3$
1	1	0	1	0	1	0	0	0	0	0	0	0
2	1	1	1	1	1	1	0	0	0	0	0	0
…	1	1	1	1	1	1	0	0	0	0	0	0
9	0	0	1	1	1	1	1	0	1	0	0	0
10	0	0	1	1	1	1	1	1	1	1	0	0
…	0	0	1	1	1	1	1	1	1	1	0	0
13	0	0	0	0	1	1	0	0	1	1	1	0
14	0	0	0	0	1	1	0	0	1	1	1	1
…	0	0	0	0	1	1	0	0	1	1	1	1

Note that this analysis refers to the literature on monetary reaction functions, since this subject shares many features with the study problem. Indeed, independent variables consist of "stated" or "unstated" objectives (in monetary reactions, a target interest rate; here, three issues: Objective 1 = DOM, POL, FLO; Objective 2 = BOT1, BOT2, BOT3; Objective 3 = TRA, POL, STO). Moreover, dependent variables represent continuous instruments to achieve these objectives (in monetary reactions, the interbank lending rate for overnight loans; here, the importance attached to issues, to be tackled by alternative and equivalent policies). Finally, specified or unspecified exogenous random shocks are assumed to be independent and identically distributed (in monetary reactions, a pure random component to policy or an imperfect forecast idiosyncratic reserve demand; here, pressures to use some environmental policies or to achieve international visibility for the EU through its environmental policies). Table 5 shows that DOM and POL were significant and had larger coefficients for OBJ$_1$, whereas FLO was not significant; in addition, the sum of the coefficients was significantly different from 1 (i.e., $\chi^2 = 0.01$ with probability = 0.9245). Similar coefficients and significance levels were obtained for DOM, POL, and FLO if OBJ$_2$ is replaced by COBJ$_{12}$. Thus, Objective 1 appears to be insulated (i.e., pursued independently from other objectives), with DOM and POL as the only relevant features.

Table 5. Efficiency in pursuing Objective 1. Log-likelihood -274.22243, P > Wald $\chi^2 = 0.0007$, number of observations = 152, ρ_{21}, ρ_{31}, and ρ_{32} are the estimated correlation between the DOM and POL equation error terms, the FLO and DOM equation error terms, the FLO and POL equation error terms, respectively. Statistically significant values are boldfaced.

		Coeff.	Std. Err.	z	$P>\|z\|$	[95% Conf. Interval]	
DOM	OBJ$_1$	0.550	0.263	**2.09**	0.036	0.035	1.065
	COBJ$_{23}$	0.190	0.179	1.06	0.288	-0.160	0.540
	LOBJ$_3$	0.206	0.231	0.89	0.373	-0.247	0.659
POL	OBJ$_1$	0.573	0.264	**2.17**	0.030	0.055	1.092
	COBJ$_{23}$	0.192	0.178	1.08	0.279	-0.156	0.541
	LOBJ$_3$	0.244	0.231	1.06	0.289	-0.208	0.697
FLO	OBJ$_1$	-0.069	0.244	-0.28	0.776	-0.547	0.408
	COBJ$_{23}$	-0.102	0.176	-0.58	0.561	-0.446	0.242
	LOBJ$_3$	0.000	0.228	0.00	0.998	-0.446	0.447
	ρ_{21}	0.611	0.094	**6.51**	0.000	0.394	0.763
	ρ_{31}	0.539	0.102	**5.31**	0.000	0.312	0.708
	ρ_{32}	0.570	0.102	**5.61**	0.000	0.339	0.737

Table 6 shows that BOT1, BOT2 and BOT3 were all significant and had larger coefficients for COBJ$_2$; in addition, the sum of the coefficients was 1 (i.e., $\chi^2 = 73.18$ with probability < 0.0001). Replacing OBJ$_1$ with COBJ$_{12}$ or COBJ$_{123}$ and replacing COBJ$_{23}$ with OBJ$_2$ produced unsatisfactory

estimates, in terms of both the size and the significance of the coefficients. Thus, Objective 2 appears to be combined both with an earlier objective (i.e., OBJ_1 is highly significant) and with a later objective (i.e., $COBJ_{23}$ must be used rather than OBJ_2), with BOT1, BOT2, and BOT3 all becoming crucial features.

Table 6. Efficiency in pursuing Objective 2. Log-likelihood -148.17416, P > Wald χ^2 < 0.0001, number of observations = 152, ρ_{21}, ρ_{31}, and ρ_{32} are the estimated correlation between the BOT2 and BOT1 equation error terms, the BOT3 and BOT1 equation error terms, the BOT3 and BOT2 equation error terms, respectively. Statistically significant values are boldfaced.

		Coeff.	Std. Err.	z	$P>|z|$	[95% Conf. Interval]	
BOT1	OBJ_1	-1.097	0.293	-3.75	0.000	-1.670	-0.523
	$COBJ_{23}$	-0.850	0.204	**-4.18**	0.000	-1.249	-0.451
	$LOBJ_3$	-0.521	0.292	-1.78	0.075	-1.094	0.052
BOT2	OBJ_1	-1.856	0.454	-4.09	0.000	-2.746	-0.967
	$COBJ_{23}$	-1.075	0.220	**-4.89**	0.000	-1.506	-0.644
	$LOBJ_3$	-0.077	0.287	-0.27	0.788	-0.640	0.486
BOT3	OBJ_1	-1.470	0.347	-4.23	0.000	-2.151	-0.789
	$COBJ_{23}$	-1.075	0.221	**-4.86**	0.000	-1.509	-0.641
	$LOBJ_3$	0.114	0.279	0.41	0.684	-0.434	0.662
	ρ_{21}	0.192	0.206	0.93	0.352	-0.221	0.547
	ρ_{31}	0.242	0.194	1.25	0.211	-0.155	0.572
	ρ_{32}	0.879	0.064	**13.69**	0.000	0.674	0.958

Table 7 shows that TRA, POL, and STO all had significant and larger values for the coefficient of $LOBJ_3$: the sum of coefficients is 1 (i.e., χ^2 = 28.28 with probability < 0.0001). Replacing OBJ_1 with $COBJ_{12}$ or $COBJ_{123}$ and replacing OBJ_2 with $COBJ_{23}$ produces unsatisfactory estimates in terms of both the size and the significance of the coefficients. Thus, Objective 3 appears to be insulated (i.e., pursued independently from other objectives), with TRA, POL, and STO all becoming crucial features.

Table 7. Efficiency in pursuing Objective 3. Log-likelihood -260.73435, P > Wald χ^2 < 0.0001, number of observations = 152, ρ_{21}, ρ_{31}, and ρ_{32} are the estimated correlation between the POL and TRA equation error terms, the STO and TRA equation error terms, the STO and POL equation error terms, respectively. Statistically significant values are boldfaced.

		Coeff.	Std. Err.	z	$P>|z|$	[95% Conf. Interval]	
TRA	OBJ_1	-0.960	0.275	-3.49	0.000	-1.499	-0.421
	OBJ_2	-0.859	0.221	-3.88	0.000	-1.292	-0.425
	$LOBJ_3$	-0.633	0.156	**-4.05**	0.000	-0.939	-0.326
POL	OBJ_1	0.509	0.249	2.04	0.041	0.021	0.997
	OBJ_2	0.302	0.196	1.54	0.124	-0.082	0.687
	$LOBJ_3$	0.441	0.151	**2.92**	0.004	0.145	0.736
STO	OBJ_1	-0.134	0.232	-0.58	0.565	-0.589	0.322
	OBJ_2	-0.234	0.193	-1.21	0.227	-0.613	0.145
	$LOBJ_3$	-0.299	0.148	**-2.02**	0.043	-0.590	-0.009
	ρ_{21}	-0.296	0.132	**-2.24**	0.025	-0.529	-0.021
	ρ_{31}	0.748	0.080	**9.40**	0.000	0.547	0.867
	ρ_{32}	-0.208	0.129	-1.61	0.107	-0.443	0.053

Therefore, the econometric analysis confirms the previous statistical results:

- The EU adopted three different environmental policies during three different periods rather than a single policy that they fine-tuned over time; indeed, estimations based on a constant (i.e., $COBJ_{123}$) and two dummy variables (i.e., OBJ_2 and OBJ_3) were rejected.
- The EU pursued its stated objectives; indeed, the significance and size of the coefficients were consistent with the relative importance of the issues in each environmental policy.
- The EU attempted a sustainable development objective (Objective 2) with no temporal lag, and a GHG reduction objective (Objective 3) with a small temporal lag: indeed, there is no Cholesky factorisation of the covariance matrix for the errors with a 2-year lags for OBJ3.

However, the econometric analysis adds some insights to the previous statistical results:

- Many issues are meaningfully correlated; indeed, significant positive correlations were observed between DOM and POL, DOM and FLO, and POL and FLO (i.e., ρ_{21}, ρ_{31}, and ρ_{32} in Table 5); a significant negative correlation existed between TRA and POL (i.e., ρ_{21} in Table 7); and significant positive correlations were observed between BOT2 and BOT3 (i.e., ρ_{32} in Table 6), and TRA and STO (i.e., ρ_{31} in Table 7).
- The approach to identify environmental policies adopted in this study is supported; indeed, the overall significance of the estimations was high (all Wald χ^2 tests had $P < 0.0001$).
- The objectives overlapped temporally only to a small extent; indeed, only the sustainable development objective (Objective 2) overlapped significantly with the GHG reduction objective (Objective 3).

Note that similar results were obtained (data not shown) by applying the Geweke–Hajivassiliou–Keane (GHK) smooth recursive conditioning simulator (Cappellari & Jenkins, 2003), whereas introducing a constant to increase consistency amounts to using $COBJ_{123}$.

However, the econometric analysis misses some results revealed by the statistical analysis:

- The relative importance of single issues in each policy over time.
- The identification of the year when a given issue became more or less important for a given objective.
- The specific lag time for tackling single issues in each policy.

In particular, the sum of the three interpolation functions that depict each objective, after transformation into scores in the interval [0,1] by dividing the values by 3 (i.e., the maximum proportion achievable by the three issues that characterize an objective, each with a value of 1) allows estimation of changes in the relative preferences for the stated objectives over time, based on the assumption that all three objectives could be pursued simultaneously (ALLOBJ):

$$OBJ_1 (t) = [DOM (t) + POL (t) + FLO (t)]/3$$
$$OBJ_2 (t) = [BOT1 (t) + BOT2 (t) + BOT3 (t)]/3$$
$$OBJ_3 (t) = [TRA (t) + POL (t) + STO (t)]/3$$
$$ALLOBJ (t) = OBJ_1 (t) + OBJ_2 (t) + OBJ_3 (t)$$

Figure 9 shows that Objective 1 > Objective 3 > Objective 2 for most of the study period, except for Objective 3 > Objective 1 starting in 2011. Objective 2 appears to be declining in importance before 1997, increases in importance until 2005, and then decreases to a relative importance of 0 by the end of the period. Thus, although a GHG reduction objective has been preferred to a safe environment objective only during the last year of the study period, the latter (Objective 1) has been preferred to the former (Objective 3), which in turn has been preferred to a sustainable development objective. Although this last objective (Objective 2) was pursued before it was formally stated, it quickly became unimportant towards the end of the study period.

Figure 9. Changes in the values of the implicit relative preferences for the three stated objectives from 1990 to 2012.
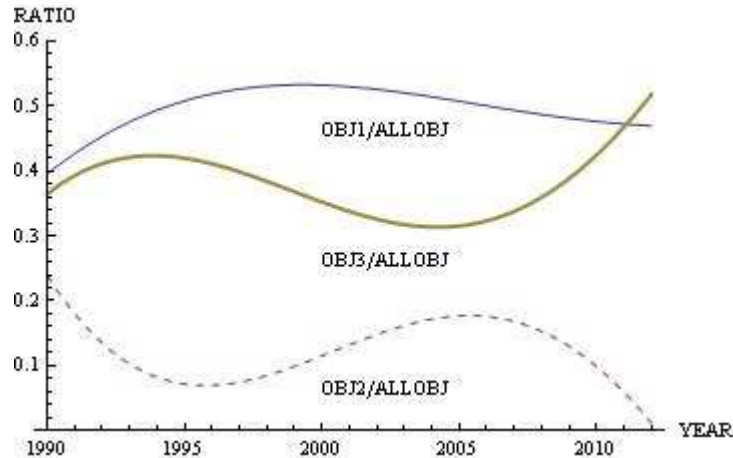
Note that these dynamics confirm that a sustainable development objective and a GHG reduction objective have been tackled with no temporal lag and with a 2-year lag, respectively.

4. Discussion

Although the present study provided useful results, it has some weaknesses that should be addressed in future research. First, there are no meta-preferences for coherence, efficiency, and independence that could be jointly pursued and no overall objective function to be maximized. However, the different characteristics of coherence, efficiency, and independence suggested that they should be considered separately using different analytical tools. Moreover, both the statistical results and the econometric results depend on the (sometimes subjective) allocations of EU laws among the three dichotomous classes (i.e., TRA vs. DOM, POL vs. RES, FLO vs. STO) and the 11 environmental and contextual policies (i.e., TAX, STA, PER, SUB, GRO, TEC, COS, INF, UNC, COO, RIG). However, since these criteria are well established in the literature, and the results are easily understood and interpreted, those classes and policies seem to provide plausible descriptions. Finally, the econometric analysis does not apply dummy variables to control for structural changes such as modifications of the EU Commission or EU parliament (i.e., the changes that occurred in 1989, 1994, 1999, 2004, 2009). However, the statistical analysis highlights these changes: interpolation functions for BOT1, BOT2, and BOT3 are increasing and convex from 1995 to 1999, and increasing and concave from 2000 to 2004; in contrast, the interpolation functions for TRA, POL, and STO are increasing and convex from 2005 onward).

The main strengths of the present approach are as follows: Analyses could be extended to cases or councils by the Court of Justice, which mainly aims at implementing past EU policies such as standards, and at addressing past issues such as waste management or water quality. Moreover, the results arise from complementary statistical and econometric analyses, which provides mutual support for the conclusions. Indeed, these analyses focus on different aspects of the study system: on the one hand, the relative importance values that are implicitly attached to single issues and objectives, the years when an issue increased or decreased in importance, and specific time lags in tackling single issues and objectives; on the other hand, the possible correlation between issues and the possible combination of objectives. However, the statistical and econometric analyses support each other: the statistical analysis assumes that the sum of the issue coefficients equals 1 for each objective, and the econometric analysis tests this assumption; the statistical analysis assumes the significance of some issues for some objectives, and the econometric analysis tests this for significance; the statistical analysis assumes the existence of three alternative objectives, and the econometric analysis tests this assumption; the econometric analysis highlights a temporal lag in tackling Objective 3, but the statistical analysis specifies it over 2 years; and the econometric analysis suggests a changed focus on alternative objectives, and the statistical analysis identifies the

years when an issue increased or decreased in importance. Finally, the dataset could be updated and analyses could be applied to Objective 4 (a dematerialized economy), as stated in the Lisbon Treaty (2007).

5. Conclusions

The statistical and econometric analyses developed in this study based on the proposed classification criteria provided insights into how EU institutions have exploited the available policy tools to deal with environmental issues.

In particular, principles and concepts introduced in treaties and DIR were implemented via DEC and REG. Command-and-control policies (STA and GRO) were adopted first, followed by context policies (COO, then INF, then RIG), and finally by incentive policies (PER, TAX, and TEC). In other words, the overall EU environmental policy system shows coherence (i.e., consistency of the policies within the competitive general equilibrium framework). Moreover, a set of overlapping policies (here, considered as theoretically equivalent within that framework) is properly used in a timely manner to pursue all three stated objectives (here, defined as a trio of environmental issues), with Objective 2 (sustainable development) being assigned a smaller relative importance than Objective 3 (GHG reduction) and with Objective 3 having a smaller (but increasing) importance than Objective 1 (a safe environment). In other words, the overall EU environmental policy system shows efficiency (i.e., the ability of the policies to meet their objectives). Finally, objectives are stated then pursued, although sometimes with temporal lags. In other words, overall EU environmental policy system shows independence (i.e., logical priority of objectives over policies). Note that I did not consider other determinants of the EU environmental policy such as interest groups (Bunea, 2013) or external factors (Schultze & Tosun, 2013) due to lack of reliable and comprehensive data.

I also examined whether the overall EU environmental policy system showed innovation (i.e., scientific debate about single policies). In particular, I collected data from references published between 2010 and 2013 from scopus.com related to assessment of EU policy (i.e., impacts on the environment) or on the relationships among EU policies (e.g., synergies or inconsistencies between policies), based on cross-country and cross-sector data. However, I excluded studies of the impacts on competitiveness, trade, health, and sectoral or regional case studies. My focus was on English articles in economics, environmental sciences, social sciences, and Earth sciences. I then linked the 174 policies and the 235 references to support my examination. The literature was subdivided as follows: PER (1 policy/41 references), TEC (1/11), UNC (3/6), INF (36/68), GRO (12/13), RIG (12/12), TAX (2/2), STA (79/68), and COO (28/14). Thus, DIR2003/87 (Greenhouse gas emission allowance trading scheme) and DIR2009/28 (Promotion of the use of energy from renewable sources) turned out to be the most innovative EU policies These results of my analysis were similar to those of Rogge et al. (2011). Note that some EU policies are not recent, and that the literature I analyzed refers only to the period from 2010 to 2013.

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Supplementary Material

Table S1. Summary of DECISIONS (DEC, directly applicable to member states). If EURATOM is unspecified, the decision was by the EC or the EEC. BOT, cases in which both sub-categories were plausible; COO, policies to improve cooperation; COS, marginal costs; DOM, domestic issues; FLO, flow-related terms; GRO, growth rate; INF = policies to share information; PER, permits; POL, pollution production; RES, resource use; RIG, policies to enforce rights; STA, standards; STO, stock-related terms; SUB, subsidies; TAX, taxes; TEC, prices of substitutive technology; TRA, trans-boundary issues; UNC, policies to reduce uncertainty.

DOM/TRA	RES/POL	STO/FLO	DESCRIPTION	YEAR	NUMBER	I POL	II POL
BOT1	RES	STO	•Barcelona Convention for the protection of the Mediterranean	1977	585	COO	GRO

BOT1	RES	STO	•Barcelona Convention for the protection of the Mediterranean	1981	420	COO	GRO
TRA	POL	FLO	•Geneva Convention on Long-Range Trans-boundary Air Pollution	1981	462	COO	STA
BOT1	RES	STO	•Conservation of Antarctic marine living resources	1981	691	GRO	COO
TRA	RES	STO	•Berne Convention	1982	72	COO	GRO
TRA	RES	STO	•Conservation of migratory species—Bonn Convention	1982	461	COO	GRO
BOT1	RES	STO	•Barcelona Convention for the protection of the Mediterranean	1983	101	COO	GRO
BOT1	RES	STO	•Barcelona Convention for the protection of the Mediterranean	1984	132	COO	GRO
DOM	POL	STO	•Basel Convention	1993	98	COO	STA
TRA	RES	STO	•The Rio de Janeiro Convention on biological diversity	1993	626	COO	GRO
BOT1	RES	STO	•Helsinki Convention on the protection of the Baltic Sea	1994	156	COO	GRO
BOT1	RES	STO	•Helsinki Convention on the protection of the Baltic Sea	1994	157	COO	GRO
TRA	RES	BOT3	•Helsinki Convention: trans-boundary watercourses and international lakes	1995	308	COO	STA
BOT1	RES	STO	•Convention on the Protection of the Alps	1996	191	COO	GRO
DOM	POL	STO	•Basel Convention	1997	640	COO	STA
TRA	RES	STO	•UN Convention to combat desertification in countries seriously affected by drought	1998	216	COO	GRO
BOT1	RES	FLO	•OSPAR Convention	1998	294	COO	GRO
TRA	POL	FLO	•Trans-boundary effects of industrial accidents	1998	685	STA	
BOT1	RES	FLO	•Convention for the Protection of the Rhine	2000	706	COO	STA
DOM	POL	STO	•Protocol on Heavy Metals	2001	379	COO	STA
DOM	POL	BOT3	•Community eco-management and audit scheme (EMAS)	2001	681	INF	
DOM	RES	STO	•Financial framework for the urban environment Archives	2001	1411	RIG	INF
TRA	POL	STO	•Kyoto Protocol on climate change	2002	358	COO	STA
DOM	POL	FLO	•Maritime safety: Bunkers Convention	2002	762	COO	STA
BOT1	BOT2	BOT3	•Sixth Environment Action Programme	2002	1600	COO	INF
TRA	POL	STO	•Mechanism for monitoring greenhouse gas emissions	2004	280	INF	
BOT1	RES	STO	•Barcelona Convention for the protection of the Mediterranean	2004	575	COO	GRO
DOM	BOT2	BOT3	•Access to information—public participation and access to justice	2005	370	RIG	INF
DOM	BOT2	BOT3	•Community eco-management and audit scheme (EMAS)	2006	193	INF	
DOM	POL	FLO	•Stockholm Convention on persistent organic pollutants (POPs)	2006	507	COO	STA
TRA	POL	FLO	•The Rotterdam Convention on the international trade in hazardous chemicals	2006	730	COO	STA
DOM	BOT2	BOT3	•Seventh Framework Programme (2007 to 2013)	2006	969	INF	COO
DOM	POL	BOT3	•Competitiveness and Innovation Framework Programme (CIP; 2007 to 2013)	2006	1639	INF	COO
DOM	BOT2	BOT3	•Seventh Framework Programme (2007 to 2013)	2006	1982	INF	COO
DOM	POL	FLO	•Financing of civil protection measures (2007 to 2013) EURATOM	2007	162	RIG	COO
DOM	POL	FLO	•Civil Protection Mechanism EURATOM	2007	779	RIG	
DOM	POL	BOT3	•Scientific Committees for consumer safety—public health and the environment	2008	721	INF	COO
TRA	POL	STO	•Reducing greenhouse gases by 2020	2009	406	STA	
BOT1	RES	STO	•Barcelona Convention for the protection of the Mediterranean	2010	631	COO	GRO

Table S2. Summary of DIRECTIVES (DIR, to be implemented by EU's member states). If EURATOM is unspecified, the decision was by the EC or the EEC. BOT, cases in which both sub-categories were plausible; COO, policies to improve cooperation; COS, marginal costs; DOM, domestic issues; FLO, flow-related terms; GRO, growth rate; INF = policies to share information; PER, permits; POL, pollution production; RES, resource use; RIG, policies to enforce rights; STA, standards; STO, stock-related terms; SUB, subsidies; TAX, taxes; TEC, prices of substitutive technology; TRA, trans-boundary issues; UNC, policies to reduce uncertainty.

DOM/TRA	RES/POL	STO/FLO	DESCRIPTION	YEAR	NUMBER	I POL	II POL
DOM	POL	FLO	•Motor vehicles with trailers: permissible sound level	1970	157	STA	
DOM	POL	FLO	•Bathing water quality (until 2014)	1976	160	STA	
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	1976	769	INF	STA
DOM	POL	STO	•Disposal of titanium dioxide industrial waste	1978	176	STA	
DOM	POL	STO	•Other substances: protection of groundwater	1980	68	STA	

DOM	POL	FLO	•Environmental quality standards applicable to surface water	1982	176	STA	
DOM	POL	STO	•Surveillance and monitoring of titanium dioxide waste	1982	883	INF	STA
TRA	RES	STO	•Protection of certain seal species	1983	129	GRO	
DOM	POL	FLO	•Environmental quality standards applicable to surface water	1983	513	STA	
DOM	POL	FLO	•Environmental quality standards applicable to surface water	1984	156	STA	
DOM	POL	FLO	•Environmental quality standards applicable to surface water	1984	491	STA	
DOM	BOT2	BOT3	•Assessment of the effects of plans and programmes (Impact Assessment)	1985	337	INF	
DOM	POL	STO	•Use of sewage sludge in agriculture	1986	278	STA	
DOM	POL	FLO	•Environmental quality standards applicable to surface water	1986	280	STA	
TRA	RES	STO	•Deliberate release of genetically modified organisms (GMOs)	1990	220	STA	INF
BOT1	BOT2	BOT3	•Freedom of access to information	1990	313	INF	RIG
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	1991	155	INF	STA
DOM	POL	FLO	•Urban wastewater treatment	1991	271	STA	
DOM	POL	FLO	•Agricultural nitrates (nitrates)	1991	676	STA	
DOM	POL	STO	•Controlled management of hazardous wastes (until the end of 2010) Archives	1991	689	STA	INF
DOM	POL	STO	•Reduction of pollution caused by waste from the titanium dioxide industry	1992	112	STA	
TRA	RES	STO	•Natural habitats (Natura 2000)	1993	43	GRO	
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	1993	67	INF	STA
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	1993	105	INF	STA
DOM	POL	STO	•Packaging and packaging waste	1994	62	STA	
DOM	POL	FLO	•Recovery of petrol vapors during storage	1994	63	STA	
DOM	POL	FLO	•Disposal of polychlorinated biphenyls (PCBs) and polychlorinated terphenyls (PCTs)	1996	59	STA	
DOM	POL	FLO	•European Pollutant Release and Transfer Register (PRTR)	1996	61	INF	
DOM	POL	FLO	•Major accidents involving dangerous substances	1996	82	STA	
DOM	POL	FLO	•Non-road mobile machinery: gaseous pollutants	1997	68	STA	
DOM	POL	FLO	•Quality of petrol and diesel fuels: sulfur and lead	1998	70	STA	
DOM	POL	FLO	•Quality of drinking water	1998	83	STA	
DOM	POL	FLO	•Reducing the emissions of volatile organic compounds (VOCs)	1999	13	STA	
BOT1	RES	FLO	•The keeping of wild animals in zoos	1999	22	RIG	
DOM	POL	STO	•Landfill of wastes	1999	31	STA	
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	1999	45	INF	STA
DOM	POL	FLO	•Taxation of heavy goods vehicles: Eurovignette Directive	1999	62	TAX	
DOM	POL	FLO	•Information on the fuel consumption and CO_2 emissions of new cars	1999	94	INF	
TRA	RES	STO	•International Dolphin Conservation Programme	1999	337	GRO	INF
DOM	POL	FLO	•Noise emission by equipment used outdoors	2000	14	STA	
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	2000	21	INF	STA
DOM	POL	FLO	•Pollutant gases of wheeled agricultural or forestry tractors	2000	25	STA	
DOM	POL	STO	•End-of-life vehicles	2000	53	STA	
DOM	POL	STO	•Port facilities for ship-generated wastes and cargo residues	2000	59	STA	
BOT1	RES	BOT3	•Water protection and management (Water Framework Directive)	2000	60	INF	COO
DOM	POL	STO	•Waste incineration	2000	76	STA	
TRA	RES	STO	•Deliberate release of genetically modified organisms (GMOs)	2001	18	STA	
TRA	RES	STO	•Traceability and labeling of GMOs	2001	18	STA	
DOM	BOT2	BOT3	•Assessment of the effects of plans and programmes (Strategic Assessment)	2001	42	RIG	INF
DOM	POL	FLO	•Pollutants from large combustion plants	2001	80	STA	
DOM	POL	FLO	•National emission ceilings for certain atmospheric pollutants	2001	81	STA	
DOM	POL	FLO	•Noise management at EU airports	2002	30	STA	
DOM	POL	FLO	•Assessment and management of environmental noise	2002	49	STA	
BOT1	POL	FLO	•Maritime safety: prevention of pollution from ships	2002	84	STA	
DOM	POL	STO	•Waste electrical and electronic equipment	2002	95	STA	
DOM	POL	STO	•Waste electrical and electronic equipment	2002	96	STA	
BOT1	BOT2	BOT3	•Freedom of access to information	2003	4	INF	

DOM	RES	FLO	•Motor vehicles: use of biofuels Archives	2003	30	STA	TEC
TRA	POL	STO	•Greenhouse gas emission allowance trading scheme	2003	87	PER	
DOM	BOT2	FLO	•Community framework for the taxation of energy products and electricity	2003	96	TAX	INF
DOM	BOT2	FLO	•Environmental liability	2004	35	RIG	STA
DOM	POL	FLO	•Ship-source pollution and criminal penalties	2005	35	STA	RIG
DOM	POL	STO	•The reusing, recycling, and recovery of motor vehicles	2005	64	STA	
DOM	POL	FLO	•Bathing water quality	2006	7	STA	
DOM	POL	FLO	•Protection of the aquatic environment against discharges of dangerous substances (until 2013)	2006	11	STA	
TRA	POL	STO	•Carbon dioxide capture and geological storage	2006	12	STA	
DOM	POL	STO	•Management of wastes from extractive industries	2006	21	STA	
TRA	POL	FLO	•Emissions from air conditioning systems in motor vehicles	2006	40	STA	
DOM	POL	FLO	•Water suitable for fish reproduction	2006	44	STA	
DOM	POL	STO	•Disposal of spent batteries and accumulators	2006	66	STA	
DOM	POL	FLO	•Quality of shellfish waters	2006	113	STA	
DOM	POL	STO	•Shipments of radioactive waste: supervision and control EURATOM	2006	117	STA	
DOM	POL	STO	•Protection of groundwater against pollution	2006	118	STA	
BOT1	POL	FLO	•Infrastructure for Spatial Information (INSPIRE)	2007	2	INF	
BOT1	RES	FLO	•Flood management and evaluation	2007	60	UNC	COO
DOM	POL	FLO	•Motor vehicles with trailers: permissible sound level	2007	734	STA	
DOM	POL	BOT3	•Integrated pollution prevention and control (until 2013; IPPC)	2008	1	INF	STA
DOM	POL	FLO	•Pure air for Europe	2008	50	STA	
BOT1	RES	STO	•Strategy for the marine environment (Marine Strategy Framework)	2008	56	INF	COO
DOM	POL	STO	•Directive on wastes	2008	98	STA	
DOM	BOT2	FLO	•Protection of the environment through criminal law	2008	99	RIG	
DOM	POL	FLO	•Environmental quality standards applicable to surface water	2008	105	STA	
DOM	RES	FLO	•Promotion of the use of energy from renewable sources	2009	28	TEC	
TRA	POL	STO	•Carbon dioxide capture and geological storage	2009	31	STA	
DOM	POL	FLO	•Clean and energy-efficient road transport vehicles	2009	33	STA	
TRA	RES	STO	•Contained use of genetically modified micro-organisms (GMMs)	2009	41	STA	
DOM	POL	FLO	•Petrol vapor recovery during refueling of vehicles	2009	126	STA	
TRA	RES	STO	•Conservation of wild birds	2009	147	GRO	
DOM	RES	FLO	•Protection of laboratory animals	2010	63	RIG	
DOM	POL	FLO	•Industrial emissions	2010	75	STA	
DOM	POL	STO	•Management of spent fuels and radioactive wastes EURATOM	2011	70	UNC	

Table S3. Summary of REGULATIONS (REG, directly applicable to member states). If EURATOM is unspecified, the decision was by the EC or the EEC. BOT, cases in which both sub-categories were plausible; COO, policies to improve cooperation; COS, marginal costs; DOM, domestic issues; FLO, flow-related terms; GRO, growth rate; INF = policies to share information; PER, permits; POL, pollution production; RES, resource use; RIG, policies to enforce rights; STA, standards; STO, stock-related terms; SUB, subsidies; TAX, taxes; TEC, prices of substitutive technology; TRA, trans-boundary issues; UNC, policies to reduce uncertainty.

DOM/TRA	RES/POL	STO/FLO	DESCRIPTION	YEAR	NUMBER	I POL	II POL
DOM	POL	FLO	•Production and labeling of organic products	1991	2092	INF	STA
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	1993	793	INF	STA
DOM	POL	STO	•Shipments of radioactive substances	1993	1493	UNC	STA
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	1994	1488	INF	STA
DOM	POL	FLO	•Novel foods and food ingredients	1997	258	STA	
TRA	RES	STO	•Endangered species of wild fauna and flora (CITES)	1997	338	GRO	
DOM	BOT2	FLO	•Environmental inspections: minimum criteria	2001	331	INF	
DOM	BOT2	BOT3	•Community eco-management and audit scheme (EMAS)	2001	761	INF	
TRA	RES	STO	•Conservation of certain stocks of migratory fish	2001	1936	GRO	
BOT1	BOT2	BOT3	•Development and integrated management of coastal zones	2002	413	GRO	INF
DOM	POL	STO	•Waste management statistics	2002	2150	INF	

BOT1	RES	STO	•Conservation and exploitation of marine resources	2002	2371	GRO	
BOT1	POL	FLO	•Maritime safety: prohibition of organotin compounds on ships	2003	782	STA	
DOM	POL	FLO	•The Marco Polo II programme	2003	1382	STA	
TRA	RES	STO	•Traceability and labeling of GMOs	2003	1830	STA	
TRA	RES	STO	•Transboundary movement of genetically modified organisms	2003	1946	STA	
BOT1	POL	FLO	•Framework for creation of the Single European Sky (SES)	2004	549	STA	
DOM	POL	FLO	•Detergents	2004	648	STA	
TRA	RES	STO	•Protecting cetaceans against incidental catch	2004	812	GRO	
DOM	POL	FLO	•European Pollutant Release and Transfer Register (PRTR)	2006	166	INF	
TRA	POL	STO	•Reduction in fluorinated greenhouse gases	2006	842	STA	
DOM	POL	STO	•Shipments of waste	2006	1013	STA	
DOM	BOT2	BOT3	•Application of the Aarhus Convention to EU institutions	2006	1367	COO	RIG
DOM	POL	FLO	•The Marco Polo II programme	2006	1692	INF	STA
DOM	POL	FLO	•Regulatory framework for the management of chemicals (REACH)	2006	1907	INF	STA
DOM	RES	BOT3	•Programme LIFE+	2007	614	RIG	COO
TRA	RES	STO	•Alien and locally absent species	2007	708	GRO	
TRA	POL	FLO	•Reduction of pollutant emissions from light vehicles	2007	715	STA	
DOM	POL	FLO	•Production and labeling of organic products	2007	834	INF	
TRA	RES	FLO	•Ban on trade in cat and dog fur	2007	1523	RIG	
DOM	POL	FLO	•Clean Sky	2008	71	STA	
TRA	POL	FLO	•The Rotterdam Convention on the international trade in hazardous chemicals	2008	689	COO	STA
DOM	RES	STO	•Protection of vulnerable marine ecosystems in the high seas from bottom fishing	2008	734	GRO	
TRA	POL	STO	•Export and storage of mercury	2008	1102	STA	
TRA	RES	STO	•Food and Feed (GMO)	2008	1829	STA	
TRA	POL	FLO	•Reduction in CO_2 emissions of new passenger cars	2009	443	STA	
TRA	POL	FLO	•Emissions from heavy duty vehicles (Euro VI): certification rules	2009	595	INF	
TRA	POL	STO	•Substances affecting the ozone layer	2009	1005	STA	
TRA	POL	FLO	•Trade in seal products	2009	1007	STA	
DOM	BOT2	BOT3	•Community eco-management and audit scheme (EMAS)	2009	1221	INF	
DOM	POL	BOT3	•Ecolabeling	2010	66	INF	
DOM	BOT2	BOT3	•European Earth monitoring programme (GMES)	2010	911	COO	INF
DOM	RES	STO	•Fight against illegal logging	2010	995	RIG	
TRA	POL	FLO	•Reduction of carbon dioxide emissions from light commercial vehicles	2011	510	STA	

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