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Coherence, efficiency, and independence of the EU environmental policy system: results of complementary statistical and econometric analyses

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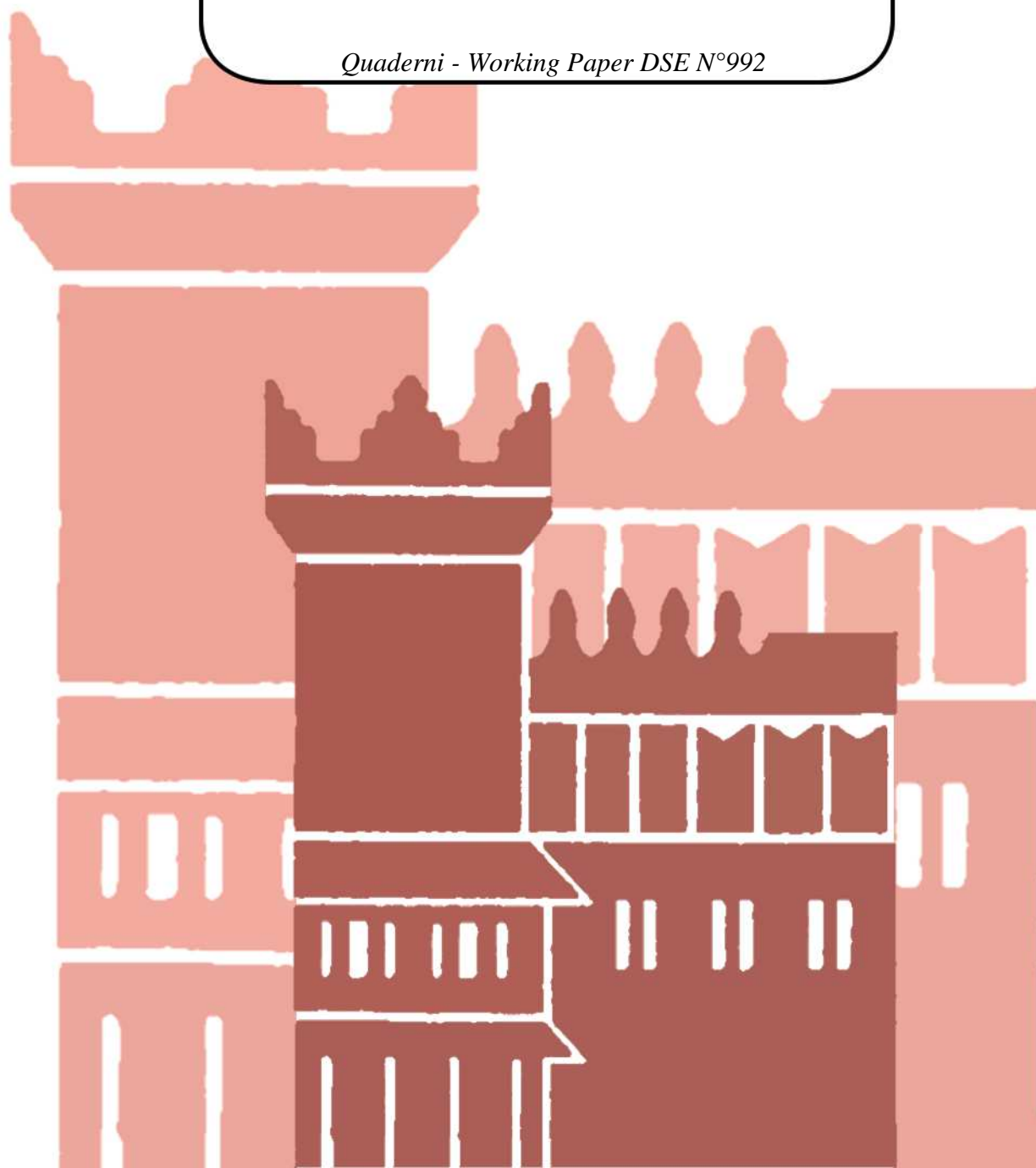
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**Coherence, efficiency, and independence
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and econometric analyses**

Fabio Zagonari

Quaderni - Working Paper DSE N°992



Coherence, efficiency, and independence of the EU environmental policy system: results of complementary statistical and econometric analyses

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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 & Daughjerg (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 & Dobрева, 2011; Newig & Koontz, 2013; Wolking 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 CO₂ 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 (CO₂ 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 1 and 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.

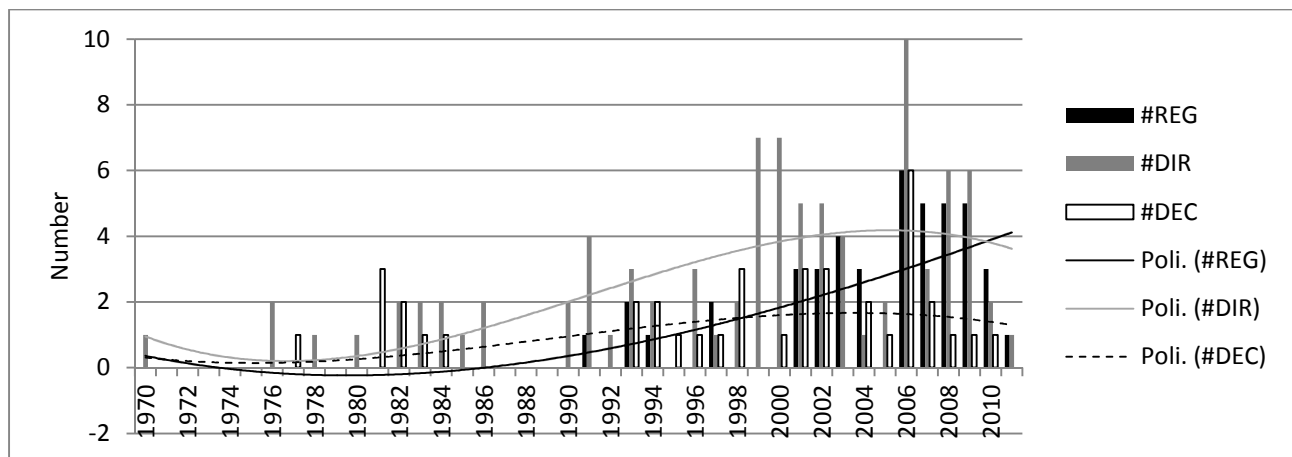


Figure 2. Changes in the number of pollution policies from 1970 to 2011. Policies: STA, standards; TAX, taxes; PER, permits. Lines represent the results of polynomial regressions.

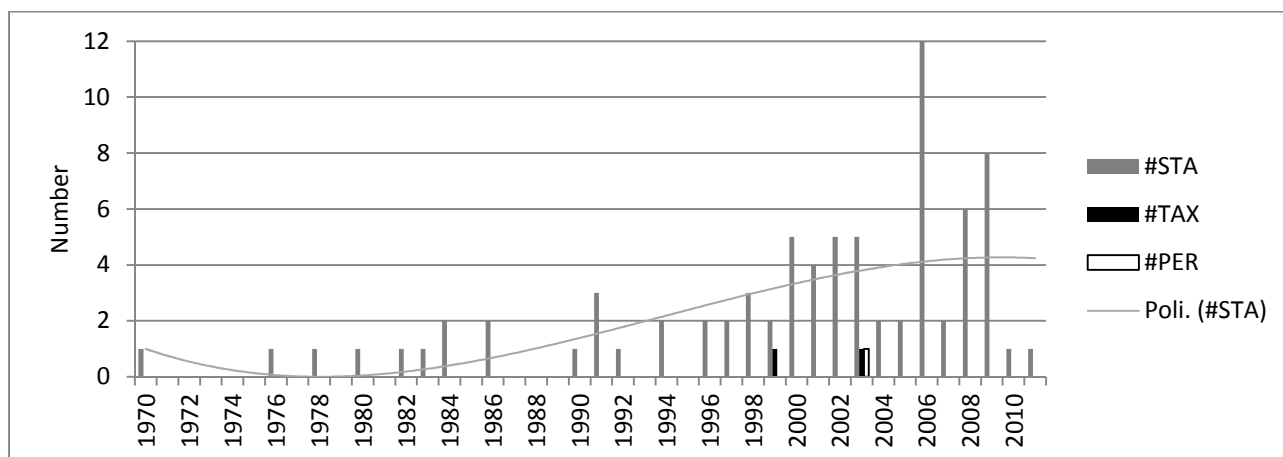


Figure 3. Changes in the number of resource policies from 1970 to 2011. Policies: GRO, growth rates; TEC, prices of substitutive technology. Lines represent the results of polynomial regressions.

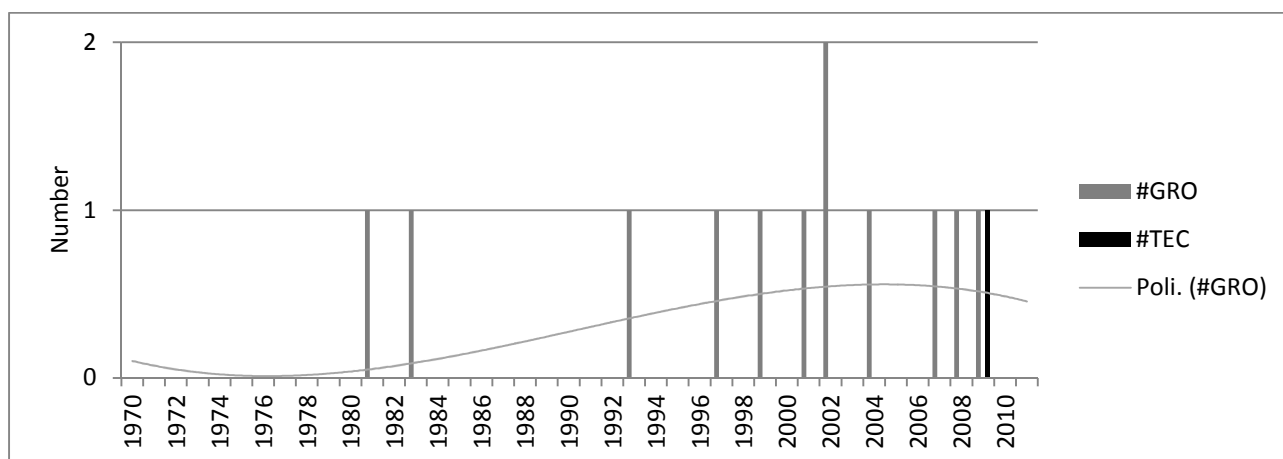
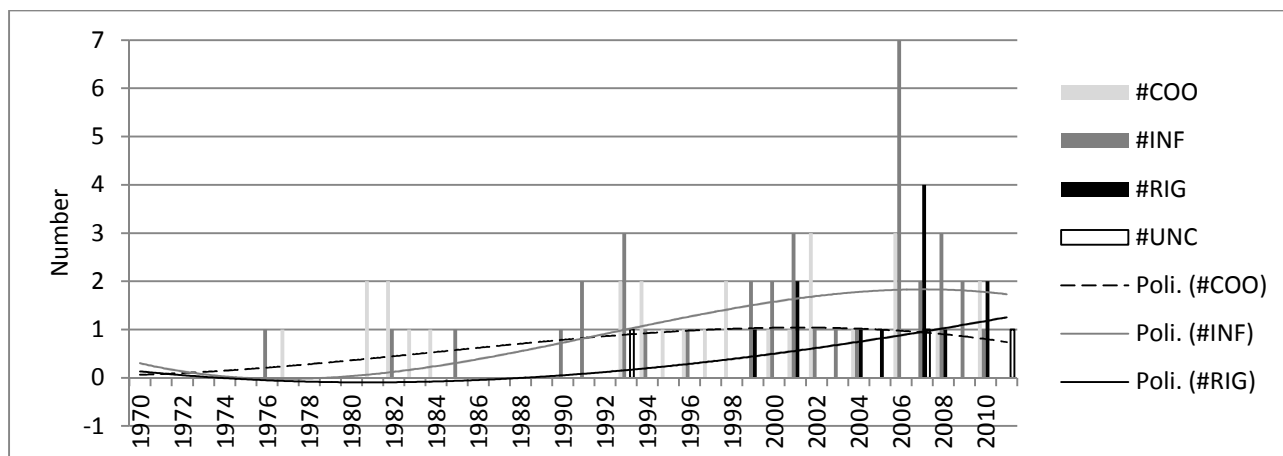


Figure 4. Changes in context policies from 1970 to 2011. Policies: COO, cooperation; INF, sharing of information, RIG, enforcement of rights; UNC, reduction of uncertainty. Lines represent the results of polynomial regressions.



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.

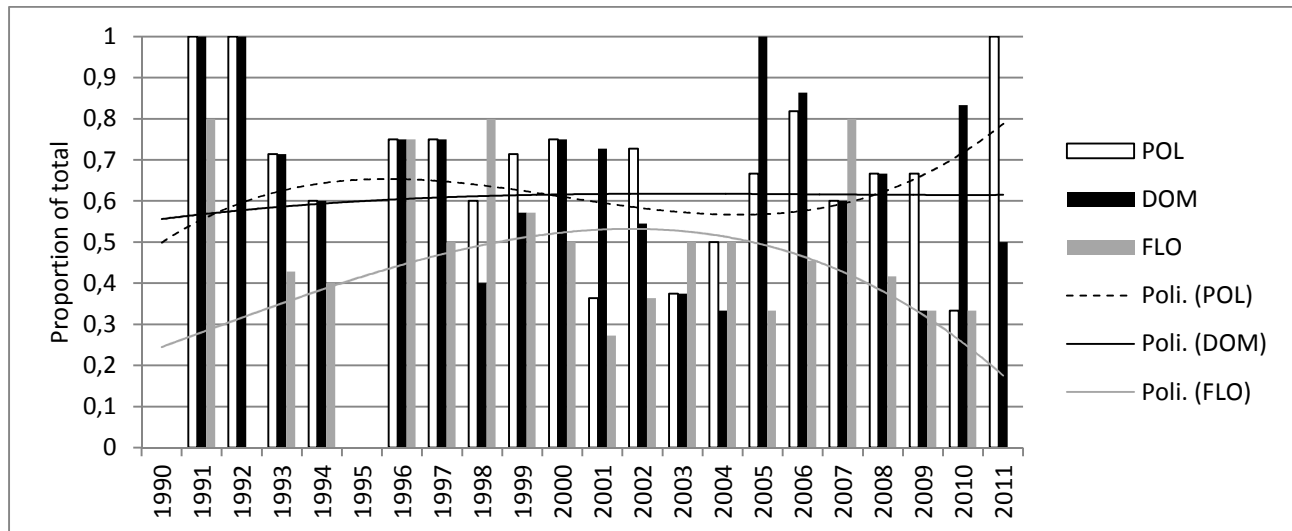


Figure 6. Changes in the relative importance of BOT1 (trans-boundary and domestic issues, TRA and DOM), BOT2 (pollution and resource issues, POL and RES), and BOT3 (stock and flow issues, STO and FLO) issues from 1990 to 2011 (Objective 2). Lines represent the results of polynomial regressions.

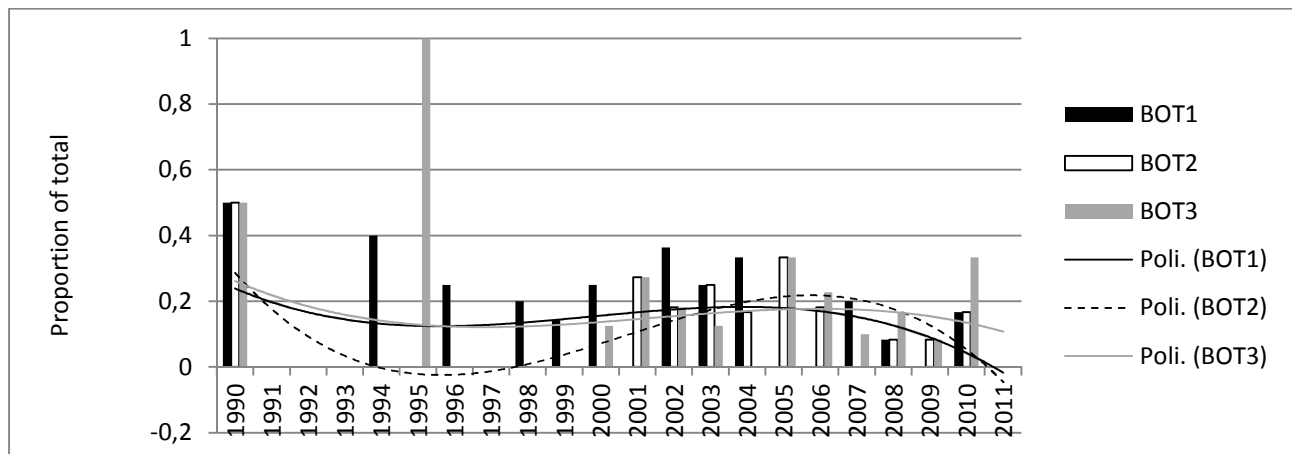
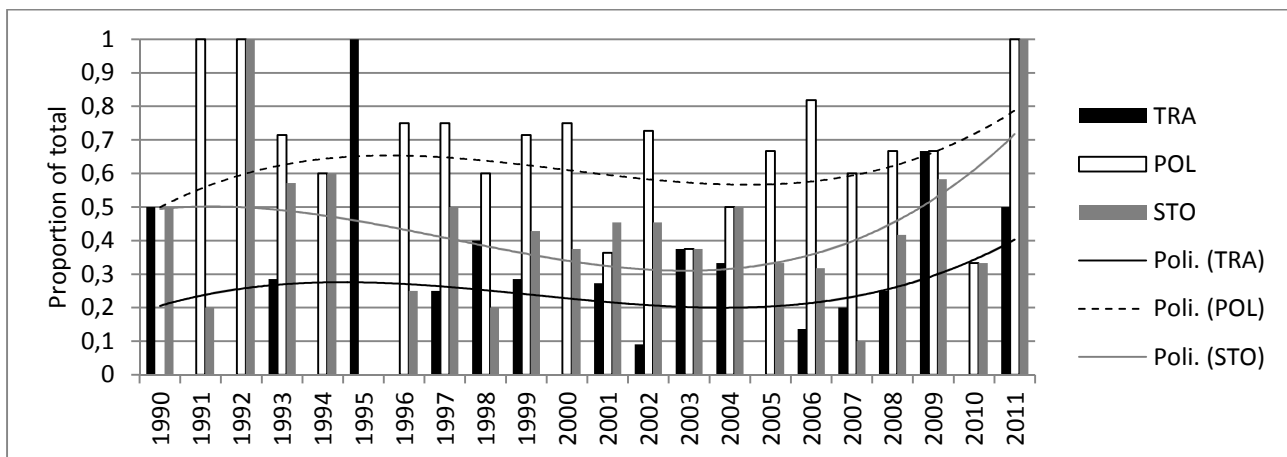


Figure 7. Changes in the relative importance of trans-boundary (TRA), pollution (POL), and stock (STO) issues from 1990 to 2011 (Objective 3). Lines represent the results of polynomial regressions.



Based on this analysis, I obtained the following interpolation functions for each feature attached to each objective:

| | |
|--------------|---|
| Objective 1: | $DOM(t) = 0.00002t^3 - 0.0008t^2 + 0.0139t + 0.5428$ |
| | $POL(t) = 0.0003t^3 - 0.0085t^2 + 0.0792t + 0.4286$ |
| | $FLO(t) = -0.0001t^3 + 0.0005t^2 + 0.035t + 0.2094$ |
| 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.

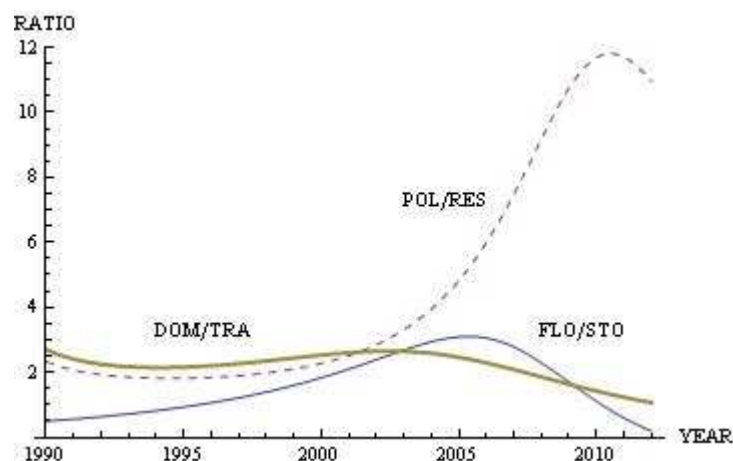


Figure 8 shows changes in the implicit relative preferences (i.e., importance) attached to the main issues from 1990 to 2012: DOM/TRA is initially larger than 1, then smaller; POL/RES is always larger than 1 and increases rapidly towards the end of the period; and FLO/STO is initially smaller than 1, 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:

$$\begin{aligned} FEA_{1j}(t) &= \text{probit} [\text{OBJ}_1(t) \vee \text{LOBJ}_1(t) \vee \text{COBJ}_{12}(t) \vee \text{LCOBJ}_{12}(t) \vee \text{COBJ}_{123}(t) \vee \text{LCOBJ}_{123}(t), \\ &\quad \text{OBJ}_2(t) \vee \text{LOBJ}_2(t) \vee \text{COBJ}_{23}(t) \vee \text{LCOBJ}_{23}(t), \text{OBJ}_3(t) \vee \text{LOBJ}_3(t)] \\ FEA_{2j}(t) &= \text{probit} [\text{OBJ}_1(t) \vee \text{LOBJ}_1(t) \vee \text{COBJ}_{12}(t) \vee \text{LCOBJ}_{12}(t) \vee \text{COBJ}_{123}(t) \vee \text{LCOBJ}_{123}(t), \\ &\quad \text{OBJ}_2(t) \vee \text{LOBJ}_2(t) \vee \text{COBJ}_{23}(t) \vee \text{LCOBJ}_{23}(t), \text{OBJ}_3(t) \vee \text{LOBJ}_3(t)] \\ FEA_{3j}(t) &= \text{probit} [\text{OBJ}_1(t) \vee \text{LOBJ}_1(t) \vee \text{COBJ}_{12}(t) \vee \text{LCOBJ}_{12}(t) \vee \text{COBJ}_{123}(t) \vee \text{LCOBJ}_{123}(t), \\ &\quad \text{OBJ}_2(t) \vee \text{LOBJ}_2(t) \vee \text{COBJ}_{23}(t) \vee \text{LCOBJ}_{23}(t), \text{OBJ}_3(t) \vee \text{LOBJ}_3(t)] \end{aligned}$$

where $FEA_{1j}(t) = 1$ 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; $\text{LCOBJ}_{12}(t) = 1$ 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 OBJ₁, 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 OBJ₂ is replaced by COBJ₁₂. 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, $P > \text{Wald } \chi^2 = 0.0007$, 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 COBJ₂; in addition, the sum of the coefficients was 1 (i.e., $\chi^2 = 73.18$ with probability < 0.0001). Replacing OBJ₁ with COBJ₁₂ or COBJ₁₂₃ and replacing COBJ₂₃ with OBJ₂ 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., OBJ₁ is highly significant) and with a later objective (i.e., COBJ₂₃ must be used rather than OBJ₂), with BOT1, BOT2, and BOT3 all becoming crucial features.

Table 6. Efficiency in pursuing Objective 2. Log-likelihood -148.17416, $P > \text{Wald } \chi^2 < 0.0001$, 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 LOBJ₃: the sum of coefficients is 1 (i.e., $\chi^2 = 28.28$ with probability < 0.0001). Replacing OBJ₁ with COBJ₁₂ or COBJ₁₂₃ and replacing OBJ₂ with COBJ₂₃ 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, $P > \text{Wald } \chi^2 < 0.0001$, 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., COBJ₁₂₃) and two dummy variables (i.e., OBJ₂ and OBJ₃) 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 COBJ₁₂₃.

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

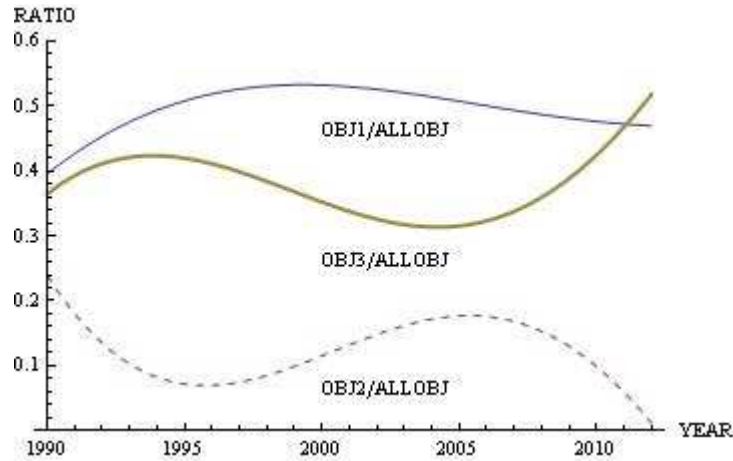
- The relative importance of single issues in each policy over time.
- The identification of the year when a given issue became more or less important for a given objective.
- The specific lag time for tackling single issues in each policy.

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):

$$\begin{aligned} \text{OBJ}_1(t) &= [\text{DOM}(t) + \text{POL}(t) + \text{FLO}(t)]/3 \\ \text{OBJ}_2(t) &= [\text{BOT1}(t) + \text{BOT2}(t) + \text{BOT3}(t)]/3 \\ \text{OBJ}_3(t) &= [\text{TRA}(t) + \text{POL}(t) + \text{STO}(t)]/3 \\ \text{ALLOBJ}(t) &= \text{OBJ}_1(t) + \text{OBJ}_2(t) + \text{OBJ}_3(t) \end{aligned}$$

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 |

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|------|------|------|---|------|------|-----|-----|
| 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 | |

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|------|------|------|---|------|-----|-----|-----|
| 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 | |

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|------|------|------|--|------|-----|-----|-----|
| 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 | |

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|------|------|------|--|------|------|-----|-----|
| 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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