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# Understanding renewable energy policy adoption and evolution in Europe: The impact of coercion, normative emulation, competition, and learning

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ABSTRACT

This article explores the diffusion of renewable energy policies across nation-states of Europe. In doing so, alternative models of diffusion processes are compared to understand the role of coercion, emulation, competition and learning. Going beyond the traditional analysis of individual policies, this paper explains the adoption of five groups of renewable energy policies. It proceeds by estimating logit event history analysis and stratified Cox conditional gap time models for first time and subsequent policy adoptions for 30 European countries from 1990 to 2012. The findings suggest that the impact of external forces varies across policy instrument groups and along the policy development timeline. Initial renewable energy policy adoptions are mainly driven by EU coercive power, competition pressure from economic peers and policy learning from intergovernmental organizations, while subsequent policy evolution is more heavily influenced by EU coercion and regional emulation. Thus, we specify the causal mechanisms of EU energy policy convergence and coalescence.

## 1. Introduction

The challenges of climate change present policy problems at scales large enough that no one nation-state acting alone is capable of affecting a remedy. This has led researchers in recent years to an interest in comparing the variety of environmental policy instruments focused on renewable energy (RE) being adopted and implemented across governments. The growing sophistication of this literature has also led scholars to address the bias that can arise from focusing on single policy instruments by comparing the adoption and implementation of more complete portfolios of renewable energy policy instruments over time (see for example, [71,76,72]. In this study, we follow the practice of examining the diffusion of multiple policy instruments. However, we continue the quest for an appropriate scale of analysis by comparing a more complete set of social forces influencing transnational diffusion of RE policy instruments over time.

Several contending theories of policy diffusion have been developed focusing on coercion, emulation, competition, and learning. Coercive influences from foreign actors, governments or institutions may affect domestic policy adoption due to power asymmetry and incentive manipulation [5]. Emulation theorists argue that copying from peers is often the low-cost approach to policy making, mimicking what may happen due to common sociocultural characteristics or geographic proximity [6,7]. Competition effects exist when nation-states adopt policies to lure global investment and keep exports attractive, especially when their competitors have done so [8]. The learning mechanism points to the role of new information and ideas, which lead to changes in policy makers' beliefs and create momentum for policy innovations [5].

Dobbin and colleagues [9] note that most policy diffusion studies are incomplete because they focus on only one social force. Busch and Jörgens demonstrate the necessity to distinguish between groups of diffusion mechanisms in empirical analyses [10]. Some studies acknowledge the existence of different diffusion mechanisms but do not directly test them (e.g [3,4,11].). Few exceptions (see [12–14]) have quantitatively tested competing theories of social forces against each other, but mostly examine the adoption of a particular policy or policy type.

Studies of transnational policy diffusion have tended to distinguish between domestic and international determinants of policy diffusion. In doing so they seemingly emulate [73] model which identifies internal and external determinants of policy diffusion among sub-national governments. For instance, international factors are found to be at least as important as domestic factors in influencing environmental treaty ratification choices [11,15]. Biesenbender and Tosun [14] distinguished between domestic and international determinants of policy

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diffusion in their study of nitrogen oxide emission standards for large combustion plants across OECD nation-states. Schaffer and Bernauer [3] took a similar approach in their study of policy adoptions of feed-in tariffs and green energy schemes amongst 26 nation-states who are members of the International Energy Agency.

Studies at the subnational levels of government demonstrate a similar reliance upon the Berry and Berry model (1990). Recent advances in the study of RE policy diffusion have demonstrated the importance of internal determinants associated with politics and political culture [76,1,16,17]. Lee and Koski [18] demonstrate the robustness of this finding in the context of multi-level governance decisions. Bromley-Trujillo and colleagues (2016) demonstrate the importance of political influences in a quantitatively sophisticated model testing the influence of policy heterogeneity across RE policy instruments. Surprisingly, despite the extensive scholarship on RE policy diffusion, little is known about what type of diffusion mechanisms is at play under what circumstances and how the impacts of diffusion mechanisms differ across policy domains.

To address this gap, we apply event history analysis to investigate how external forces influence the adoption of a variety of RE policy instruments in 30 European countries between 1990 and 2012. This corresponds to a time period marked by an expansion of the EU with 14 of the current 28 member nations making the decision to join and adopt EU policies and regulations (including those related to RE). We use policy adoption data for 30 European countries from the IEA/IRENA Global Renewable Energy Policies and Measures Database. The IEA/IRENA database is one of the most comprehensive policy databases, which has been widely used in RE technology and policies studies (see for instance [19–21]). The IEA/IRENA database organizes all RE policies into six policy types, including information and education policies, research development and demonstration (RD&D) policies, supportive policy schemes, regulatory instruments, economic instruments and voluntary approaches. In this paper, we focus on conventional regulations - the first five policy types (definitions of the policy instruments are described in the *Data and Methodology* section). Voluntary approaches, including industry self-regulation, public-private negotiations and agreements, often have limited or no government involvement. Hence, we do not include voluntary RE approaches in our analysis. We argue that it is useful to consider a broad spectrum of policies in a particular field, as countries may have similar policy goals but different preferences for policy instruments. Focusing on diffusion of a variety of policy instruments also allows us to build off recent work on international convergence in climate and energy policy instrument choice [2].

Following Biesenbender and Tosun [14], our analysis differentiates between initial and subsequent policy adoptions to better understand how the impact of external forces evolves over time. We estimate logit event history analysis models for first time policy adoptions and Cox conditional gap time models for subsequent policy modifications. Results show that initial diffusion of all policy groups except supportive policy schemes can be explained by coercion, learning and/or competition, while for subsequent policy adoptions, only supportive policy scheme and RD&D policy are positively influenced by external forces (coercion and emulation). This indicates that the impact of external forces varies across policy groups and along the policy development timeline.

This analysis also offers an international perspective comparing national RE decision-making by focusing on one of the most active regions in the world for RE technology and policy development. Supported by policy initiatives of the EU and its member countries, EU has become one of the world's largest renewable energy producers, with renewables accounting 24.3% of its total primary energy production and totaling 192 million tonnes of oil equivalent (toe) in 2013 [75]. Examining RE policy adoption and evolution in this region can potentially offer useful insights for understanding global progress of clean energy technology diffusion and climate mitigation. In addition, while RE policy adoption has been extensively studied in the subnational level of the U.S. [76,1,17,22,23], whether the policy adoption mechanisms are the same in the cross-national context in Europe is unclear, given their differences in political institutions and international commitment to reduce carbon emissions. The unique geopolitical situation in Europe makes it particularly interesting to examine how EU energy policy and peer pressure affect nation-state's RE policy-making. It also allows us to test the influence of EU's supra-national governance as a factor influencing the decisions of member states against other social forces.

This article is organized as follows. The theory and hypotheses section provides a literature review and presents hypotheses. The data and methodology section discusses variable definitions, data sources, descriptive statistics, and methodology. The next section presents model results and discussion. The conclusion offers summary remarks and implications for policy scholars and professionals.

## 2. Theory and hypotheses

In this section, we discuss four types of external driving forces for RE policy adoption, including coercion, normative emulation, competition and learning. Hypotheses are postulated and variable operationalizations are discussed. We then present the literature review of internal determinants for policy adoption.

### 2.1. Coercion

Coercive diffusion involves power asymmetries between entities, and the imposing of policy preferences on one entity by others. Powerful countries and international organizations can influence weaker countries' policy adoption [9,5]. The EU is a typical example of a commanding institution that exerts coercive power [3,4,14]. Studies of transnational policy diffusion amongst OECD and IEA countries have found the EU institution to be a significant explanatory factor (see for instance [24]). On the one hand, the European Commission monitors and assesses policy activities of member states, and non-compliance with EU rules is taken to the European Court of Justice, with the possibility of financial penalties. On the other hand, the EU can have more coercive influence in its applicants' domestic policy making than in existing member states because applicants face additional conditions and incentives for accession that current members do not [25].

Tew (2015) notes the on-going tension among EU nation-states between the grand goal of creating an integrated European marketplace and national desires for discretion by member states in setting policy in a variety of policy fields. In the field of environmental protection, EU harmonized standards have offered a strong "coercive floor" which lead to comparably high levels of regulation stringency in member states [26]. Historically, individual EU member states have taken the lead in setting policies for the energy mix and type of market signaling pursued. The European Commission advocated strongly for a joint renewable electricity certificate trading policy in the 1990s [24]. The harmonization of policy instruments ultimately failed in 2001. The Commission then started pushing for the adoption of best practices, particularly FITs [27,28]. Several EU-wide RE targets have been set since the early 1990s, requiring, for instance, the EU as a whole to have at least 20% final energy consumption from renewable sources by 2020 (Directive (2009/28/EC)). Recent evidence shows that rather than directly mandating targets, the EU has gravitated towards incorporating guidance on renewable energy markets into the competition policy as an indirect way of influencing the policy instrument choices of national renewable energy support schemes [74]. There is reason to believe that EU member states and non-members face different coercive pressure from the EU when making renewable energy policy adoption decisions. We hypothesize that EU's coercive power to harmonize and advocate renewable energy policy innovations adopted at nation-state level can be an important driving force for RE policy diffusion in the region.

Following Schaffer and Bernauer [3], we measure EU coercive pressure with two dummy variables: whether a country is a candidate for EU membership, and whether a country is already an EU member state. Some may question the alignment between the metrics and the theory, as EU candidacy or membership can be correlated with emulation and learning (see for instance discussions on EU's normative power [29,30]). It is important to note that we do allow our metrics to overlap since diffusion mechanisms themselves are not exclusive. Here we are interested in testing the correlation between countries' RE policy instrument choices and their membership status in an international institution that has coercive power, controlling for our emulation and learning metrics.

**Hypothesis 1.** EU's coercive power to harmonize and advocate renewable energy policy innovations adopted at nation-state level is an important driving force for RE policy diffusion in the region.

### 2.2. Normative emulation

Finnemore and Sikkink [31] argue that international policy diffusion is similar to the diffusion of norms, which are first established in some countries, and then spread to others [31]. Countries that see themselves as members of a group based on common characteristics or geography may copy one another's policies because they infer that what works for a peer will work for them [9].

Scholars use several ways to define peers. Some emphasize the importance of shared cultural values, beliefs and similar historical legacies, as it is easier for countries to attend to those with similar background characteristics [32]. Others define peers as those in the same geographic region and treat policy diffusion as geographic clustering [14]. For environmental and energy policy diffusion, empirical evidence exists for emulating from peer groups sharing similar political culture [76] and from geographic neighbors [33,34]. In this study, we assume that countries adopt RE policies, in part, to search for best practices with minimum costs and to demonstrate conformity with policy behaviors of peer groups. Our grouping of countries (see Table 1) considers geographic proximity, as well as similar social, cultural and historical identity.

Biesenbender and Tosun [14] use the number of policies adopted in neighboring countries as the proxy for normative pressure. Shipan and Volden [12] show that imitation is mostly focused on larger neighbors [12]. To account for the sizes of peer countries, we used the population-weighted average version of Biesenbender and Tosun [14]'s emulation metric.

**Hypothesis 2.** The diffusion of renewable energy policies in Europe is positively driven by normative emulation.

### 2.3. Competition

Competition for resources is another driving factor for policy diffusion. National policies affecting the comparative advantages of domestic industries can alter financial capital and markets that are accessible to other countries, which in turn can change others' policy adoption behavior [9,35]. In the context of renewable energy development, countries may adopt policies to obtain "early mover" advantages, such as the case of FITs in Germany [36]. RE policies can help expand and strengthen domestic renewable technology industries (i.e. improved competitiveness through economies of scale), which may eventually lead to increased exports to global markets [37]. In particular, mandates and targets create clear demand for RE [37], FITs bring down the costs of RE technologies and provide comparative advantages for domestic industries [38], whereas RD&D policies foster technology development, deployment and diffusion, and promote RE industrial success in the global market [37]. Given these economic implications, we expect that countries are more likely to adopt RE policies to strengthen the competitiveness of their clean energy sector, when their economic peers have already done so. Regulatory instruments, FITs and RD&D policies are most likely to be driven by the competition effect as they tend to encourage investments in domestic RE technology and hence increase the competitiveness of a country's RE sector.

**Table 1**
Geographic region and composition.

| Geographic Regions | Country |
|---|---|
| Central Europe | Czech, Hungary, Poland, Slovakia, Slovenia |
| Southern Europe | Spain, Greece, Italy, Portugal, Cyprus, Malta |
| Western Europe | Austria, Germany, Luxembourg, Belgium, France, Ireland, UK, Netherlands |
| Northern Europe | Denmark, Finland, Norway, Sweden, Iceland |
| Eastern Europe | Croatia, Romania, Bulgaria, Estonia, Lithuania, Latvia |

The literature often points to competitive pressure from trade networks: governments respond to policy behaviors of their trade competitors by relaxing the enforcement of existing environmental regulations [8]. However, recent empirical analyses have generally failed to identify a significant impact of trade bloc partners on RE policy adoption [3,4]. To improve the competition metric, we follow Brooks and Kurtz [32] and define economic peers as countries of similar status in the global technology and/or capital market. As suggested by Dobbin et al. [9], we use the population-weighted average number of policies adopted by a country's economic peers to measure competitive pressure.

In this study, countries are grouped into economic peer blocs based on the global competitiveness index (GCI) developed by the World Economic Forum. The GCI measures twelve components[1] of an economy, reflecting a country's attractiveness to investors and the comparative advantage of its technology sectors [39]. For each country, five economic peer countries that have the closest GCI values were identified. The 2011–2012 GCI value was used in the grouping. We assume that countries with close GCI values tend to have similar status in the global technology and capital market, and they are likely to compete with each other for capital and investment in the global market.

**Hypothesis 3.** Policy activities of economic peers create competitive pressure for a country to adopt renewable energy policies.

**Hypothesis 3.1.** Diffusion of renewable energy regulatory instruments, FITs and RD&D policies are affected by the competition effect.

### 2.4. Learning

Levy [40] defined learning as "a change of beliefs or the development of new beliefs, skills, or procedures as a result of the observation and interpretation of experience" [40]. Countries tend to learn from success stories of others, via network and communication links established by both intergovernmental organizations and private sectors, and from analogous cases of their cultural reference groups [5]. The learning effect can be measured by the level of exposure to ideas, policies, and pressures of a pivotal international institution [32].

Empirical findings suggest that intergovernmental organizations (IGOs) facilitate policy diffusion through coercion and policy learning, but not emulation [41]. Our first hypothesis has tested one of the most important IGOs' (the EU) coercive power on RE policy diffusion. In this section, we focus on IGOs' role in information-driven policy learning. IGOs have been viewed by international relations scholars as important

[1] The twelve components include institutions, infrastructure, macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication, and technology innovation.

mechanisms to reduce transaction costs of negotiation and implementation, and to provide a common information base for decision making [42]. IGOs can facilitate the exchange of policy information across national borders [9,43,44]. They encourage learning and lesson-drawing, through their policies and loan conditions [45], information dissemination and experience sharing [5], and influence on member countries' agenda setting and policy implementation [46].

In the energy arena, IGOs play a crucial role in global energy governance [47]. They significantly influence member countries' energy policy making by providing authoritative information on energy statistics and policy experiences, and creating norms of appropriate behavior and best practices [47]. Following Saikawa [13], we use the total number of IGOs in which a country holds a membership in a given year to measure the learning effect [13]. We only include IGOs that operate in the areas of energy, environment, climate change, and sustainability. In addition, The IGO needs to be regional, meaning its membership is open to more than one country, and at least one of its members are European countries. (See Appendix A for the full list of IGOs). When selecting IGOs, we used the Correlates of War IGO dataset as our starting point, as it includes state memberships in the network of international governmental organizations from 1964 to 2000 [48]. For IGOs established after 2000, the identification and selection process were mainly done by web search and cross checking with scholarly publications on international energy governance (i.e [47]). Dates of membership were collected from IGO websites.

The number of IGO memberships is a good proxy as it is highly related to the exposure of policy information, international interaction and communication. High-level intergovernmental conferences, events and related preparatory processes institutionalize the communication and exchange of experiences among nations, which in turn affect member countries' environmental policy decisions [10]. Therefore, we expect countries that hold more memberships in IGOs have more chance to communicate with others in international gatherings and are exposed to more information about best policy practices, which lead to a higher probability of RE policy adoption.

**Hypothesis 4.** Learning through IGOs drives the diffusion of RE policies across European countries.

### 2.5. Internal determinants for policy diffusion

Following Berry and Berry (1990), we test the cross-national RE policy diffusion process as a function of both external diffusion mechanisms and internal determinants. Three groups of internal factors suggested by the literature were considered, including problem severity, economic resources, and political ideology [17,34].

First, problem severity creates pressure for government to adopt policies to solve the problem. Countries with more pressure to cut carbon and air pollution may be more likely to adopt RE policies. We use carbon intensity and sulfur dioxides emissions from energy production and distribution as two proxies for problem severity. Second, national economic resources can be important, as RE implementation is often capital intensive. We use GDP per capita to measure national economic resources, which is a proxy widely used in the literature [33,16,34,49]. Third, Schaffer and Bernauer [3] show that federalism significantly influences the adoption of feed-in tariffs and green certificate systems in 26 industrialized countries. Proportional election systems provide incentives for parties to seek broad support from the public by providing public goods, which is often improved environmental quality [50]. Fredriksson and Millimet [50] find that governments do set stricter environmental policies under proportional systems. Following Schaffer and Bernauer [3] and Fredriksson and Millimet [50], we take into account the features of each country's political system by including two variables in our models: federalism and proportional representation. Besides the factors discussed above, we also control for energy dependence and population.

## 3. Data and methodology

We seek to understand how external forces influence first time and subsequent policy adoptions in the cases of five different RE policy instruments, using data for 30 European countries[2] between 1990 and 2012. The unit of analysis is the country-year. The dependent variable measures whether or not a country adopted a particular type of RE policy instrument in a given year. According to the IEA/IRENA Global Renewable Energy Policies and Measures Database, a total number of 629 RE policies[3] were adopted at the national level by the 30 European countries to encourage the uptake of RE[4] during the time period of interest. These policies were categorized into five instrument groups by IEA/IRENA (see definitions and examples of the policy groups in Table 2).

Independent variables, their operationalization and data sources are presented in Table 3. Descriptive statistics are presented in Table 4. Correlation matrices are presented in Appendix B. In our empirical models, all explanatory variables are lagged by one year to isolate casual effects. All models are estimated with clustered robust standard errors at the country level using STATA.

We use event history analysis (EHA) to analyze our data – an approach widely used in both state-level and transnational policy diffusion studies to analyze internal and regional diffusion influences [52,4,34,53]. EHA is also known as survival analysis or duration analysis. It considers policy adoption as a binary outcome and estimates the probability of the occurrence of a policy adoption event.

The time period of analysis is divided into a set of distinct yearly observations. The hazard rate *h(t)* is defined as the instantaneous risk of experiencing the policy adoption event at time *t*, conditional on survival to that time (Eq. (1)). The hazard rate for each observation *i* is assumed to be determined by external diffusion mechanisms and internal determinants. Eq. (2) specifies how this hazard rate depends on time and the array of explanatory variables ($x_{it}$).

$$h_i(t;\, \boldsymbol{x_{it}}) = \Pr[T_i = t | T_i \geq t,\, \boldsymbol{x_{it}}] \tag{1}$$

$$h_i(t;\, \boldsymbol{x_{it}}) = h_0(t) exp(\boldsymbol{\beta}' \boldsymbol{x_{it}}) \tag{2}$$

***First-time Policy Adoption Model.*** First time policy adoption EHA models exclude a country from the dataset after it experiences the first adoption. The data are conditional: to experience the first-time policy adoption event at some time *t*, one country must necessarily have not experienced any event until the time *t-1*. When the baseline hazard function ($h_0(t)$) is assumed to be constant, expressed by $e\beta_0$, Eq. (2) can be written in logit form as shown in Eq. (3). This means the probability of a country adopting a policy is invariant to time. In this study, we estimate logit EHA models for first time policy adoptions. Following previous studies [17], we use a time variable to account for duration dependency as well as additional temporal heteroskedasticity.

$$\log[h_i(t;\, \boldsymbol{x_{it}})/(1 - h_i(t;\, \boldsymbol{x_{it}}))] = \beta_0 + \boldsymbol{\beta}' \boldsymbol{x_{it}} \tag{3}$$

***Subsequent Policy Adoption Models.*** Logit or probit approach is not flexible in handling cases when countries adopt the same kind of policy multiple times to modify the original policy. Cox conditional gap time model provides a way to model repeatable policy adoptions [14,54], assuming that baseline hazard may vary substantially over the different ordered policy events. The baseline hazard function ($h_0(t)$) is left unspecified, which gives the Cox model flexibility in explaining repeated events. Eq. (2) can be written in logit form as shown in Eq. (4). After a country adopted its $1^{st}$ policy, it is still at risk of adopting the $2^{nd}$ … and

[2] This includes the current twenty-eight EU member countries, Norway and Iceland.

[3] These are all conventional government policies. Voluntary policies are not considered here.

[4] Renewable energy sources include bioenergy, geothermal, hydropower, ocean energy, solar photovotaics, solar thermal and wind.

**Table 2**
Five Types of Renewable Energy Policy.

| Policy Type | Categories | Example |
|---|---|---|
| Information and education policy | • Information provision<br>• Performance label<br>• Professional training and qualification<br>• Advice/aid in implementation | UK's *the Electricity (Guarantees of Origin of Electricity Produced from Renewable Energy Sources) Regulations 2003 (2003 No. 2563)*: the Renewable Energy Guarantee of Origin (REGOs) electronic certificate system enables producers of renewable-sourced electricity that is eligible under the EU Renewables Directive to be issued with evidence (guarantees) that their electricity is indeed renewable. |
| Research, development and deployment policy | • Research program for technology development, deployment and diffusion<br>• Demonstration project | France's *Green Innovation Funding: the French Programme of Investments for the Future (2010)*: it supported testing in real conditions and demonstration plants for renewable energy and green chemistry, low carbon vehicle, smart grid and circular economy projects. It aims to bring innovation to the market. |
| Supportive policy scheme | • Institutional creation<br>• Strategic planning | Denmark's *National Renewable Energy Action Plan (NREAP 2010)*: it outlined a pathway that will allow Denmark to meet its 2020 renewable energy, energy efficiency and GHG reduction targets. |
| Regulatory instrument | • Codes and standards<br>• Obligation schemes<br>• Other mandatory requirements | Belgium's *Law of Obligation for the Incorporation of Biofuels in Fossil Fuels (2009)*: from 2009, all registered fossil fuel companies in Belgium must incorporate 4% of biofuels in fossil fuels which are made available in the Belgian market. Penalties are applied where the quantity of biofuels incorporated does not meet the requirement. |
| Economic instrument | • Market-based instruments<br>• Fiscal/financial incentives<br>• Direct investment | Austria's *Ökostromverordnung 2009 (2009 feed-in tariffs for green electricity)*: feed-in tariffs were provided for electricity produced from wind biomass, biogas, landfill and sewage gas, geothermal, solar, and small hydro. |

**Table 3**
Variables, Operationalization and Data Sources.

| Variables | | Operationalized Variables | Data Sources |
|---|---|---|---|
| RE policy adoption | | Whether or not a country adopts a RE policy in that year.<br>Coded: 0 = no; 1 = yes. | IEA/IRENA Joint Policies and Measures database |
| Coercion | EU membership | Whether or not a country is a EU member state.<br>Coded: 0 = no; 1 = yes. | EU website |
| | EU candidacy | Whether or not a country is a candidate for EU membership<br>Coded: 0 = no; 1 = yes. | EU website |
| Emulation | | Population weighted average number of policies adopted by all neighboring countries in the same geographic region in a given year | Authors' calculation |
| Competition | | Population weighted average number of policies adopted by five competitors in a given year | Authors' calculation |
| Learning | | Total number of environmental and energy IGOs to which a country holds membership in a given year | IGO websites |
| Carbon intensity | | Metric tonne of carbon emission per 1000 $ GDP | European Environmental Agency; World Bank |
| Sulfur oxide (SOx) | | Tonne of SOx emission per million $ GDP | Eurostat |
| National economic strength | | GDP per capita at market prices (ten thousand $ per inhabitant) | World Bank |
| Federalism | | Federalism.<br>Coded: 0 = no; 1 = yes. | Comparative Political Data set [51] |
| Proportional representation | | Electoral system: single member districts or proportional representation.<br>Coded: 0 = single-member/simple plurality system;<br>1 = modified proportional representation /proportional representation. | Comparative Political Data set [51] |
| Energy dependence | | The extent to which an economy relies upon imports in order to meet its energy needs (net imports divided by the sum of gross inland energy consumption plus bunkers) | Eurostat |
| Population | | Total population on January 1 (hundred million) | Eurostat |

the $k^{th}$ policy. We estimate stratified Cox models to investigate driving mechanisms for subsequent policy adoptions ($2^{nd}$…$k^{th}$ policy adoptions). In this part of analysis, all policy adoption events are ordered by the year of adoption. Country-year observations prior to and including first-time policy adoptions are dropped from the dataset.

$$\log[h_i(t;\boldsymbol{x_{it}})] = \log[h_0(t)] + \boldsymbol{\beta}'\boldsymbol{x_{it}} \tag{4}$$

In this study, multiple policy adoptions in the same year are counted as a single event, as observations are at country-year level. Although stratified Cox models can be used for continuous time analysis, smaller-scale (i.e. monthly) time series data for policy adoption and other social-economic variables are unavailable, which is a limitation. Another limitation is associated with the policy heterogeneity of subsequent policy changes. The data only model the occurrence and time of policy change, but not the extent or direction of policy change.

## 4. Results and discussion

Tables 5 and 6 present the logit EHA model and Cox model results respectively. First rows of the two tables show dependent variables for each model. For instance, model (2) in Table 5 tests the impact of external forces on countries' first-time adoption of RD&D policy.

Results in Table 5 show that estimated coefficients for EU membership and candidacy are statistically significant and positive for RD&D policies and regulatory instruments, respectively. This indicates EU members are more likely to adopt their first RD&D policy than their non-EU counterparts, while EU applicants tend to have a higher probability of adopting their first renewable regulatory instrument than non-EU countries. For subsequent policy changes, coefficients of EU membership and candidacy are both positively significant for supportive policy schemes. EU member states and applicants are more likely to revise policies for RE institutional creation and strategic planning than non-EU countries, holding all other variables constant.

These findings support Hypothesis 1. Compulsion to adopt RE policies results from both EU membership and the accession negotiation process. This is in line with empirical findings on EU's influential role in driving environmental and energy policy convergence [4,14,55,56]. Our results improve the current understanding of the coercion

**Table 4**
Descriptive Statistics.

| Variable | | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Information and education policy | | 690 | 0.065 | 0.275 | 0 | 3 |
| Research, development and demonstration policy | | 690 | 0.116 | 0.397 | 0 | 3 |
| Supportive policy scheme | | 690 | 0.316 | 0.652 | 0 | 6 |
| Regulatory instrument | | 690 | 0.258 | 0.662 | 0 | 7 |
| Economic instrument | | 690 | 0.562 | 0.974 | 0 | 7 |
| Coercion | EU membership | 690 | 0.626 | 0.484 | 0 | 1 |
| | EU candidacy | 690 | 0.216 | 0.412 | 0 | 1 |
| Emulation[a] | Information and education policy | 690 | 0.082 | 0.191 | 0 | 1.337 |
| | Research, development and demonstration policy | 690 | 0.196 | 0.371 | 0 | 2.345 |
| | Supportive policy scheme | 690 | 0.471 | 0.609 | 0 | 4.298 |
| | Regulatory instrument | 690 | 0.348 | 0.590 | 0 | 4.716 |
| | Economic instrument | 690 | 0.583 | 0.734 | 0 | 3.658 |
| Competition | Information and education policy | 690 | 0.0947 | 0.242 | 0 | 2.312 |
| | Research, development and demonstration policy | 690 | 0.176 | 0.371 | 0 | 2.250 |
| | Supportive policy scheme | 690 | 0.408 | 0.519 | 0 | 3.934 |
| | Regulatory instrument | 690 | 0.379 | 0.610 | 0 | 5.507 |
| | Economic instrument | 690 | 0.719 | 0.916 | 0 | 5.798 |
| Learning | | 690 | 9.499 | 3.287 | 0 | 19 |
| Carbon intensity | | 664 | 0.976 | 1.278 | 0.104 | 7.952 |
| Sulfur oxide ($SO_x$) | | 664 | 3.924 | 11.547 | 0 | 120.279 |
| GDPPC | | 663 | 2.417 | 1.892 | 0.110 | 11.468 |
| Federalism | | 663 | 0.134 | 0.341 | 0 | 1 |
| Proportional representation | | 663 | 0.965 | 0.183 | 0 | 1 |
| Energy dependence | | 690 | 0.313 | 1.287 | −8.031 | 1.125 |
| Population | | 689 | 0.164 | 0.215 | 0.00254 | 0.825 |

[a]Note that emulation and competition effects are measured for each policy type, which explain the subdivisions of these two variables in the descriptive statistics table.

mechanism by examining the different effects of EU coercive power across policy instruments and along the policy development timeline. We find that the first-time adoption of RD&D policies and regulatory instruments are particularly driven by EU coercion. While EU member states are required to follow EU RE directives and mandates, there are often no specific requirements on the choice of policy instruments (see for instance Council Decision of 13 September 1993, Directive 2001/77/EC, and Directive 2009/28/EC). Member states' inclination to adopt RD&D policies may be due to the high policy priority of research and development in the EU's overall low-carbon strategy, as well as the

**Table 5**
Logit Event History Analyses of First Time Policy Adoptions.

| VARIABLES | (1) Information & education policy | (2) RD&D policy | (3) Supportive policy scheme | (4) Regulatory instrument | (5) Economic instrument |
|---|---|---|---|---|---|
| EU member | 0.316 | 3.145** | 1.070 | 1.330 | 0.645 |
| | (1.692) | (1.264) | (1.206) | (1.191) | (1.813) |
| EU candidate | 1.364 | 1.093 | 1.632 | 2.635*** | 0.282 |
| | (1.034) | (1.172) | (1.115) | (0.792) | (1.650) |
| Emulation | −0.878 | 0.848 | 0.412 | 0.376 | −0.193 |
| | (0.964) | (0.980) | (0.736) | (0.578) | (0.648) |
| Competition | 2.111* | −0.314 | 0.220 | 0.472 | 0.563 |
| | (1.157) | (0.979) | (0.717) | (0.442) | (0.557) |
| Learning | 0.631* | 0.0933 | 0.178 | 0.371* | 0.745** |
| | (0.327) | (0.201) | (0.187) | (0.195) | (0.368) |
| Carbon intensity | −2.024** | −0.878 | 0.118 | 0.418 | 0.158 |
| | (0.966) | (1.306) | (0.357) | (0.323) | (0.445) |
| SOx | 0.124** | −0.0725 | −0.0254 | −0.167** | −0.127 |
| | (0.0578) | (0.212) | (0.0282) | (0.0657) | (0.108) |
| GDPPC | −0.0174 | 0.277 | 0.479* | −0.0366 | −0.0331 |
| | (0.196) | (0.307) | (0.250) | (0.254) | (0.407) |
| Federalism | −0.0661 | 1.453** | −0.430 | 0.582 | −1.990 |
| | (0.584) | (0.604) | (0.535) | (0.802) | (1.279) |
| Proportional representation | 1.176*** | −0.450 | 1.320** | 1.275** | 1.491* |
| | (0.416) | (0.433) | (0.573) | (0.526) | (0.787) |
| Energy dependence | −0.292 | −0.258 | −0.0889 | −0.0103 | −0.843** |
| | (0.211) | (0.159) | (0.109) | (0.123) | (0.404) |
| Population | 4.975*** | −1.486 | 1.970* | 3.247* | −1.569 |
| | (1.516) | (0.926) | (1.014) | (1.734) | (1.356) |
| Time | −0.00337 | −0.000215 | 0.145 | 0.0892 | −0.0399 |
| | (0.0783) | (0.0732) | (0.0963) | (0.0669) | (0.115) |
| Constant | −10.36*** | −5.613*** | −8.577*** | −9.731*** | −7.969*** |
| | (2.679) | (1.618) | (1.827) | (1.750) | (2.413) |
| Observations | 454 | 398 | 267 | 271 | 205 |

Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

**Table 6**
Cox Conditional Gap Time Model for Subsequent Policy Adoptions[a].

| VARIABLES | (1) Information & education policy | (2) RD&D policy | (3) Supportive policy scheme | (4) Regulatory instrument | (5) Economic instrument |
|---|---|---|---|---|---|
| EU member | 0.284 | 5.773 | 1.887** | 0.908 | −0.464 |
| | (4.444) | (8.841) | (0.935) | (6.768) | (0.666) |
| EU candidate | −41.93 | −37.50 | 1.962** | 2.022 | −1.107 |
| | (0) | (0) | (0.921) | (6.814) | (0.754) |
| Learning | −0.892*** | 0.168 | 0.00631 | 0.0344 | −0.0821 |
| | (0.266) | (0.215) | (0.102) | (0.132) | (0.0839) |
| Emulation | −0.180 | 1.237*** | 0.272* | 0.206 | −0.0181 |
| | (1.151) | (0.431) | (0.142) | (0.166) | (0.128) |
| Competition | −0.736 | 0.426 | −0.264 | −0.227 | 0.108 |
| | (0.597) | (0.333) | (0.176) | (0.189) | (0.106) |
| Carbon intensity | 0.439 | 4.187 | 0.0459 | −1.002 | 0.0900 |
| | (5.768) | (4.348) | (0.379) | (0.797) | (0.534) |
| SOx | −1.190 | −0.423 | 0.0887** | 0.296* | −0.0318 |
| | (1.127) | (0.720) | (0.0421) | (0.164) | (0.0665) |
| GDPPC | −0.184 | −0.151 | −0.00522 | 0.0547 | −0.0162 |
| | (0.636) | (0.190) | (0.0637) | (0.0922) | (0.0731) |
| Federalism | 0.829 | −0.852 | 0.394 | 1.039** | 0.175 |
| | (0.976) | (0.569) | (0.302) | (0.441) | (0.463) |
| Proportional representation | −4.132*** | −0.240 | −1.761*** | −1.492** | −1.149** |
| | (1.344) | (0.735) | (0.329) | (0.685) | (0.470) |
| Energy dependence | 0.0238 | −1.254 | −0.406*** | −0.122 | 0.110 |
| | (0.632) | (1.169) | (0.120) | (0.992) | (0.107) |
| Population | −2.900 | 3.204*** | 0.316 | 0.432 | 0.560 |
| | (1.858) | (0.797) | (0.512) | (0.690) | (0.836) |
| Observations | 165 | 221 | 352 | 348 | 414 |

Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
[a]There is almost no variation in the "EU candidate" variable across the 30 countries during the time period for subsequent policy adoptions in model (1) and (2), therefore, Stata reported missing standard errors for the "EU candidate" variable.

well-established institutions for RD&D policy implementation, such as the multi-annual Framework Program for Research & Technology Development which has been in place since 1984 [57]. EU candidates certainly face a different challenge compared to EU member countries, as one of their priorities is to demonstrate to the Commission that they have the "administrative and institutional capacity to effectively implement the *acquis* and ability to take on the obligations of membership" [58]. Regulatory policy instruments are well suited to this purpose, as they are often seen as a quick and convenient tool to demonstrate political commitment and to achieve guaranteed results with little uncertainty [59]. With regard to policy changes, EU member and EU candidate are more likely to update their national plans, strategies, action programs for RE development than non-EU countries. This might be because the Article 22 of the Directive 2009/28/EC requires each member state to submit to the Commission every two year a national action plan to explain how they intend to achieve the national RE targets [60]. Our results demonstrate European Commission's role in driving the continuous updates of national RE action or strategic plans in both EU member states and candidate countries.

It is noteworthy that Schaffer and Bernauer [3] find EU membership to be important in the adoption and change of two important economic instruments (FITs and green certificate system) among IEA countries, and in their explanation, they attribute this effect to both coercion and learning. Our approach of disaggregating and testing the four external mechanisms independently allows us to add precision to the explanation of the policy driving forces, and to establish empirically which of the mechanisms is at work. In our logit models, we do find that learning effect for the first-time adoption of economic instruments is significant and positive, but the coercion effect measured by EU member and candidate is not. The moderate correlation between our learning and EU membership variable may have caused the insignificance of the EU membership variable. To test this, we rerun the logit model with only the EU member and candidate variables, and coefficients (both the sign and significance) of the EU variables remain consistent.

There is some evidence for Hypothesis 2. The emulation effect is only evident for subsequent RE policy changes, but not for first-time policy adoptions. Countries are more likely to modify their RD&D policies and supportive policy schemes if their geographical neighbors have adopted more such policy actions in the previous year. In the logit models, however, estimated coefficients for emulation are insignificant for all policy instrument groups. This might be because of the high uncertainty associated with new policy ideas, in terms of both regulatory costs and benefits [61]. For first-time policy adoption, it is safer and more cost-effective for countries to follow the EU directives or to learn successful policy experiences or best practices through IGOs meetings, workshops, and information platforms. As experiences with RE policies accumulated and uncertainty diminished, countries are more attentive to neighbors' policy activities. Our results are consistent with several other studies that find no significant relation between a country's likelihood to adopt first-time RE policies and neighbors' previous policy choices [3,4,55]. However, our results contrast with the air emission standard diffusion study by Biesenbender & Tosun [14], in which they found both initial and subsequent policy adoptions are influenced by emulation. The differences in results might be because there is a stronger social norm held by countries worldwide for air quality control than for renewable energy development, as indicated by the Convention on Long-range Transboundary Air Pollution adopted in 1979. Countries sign multilateral environmental agreements to demonstrate adherence to socially accepted norms [55], while in the case of renewable energy development, there is not strong enough social norm to drive policy diffusion across geographic neighbors. In addition, recent empirical evidence points to emulation from peer groups that are not constrained to geographic proximity [62]. Matisoff and Edwards [76] find that energy policies tend to diffuse within similar political culture than from neighboring states [76]. Hence it is also possible that European countries emulate from leaders in RE deployment (e.g. Germany and Denmark) for new policies, regardless of their geographical proximity or regional grouping. This deserves future investigation.

There is little evidence to support Hypothesis 3 or 3.1. Estimated coefficient of competition is only significant for first-time adoption of information & education policies, and insignificant for subsequent changes of all five policy groups. Competition pressure from economic peers does not seem to be important for a country's RE policy instrument choices, which are in line with previous studies [55]. This might be because that RE technology market is only important for a few European countries (i.e. Germany and Denmark) which actually have a competitive advantage in the global RE market, while most countries' policy makers do not feel the pressure of adopting RE policies to incentivize domestic RE industries and to seize global RE market share.

Results support Hypothesis 4 and demonstrate the importance of policy learning through IGOs (see also Cao) [41]: coefficients for learning are positive and significant for first time adoption of information and education policies, regulatory and economic instruments. Holding membership in more IGOs increases the likelihood of first-time adoption of the three policy instruments. This indicates that energy policy research and recommendations produced by IGOs likely convey important information to their member countries and influence domestic energy policy adoptions. However, IGO membership does not seem to affect subsequent adoptions except for information and education policies (although this effect is negative). It is possible that the process leading to initial policy adoption requires greater momentum (e.g. value and belief changes, and vision of the future) to alter the incumbent energy governance structure. Without prior policy experience, countries tend to seek information and learn about policy choices and effectiveness from IGOs. As countries gain more experience with RE policy adoption and implementation, they rely less heavily on information sources from IGOs, hence the policy changes are less likely to be driven by IGOs.

Based on model results, policy learning through IGOs is more important for the transfer of new policy ideas than for subsequent policy changes, which is consistent with results of Biesenbender and Tosun [14]. The positive and significant impact of policy learning demonstrated in our models is also consistent with Schaffer and Bernauer [3], which points out that interactions of and learning among EU member states promote the diffusion of FITs and green certificates. As noted earlier, our study complements their work by testing the learning effect using a more complete set of IGOs operating in the area of energy, climate change and sustainability.

Nonetheless, there are potential weaknesses with our learning metric. For instance, we assume a positive correlation between the number of IGO memberships and the amount of information exchange. There are certainly many other information channels besides IGOs (i.e. policy entrepreneurs and their coalition building efforts [63]. As communication technologies advance and globalization proceeds, it becomes increasingly easy for governments to exchange ideas and knowledge [45]. Future research may construct metric to measure the amount of information available to policy makers and its impact on policy diffusion.

Overall, our findings suggest that external diffusion mechanisms play very different roles in the initial spread of RE policy instruments and subsequent policy revisions. New policy ideas are imported and adopted in domestic policy context driven by a variety of external forces, particularly the EU and intergovernmental organizations. Subsequent policy changes are less externally driven, with main sources of drivers coming from the EU and neighboring countries, and the effect is evidence for only RD&D and supportive policy schemes. The policy modification process may be more heavily influenced over time by domestic factors, such as an increased level of social acceptance to renewable technology, strengthened advocacy coalitions and accumulated policy experiences. As demonstrated by the case of Germany, the adoption of RD&D policy and FITs formed the constituency for renewable technology and a knowledge base about RE policy, both of which played an important role in subsequent policy making phases [36].

Our results also demonstrate that the development of RE policy instruments in Europe is affected differently by the four external driving forces, which complements previous studies on the evolution of national energy policy mixes [64]. Particularly, it is noteworthy to highlight the role of EU institutions in shaping national energy policy development in the area. EU plays an important role in both first-time and subsequent policy adoptions, but serves as a stimulus for different policy instruments in the two stages. While past studies have shown that Europe is experiencing a "bottom-up" convergence of economic instruments for RE policies [65], our results provide some empirical evidence on the EU-driven top-down harmonization for RD&D policy, regulatory instrument, and supportive policy schemes.

## 5. Conclusion

This article examines the impact of four types of diffusion mechanisms on cross-national RE policy adoption and evolution in the EU. We proceed by estimating logit event history analysis models and stratified Cox conditional gap time models for 30 European countries between 1990 and 2012. We found that the impact of external diffusion mechanisms varies greatly depending on the type of policy instruments and whether initial or subsequent policy adoptions are modeled.

First-time adoptions of four of the five renewable energy policy instruments are affected by external diffusion mechanisms. Findings support the existence of horizontal policy diffusion between countries and vertical policy diffusion between countries and intergovernmental organizations. Although countries do not imitate their geographical neighbors in initial RE policy adoptions, they are influenced by the EU, international organizations, and their economic peers.

Results of subsequent policy adoption models present a very different story: both EU membership and candidacy drives the modification of supportive policy schemes, while countries emulate their neighbors when modifying RD&D policies and supportive policy schemes. Horizontal diffusion among geographic neighbors seems more prominent in the policy modification phase than in the initial spread of policies.

In review of our research findings, it is important to keep in mind that each of the metrics might not cleanly capture each theoretical concept, for instance that EU membership and candidacy may, in fact, also capture aspects of learning and emulation. However, our claim is that conditional on everything else in the model, our metrics are, at the very least, correlated with our theoretical constructs and ought to provide some independent explanatory power for our theoretical constructs. While EU membership is likely correlated with learning, emulation and coercion, it captures the unexplained variation in the data that is related to the EU (an institution with coercive power), controlling for emulation and learning metrics in the model.

This research makes several theoretical contributions. First, while we don't measure the diffusion mechanisms perfectly, by relying on the literature we attempt to map these four theoretical constructs to testable empirical metrics. Our analysis sheds light on the effects of particular types of policy diffusion mechanisms in RE policy adoption and modification processes. This specificity is an improvement over previous studies that acknowledge the existence of these constructs without actually testing them against each other directly (e.g. Schaffer & Bernauer [3], Perrin and Bernauer [11]), and also studies that consider a particular type of external diffusion force (e.g. Bromley-Trujillo et al., 2016).

Second, this analysis provides important insights on energy policy convergence in the European political context. EU coercive power is exerted both through EU membership as well as in the accession stage. EU coercion drives the initial adoption of RD&D and regulatory policies, and subsequent modification of supportive policy schemes. This complements previous studies on the positive role of European institutions in shaping national policies [66,67] by further demonstrating that EU exerts pressure on national RE policymakers to implement only a selective group of policy instruments, namely the RD&D policy, regulatory instruments, and supportive policy schemes. In addition, this analysis shows there are other driving forces for clean energy policy convergence. Policy learning through IGOs is more important for first-time policy adoptions, while emulation from geographical neighbors is more prominent for RE policy modifications. Thus, there is a coalescence of diffusion mechanisms that drive EU energy policies toward commonality, which is consistent with the fundamental goal of creating a powerful unified market that underpinned the creation of the EU.

Third, this study demonstrates the varying impact of external diffusion mechanisms across policy groups and along the policy evolution timeline. It shows categorizing policies according to instrument types helps understand what diffusion mechanisms work under what circumstances. Our results demonstrate that countries attend to the EU and intergovernmental organizations for new policy ideas to deploy RE, but external driving forces (EU coercion and emulation) are only important for the updates of RD&D policies and supportive policy schemes. In particular, countries modify their national RE action plans and strategies due to influence from EU and neighboring countries. Emulation mechanism is also at play for modification of RD&D policies. In general, we do not see significant results for the competition mechanism in both policy development stages. This paper complements studies investigating the role of policy attributes on policy diffusion [68,69] and the diffusion of a particular policy instrument [70]. National government's choice of RE policy bundles is the result of distinctive processes of policy diffusion. Comparing our results with other RE policy diffusion studies, we argue that external forces driving the diffusion of a single policy may be different from those in the coalescence of a policy instrument group.

The findings point to several avenues for future research. First, the coding of subsequent policy adoptions may be improved to consider the direction and magnitude of policy changes. For instance, whether a policy modification leads to the weakening, strengthening or termination of the original policy. Second, although we have tried to separate and model the four diffusion mechanisms to the greatest extent possible, the metrics we use are certainly not an exhaustive list of forces and actors in-play in the blending of policy choices across countries. Future research endeavor may explore the diffusion forces exerted by vital actors, for instance, the role of policy entrepreneurs in member states' emulation and intergovernmental learning. It can also be interesting to investigate the interaction between diffusion mechanisms, as noted by Busch and Jörgens [56]. Third, policy modifications may be heavily affected by domestic interest groups, knowledge accumulated in policy adoption and implementation, and the actual policy outcome. Policy scholars may extend the policy diffusion literature to investigate the relationship between external diffusion mechanisms and policy implementation. In this analysis, it is very likely that RE policy changes are associated with the evolution of domestic RE supply chains. Correlating the role of the four diffusion mechanisms with a closer examination of domestic supply chains might offer a productive line of inquiry to address this gap. Fourth, although our competition proxy represents our endeavor to improve the current unsatisfactory measurements of competition in the policy diffusion literature, ours is still not very successful in capturing the competition effect. Future research may need to identify countries' economic competitors, and construct new competition measurements using renewable energy export data in the global market.

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## Appendix A. List of Environmental and Energy Intergovernmental Organizations

1 Global Environment Facility
2 International Energy Agency
3 World Bank
4 United Nations Environment Program (UNEP)
5 United Nations Development Program (UNDP)
6 United Nations Industrial Development Organization (UNIDO)
7 United Nations Framework Convention on Climate Change (UNFCCC)
8 Clean Energy Ministerial – International Smart Grid Action Network (ISGAN)
9 International Renewable Energy Agency (IRENA)
10 The Johannesburg Renewable Energy Coalition (JREC)
11 International Institute for Applied Systems Analysis (IIASA)
12 Organization for Economic Co-operation and Development (OECD)
13 International Carbon Action Partnership (ICAP)
14 International Energy Forum (IEF)
15 Major Economies Forum on Energy and Climate (MEFEC)
16 Energy Charter Conference (ECC)
17 Regional Environmental Center for Central and Eastern Europe (REC)
18 Energy Community
19 European Union

## Appendix B. Correlation Matrices

Information and Education Policy

| | EU member | EU candidate | Learning | Emulation | Competition |
|---|---|---|---|---|---|
| EU member | 1 | | | | |
| EU candidate | −0.68* | 1 | | | |
| Learning | 0.64* | −0.30* | 1 | | |
| Emulation | 0.24* | −0.19* | 0.30* | 1 | |
| Competition | 0.18* | −0.16* | 0.27* | 0.52* | 1 |

RD&D Policy

| | EU member | EU candidate | Learning | Emulation | Competition |
|---|---|---|---|---|---|
| EU member | 1 | | | | |
| EU candidate | −0.68* | 1 | | | |
| Learning | 0.64* | −0.30* | 1 | | |
| Emulation | 0.31* | −0.26* | 0.43* | 1 | |
| Competition | 0.25* | −0.18* | 0.40* | 0.52* | 1 |

Supportive Policy Scheme

| | EU member | EU candidate | Learning | Emulation | Competition |
|---|---|---|---|---|---|
| EU member | 1 | | | | |
| EU candidate | −0.68* | 1 | | | |
| Learning | 0.64* | −0.30* | 1 | | |
| Emulation | 0.35* | −0.23* | 0.56* | 1 | |
| Competition | 0.29* | −0.18* | 0.51* | 0.57* | 1 |

Regulatory Instrument

| | EU member | EU candidate | Learning | Emulation | Competition |
|---|---|---|---|---|---|
| EU member | 1 | | | | |
| EU candidate | −0.68* | 1 | | | |
| Learning | 0.64* | −0.30* | 1 | | |
| Emulation | 0.30* | −0.19* | 0.40* | 1 | |
| Competition | 0.26* | −0.19* | 0.40* | 0.42* | 1 |

Economic Instrument

| | EU member | EU candidate | Learning | Emulation | Competition |
|---|---|---|---|---|---|
| EU member | 1 | | | | |
| EU candidate | −0.68* | 1 | | | |
| Learning | 0.64* | −0.30* | 1 | | |
| Emulation | 0.37* | −0.32* | 0.49* | 1 | |
| Competition | 0.38* | −0.26* | 0.51* | 0.68* | 1 |

* $p < 0.05$

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