INFLUENCE OF ENVIRONMENTAL POLICIES ON WASTE TREATMENT

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Abstract

Countries' growth along with the need to protect the environment has made waste management a major global concern. In this study, a detailed analysis is carried out of the current situation in 41 countries belonging to the OECD and/or the European Union, in order to identify the most sustainable practices that could be successfully implemented in other nations with similar characteristics. Cluster analysis is used to detect homogeneous groups, shedding light on the possible connection between environmental policies and waste treatment. Contingency tables are employed to determine the relationship between the effectiveness of the policies adopted and two indicators of sustainable practices: material recycling and waste generation. The study is conducted using statistical information from the Sustainable Governance Indicators project and the OECD, with data referring to 2018. Five internally homogeneous groups of countries have been identified, where Israel, Turkey and USA have the lowest participation and compliance in environmental policies. Also, the results show that countries with a high degree of participation in environmental treaties (Croatia, Denmark, Finland, France, Germany, Japan, Luxembourg, the Netherlands, Norway, Spain, Sweden, Switzerland) are making great progress, reducing the use of landfills in favour of other, more environmentally friendly options. Moreover, the contingency tables confirm that the effectiveness of policies translates into a clear trend towards recycling and, to some extent, reduces waste generation.

Keywords: Municipal solid waste management; Sustainable Governance Indicators; Contingency tables; Cluster analysis.

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Abbreviation List:

WM: Waste Management
SGI: Sustainable Governance Indicators
KP: Kyoto Protocol
MSWM: Municipal Solid Waste Management
EU: European Union
GEP: Global Environmental Policy
MEA: Multilateral Environmental Agreements
KPA: Kyoto Participation and Achievements
EP: Environmental Policy
WG: Waste generation
MR: Material recycling

1. Introduction

Environmental policy instruments are part of the toolkit that governments have at their disposal to protect the environment. Complexity and uncertainty are two fundamental issues that reveal the importance of designing and implementing sound policies in the field of natural resource management (Pacheco-Vega, 2020). The search for mechanisms aimed at achieving long-term sustainable development is playing an increasingly important role in the implementation of related industrial strategies. Thus, since climate change has emerged as one of the biggest global challenges, waste management (WM) requires sound, targeted planning (Aldieri et al., 2019).

European Union (EU) countries are major generators of waste; on average they produce 482 kg per capita annually (Minelgaitė and Liobikienė, 2019), compared to the global average of 270 kg (Kaza et al., 2018). The management of this waste is thus a relevant issue when it comes to respecting existing environmental regulations. Municipal solid waste management (MSWM) can be classified into four categories: incineration, recycling, composting and landfill. The latter option is the most commonly used in worldwide, to the detriment of the rest (Pietzsch et al., 2017; Samadder et al., 2017).

However, according to Öztürk and Themelis (2020) European countries are at a turning point: we are beginning to see a drop in the amount of waste sent to landfills, in favour of composting, recycling and waste-to-energy conversion.

This shift towards less detrimental alternatives emerges in parallel to the tightening of the existing regulation on WM and recycling targets established in the EU's *Waste Framework Directive*, which seeks to protect the environment and human health from the possible harmful effects caused by hazardous waste (Callao et al., 2019). Specifically, the European directives indicate that from 2035 only 10% of waste can be disposed of in landfills (Directive 2018/850), also establishing more stringent restrictions on recycled waste by 2030, such as a recycling rate of 85% for paper, 55% for plastic, 60% for aluminium, 80% for ferrous metals and 75% for glass (European Commission, 2018). The MSWM solutions provided must not only be environmentally sustainable, but also efficient from a social and cost perspective (Malinauskaite et al., 2017).

The identification of MSWM cost drivers has been documented in the literature (World Bank, 2014; Pérez-López et al., 2016; Sarra et al., 2017; Di Foggia and Beccarello, 2020), some have discussed between public or private waste management to achieve the highest levels of efficiency and cost savings (Mañez et al., 2016; Zafra-Gómez, 2016). According to the International Monetary Fund (IFM, 2019), waste management expenditures currently account for about 0.5 percent of global GDP. Developing countries produce more than half the world's solid waste, their annual public expenditure on waste processing, about US$46 billion, represents only a little more than one tenth of the roughly $400 billion spent on waste processing worldwide. Population growth and limited space to store our waste encourage countries to decrease disposal and increasing management costs. This will free countries´ economic resources that could be spent to improve environmental sustainability in other highly polluting industries.

Government policies, taxes and support plans emerging as a result of signed treaties play an important role in WM and in the ability to foster new technologies, which struggle to survive without state support (Malinauskaite et al., 2017). Waste generation is sometimes a result of the environmentally inefficient use of resources, with potential adverse impacts, justifying the need to establish and promote a close relationship between environmental policies and WM (Varvazovsha and Prasilova, 2015).

In this context, the aim of this research is to determine if the implication of goverments in environmental agreements and policies improve WM. The study is based on statistical information for 2018 sourced from the SGI and OECD, and the following hypotheses are tested:

Hypothesis 1: Countries with a high level of participation in and compliance with environmental policies tend to have lower rates of landfilling.

Hypothesis 2: The effectiveness of environmental policies has a significant influence on material recycling and the reduction of waste generation.

Recent literature includes studies focused on analysing the stringency of environmental policies in different areas such as innovation, energy efficiency, emissions reduction and even the determination of the ideal location for WM industries (Martínez-Zarzoso et al., 2019; Hille and Shahbaz, 2019; Falkowska, 2020; Galeotti et al., 2020). This research aims to cover aspects that have received less attention to date, making novel contributions that complement the existing paradigm in a number of ways: (1) it analyses the link between leaders' degree of concern about environmental issues and municipal solid waste management (MSWM); (2) the wide-ranging group of countries analysed make it possible to extrapolate lines of action to other nations; (3) the use of recent statistics means conclusions can be drawn that could inform future implementations.

The rest of the article is structured as follows. Section 2 reviews the literature on environmental policies and WM. Section 3 explains the methodology and sample used to achieve the proposed objectives. Section 4 presents the results of the study. Lastly, Section 5 summarizes the main findings of the analysis.

2. Material and methods

2.1. Materials

The analysis is based on information from the SGI Project published in 2020 and referring to 2018, relating to the most developed free market democracies in the world—a total of 41 countries belonging to the EU and/or the OECD. The SGI indicators explore and compare the need for reform as well as the countries' responsiveness to current social and political challenges. Furthermore, the SGI examines governments' work on sustainable development based on three pillars: Policy Performance, Democracy, and Governance.

In this study, the key variables for the cluster analysis lie within the Policy Performance pillar. Drilling down further, they are in the sub-pillar Environmental Policies, in the category of Global Environmental Protection. They are as follows:

Global Environmental Policy (GEP): analyses whether the government actively contributes to international efforts to promote and shape the global environmental policy framework.

Multilateral Environmental Agreements (MEA): indicates the rate of participation in global and regional multilateral environmental agreements.

Kyoto Participation and Achievements (KPA): indicates the extent to which Kyoto emissions reduction targets are met.

The contingency tables have been created from the indicators belonging to the sub-pillar Environmental Policies, in the Environment category. Specifically, the following indicators have been selected:

Environmental Policy (EP): measures the effectiveness of a country's environmental policy in preserving and protecting the sustainability of natural resources and the quality of the environment. Such activities are aimed at protecting natural resources and reducing pollution, by cutting greenhouse gas emissions and eliminating waste that adversely affects air, water, or soil quality.

Waste generation (WG): indicates how much municipal waste is produced per capita.

Material recycling (MR): assesses the percentage of municipal waste recovered through material recycling.

The abovementioned SGI variables are measured from the score assigned to their performance on a scale from 10 (best) to 1 (worst). This scale is tied to four qualitative evaluation levels.

1. High (Between 10-9): Environmental policy goals are ambitious and effectively implemented as well as monitored within and across most relevant policy sectors that account for the largest share of resource use and emissions.
2. Medium-high (Between 8-6): Environmental policy goals are mainly ambitious and effectively implemented and are monitored within and across some of the relevant policy sectors that account for the largest share of resource use and emissions.
3. Medium-low (Between 5-3): Environmental policy goals are neither particularly ambitious nor are they effectively implemented and coordinated across relevant policy sectors.

4. Low (Between 2-1): Environmental concerns have been largely abandoned.

Table 1 presents the results of each indicator for all countries and main descriptive statistics of the variables used in the study. The fact that it is a homogeneous measurement scale ranging from 0 to 10 facilitates the comparison between the indicators in the sample.

Insert Table 1

The mean of the countries in all the variables used is above 5 in all cases except MR, with the highest value being registered in MEA, reflecting countries' overall positive involvement in the multilateral agreements aimed at preserving the environment. Regarding the maximum values registered, it can be seen that in KPA, EP and WG no country has obtained a score of 10 points. This underscores the need to improve these lines of action, unlike in other indicators where some countries have achieved the maximum score in more than one variable. For example, Sweden ranks first in GEP and EP, Romania in KPA and WG, Finland in MEA and South Korea in MR. On the other hand, in terms of minimum values, the USA registers the minimum in GEP, Turkey in MEA, KPA and EP, New Zealand in WG and Chile in MR, reflecting a lack of concern about the issues in question. The dispersion found in countries' level of participation reveals the need to perform a cluster analysis to homogenize the sample and thereby identify different profiles of behaviour.

2.2. Methods

Previous studies in the WM literature have grouped regions by means of cluster analysis (Castillo-Gimenez et al., 2019; İçöz and Er, 2020). Some authors, such as Onuferová et al. (2020), use international economic and social indicators to identify homogeneous groups of EU members in order to shed light on existing weak spots and guide future

political reforms. Following this line of research, the empirical analysis proposed here makes use of this methodology to identify groups of countries that are similar in terms of their participation in and compliance with environmental policies (Global Environmental Policy, Multilateral Environmental Agreements and Kyoto Participation and Achievements).

The cluster analysis is performed by establishing a hierarchical structure to evaluate the links between observations (Everitt et al., 2011). Taking the squared Euclidean distance as a measure of similarity, Ward's agglomerative method is applied, yielding a dendrogram from which the ideal number of clusters can be determined (Lance and Williams, 1967). The Kruskal-Wallis test is then used to confirm the adequacy of the defined groups, by verifying that the mean of each one is statistically different from the rest. The cluster is applied from the following steps:

Step 1: Choice the variables: Global Envrionmental Policy, Multilateral Environmental Agreements and Kyoto Participation Achievement

Step 2: Similarity measures: Squared Euclidean Distance

Step 3: Technique Hierarchical/nonhierarchical: Hierarchical clustering. Ward´s procedure

Step 4: Decision regarding the number of cluster: Dendogram and Krukall-Wallis test

Step 5: Evaluation of significance

In line with the proposed research objectives, contingency tables are then constructed to analyse the relationship between qualitative attributes of which at least one is of a multiple nature (Varvazovska and Prasilova, 2015). This method is commonly used in a wide range of fields, such as medicine, transport, and even to address socio-economic issues (Simpson et al., 2018; Álvarez de Toledo et al., 2018; Zámková et al., 2019; Awuah and

Ogbonnaya, 2020). In the context of waste, Virlanuta et al. (2020) employ contingency tables to identify the influence of very disparate characteristics such as education level, income and age on the degree of selective waste collection, finding a significant relationship only with education and age.

In this paper, a contingency table has been constructed for each of the environmental indicators, waste generation and material recycling. The columns represent the number of countries whose environmental policies have the same degree of effectiveness, and the rows the countries with similar results in the indicator in question: waste generation or material recycling, known as the observed frequency. The expected frequencies are calculated using the following expression:

$$E_{ij} = \frac{n_{i\cdot} n_{\cdot i}}{N} \quad (1)$$

where, N is the total number of observations, $n_{i\cdot}$ is the number of observations in row i, and $n_{\cdot j}$ is the number of observations in column j.

Both the observed and expected frequencies are necessary to perform the χ^2test showing whether the variables considered in the study are independent or not. The result of the χ^2 test confirms whether the levels of a qualitative variable influence those of another variable. Thus, the result of the χ^2 test used in this study indicates whether the identifying variable of the effectiveness of environmental policies is related to appropriate waste generation or the ideal recycling rate. The χ^2 test is defined by the following expression:

$$\chi^2 = \frac{\sum_{i=1}^{h} \sum_{j=1}^{k} (n_{ij} - E_{ij})^2}{E_{ij}} \quad (2)$$

where, n_{ij} is the observed frequency, and E_{ij} is the expected frequency. The null hypothesis is that of independence between factors. The alternative hypothesis is that of dependence between factors.

3. Results and discussion

In this study, in line with the research objectives, a hierarchy of the sample has been established on the basis of the three indicators of environmental policies, GEP, MEA and KPA. As a result, five internally homogeneous groups of countries (according to the dendrogram in Figure 1) have been identified, which are subsequently subjected to a more detailed analysis.

Insert Figure 1

The Kruskal-Wallis test confirms that the grouping is appropriate, as it reveals a significant difference between groups in terms of the mean value of the indicators. Table 2 shows that the χ^2statistic is significant with a p-value <0.05 in all three variables.

Insert Table 2

Based on the identified groups' distance from the total mean in each of the variables, they have been classified according to their level of commitment in terms of participation (GEP and MEA) and compliance (KPA). Thus, "low" refers to countries whose cluster mean differs by more than 2 points from the total mean. "Medium" refers to those which differ by less than 2 points, and "high" those which surpass the total mean by more than 1.5 points. The distribution depicted in Figure 2 indicates that many countries have a medium level participation in environmental policies (26 countries out of 41). The same can be seen with the degree of compliance (25 countries). At the lower end, cluster 3 contains the countries with the greatest need to improve their degree of involvement in all the sustainability indicators.

Insert Figure 2

Cluster 1: *"Medium participation and compliance"* Comprising 10 European countries, along with Canada, New Zealand and Australia. All of them have ratified the Kyoto

Protocol (KP), systematically striving to protect the environment and reduce carbon emissions. They are countries that participate in numerous multilateral and bilateral forums on environmental issues, having signed up to various international treaties.

Cluster 2: *"Medium participation and low compliance"* This group contains non-EU OECD countries (except for Cyprus). As a whole, although they have signed up to the established regulations on environmental protection, they do not make major efforts to incorporate them into internal policies. Moreover, they are not proactive: the governments of these nations are reluctant to undertake meaningful reforms or to play a leadership role within the international community.

Cluster 3: *"Low participation and compliance"*. The political leanings of the countries that comprise this cluster make it extremely difficult to achieve any progress in this field, not only in terms of their participation in the development of environmental treaties but also in meeting the targets therein. For example, in the case of the USA, the Trump administration has brought with it a radical change for the country on environmental issues; it has pulled out of the international climate change accord, thereby cancelling its contributions to support the transition to clean energy (SGI, 2020). Since the beginning of the 21st century, Israel has seen an increase in the use of economic tools that can achieve policy objectives more effectively while driving the market toward environmental improvement (Lavee, 2020).

Cluster 4: "*Medium participation and high compliance"* It is mainly made up of eastern European countries (except for Belgium). They are countries that have agreed to comply with international agreements, such as the KP, but do not have the political or economic capacity to become global leaders.

Cluster 5: *"High participation and medium compliance"* It contains countries where environmental preservation is a top foreign policy priority. Climate change and global

warming can only be tackled through multilateral efforts, and members of this group have played an important role in this regard (SGI, 2020). Most of these nations are very active in the EU's environmental policy agenda, supporting numerous international programmes by contributing funds and offering up advanced technologies that facilitate the achievement of the United Nations' Sustainable Development Goals.

Based on this classification, the analysis then focuses on whether the countries display homogeneous behaviour in WM. From another perspective, progress has been made in the literature in terms of establishing a relationship between growth and waste generation (Beigl et al., 2008; Malinauskaite et al., 2017; Minelgaitė and Liobikienė, 2019). All these studies conclude that a higher standard of living leads to a rise in consumption, driving up the amount of waste generated. Nevertheless, the form of WM is not so directly related to economic development, but rather to the use of techniques that allow the negative impact on the environment to be mitigated (Içöz and Er, 2020). Figure 3 shows the WM (according to the OECD) performed by the countries of each cluster, revealing significant within-group similarities and between-group differences, thus enabling a response to hypothesis 1.

Insert Figure 3

Hypothesis 1: *Countries with a high level of participation in and compliance with environmental policies tend to have lower rates of landfilling.*

On the basis of the results obtained, it is not possible to generally confirm/reject this hypothesis, as is clear from Figure 2. Only cluster 5—where countries show high participation and an optimal level of compliance in relation to GEP, MEA and KPA—displays good WM, with high percentages of incineration and recycling, and less use of landfill; exceptions in this group are Spain and France. In northern European nations

(Denmark, Finland, Norway and Sweden), as well as in Germany, the Netherlands and Switzerland, landfill accounts for barely 10%. As such, they are already in compliance with the European directive for 2035. These are countries that have achieved good WM through the use of advanced solutions that reduce the harmful consequences for the environment and human health (Hollins et al., 2017).

However, the degree of compliance with the agreements does not condition countries' chosen treatment option, as demonstrated by cluster 4, which is characterized as being the most compliant with the established regulations. In this group, except for Belgium, the proportion of waste sent to landfill remains very high compared to other WM procedures.

In the rest of the clusters, where the levels of participation and compliance are lower, landfill remains the most common option, although there are some anomalous behaviours. In cluster 1, Austria and the United Kingdom have achieved a shift towards incineration, while Ireland, Italy and Slovenia have opted for recycling, as has South Korea in cluster 2. Italy merits a special mention: despite the generally adequate transition in WM, the differences between regions have forced governing authorities to adopt very focused measures. The fact that the southern Italian regions are more backwards in terms of industrialization—which is exacerbated by administrative difficulties and economic imbalances—intensifies the predominance of landfills, unlike in northern regions where more sustainable, healthier methods prevail (Mazzanti and Montini, 2013).

In general, what emerges is that landfilling of waste is a well-established practice and the most widespread form of WM worldwide because, despite its harmful externalities, it offers important economic advantages and has few technical requirements (Jovanov et al., 2018; Laner et al., 2012; Mattiello et al., 2013; Vaverková, 2019). Chile (98%), Turkey (88%), Greece (80%) and Israel (76%) are the leading users of this practice,

according to the latest OECD statistics. For example, Greece has 75 active landfills, responsible for high levels of methane emissions (Kalogirou and Sakalis, 2016), while in Turkey the high population growth and consequent urbanization requires a radical change in WM to prevent a proliferation of landfills from damaging other sectors of the economy (Öztürk and Themelis, 2020).

To reduce these practices, countries have developed tools to facilitate the transition to more sustainable activities, such as raising landfill tax rates. This measure was successfully applied in several countries: between 2010 and 2018, according to the OECD statistics, the United Kingdom managed to reduce landfilling by 70%, Norway by 10% and Spain by 23% (Defra, 2013; Kjær, 2013; Almasi and Millios, 2013), while Kallay (2013) recommends the measure for Lithuania. Countries should opt for total WM transition, focusing their efforts on increasing recycling, composting and incineration.

In this respect, Slovenia, Estonia and Lithuania could serve as a model for the rest of the countries currently on the path towards establishing sustainable WM. Both NGOs and the Slovenian government have been very active in achieving the implementation of zero-waste policies and WM programmes that have enabled their early compliance with EU targets set for 2020-2030 (European Commission, 2017a; Malinauskaite et al., 2017). In Estonia, a notable landfill tax and the construction of a major incineration plant have succeeded in establishing incineration as the most commonly used WM practice (Malinauskaite et al., 2017). In the case of Lithuania, EU structural and investment funds have been an important source of funding to improve the WM system by reorienting practices towards incineration, composting and recycling (European Commission, 2017b).

Hypothesis 2: The effectiveness of environmental policies has a significant influence on material recycling and the reduction of waste generation.

In line with several studies in the literature (Veleva et al., 2017; Ardi and Brando, 2019; Virlanuta et al., 2020) and in order to achieve the research objectives, two contingency tables have been constructed to test hypothesis 2 and determine if there is a relationship between the effectiveness of the environmental policies and two waste-related indicators (Tables 3 and 4).

Insert Table 3 and 4

The results of the contingency tables confirm that the second hypothesis can be accepted. Specifically, in Table 3, the largest number of countries show medium-high environmental policy effectiveness, corresponding to medium-low waste generation (15). This is followed by a notable number of countries with medium-low policy effectiveness and medium-high waste generation (10). In addition, Pearson's Chi-squared test confirms a significant relationship between the two variables.

Regarding recycling, it can be seen that the work being done is leading in the right direction, but greater efforts are still needed. The relationship between the two variables is confirmed by the level of significance of Pearson's Chi-squared. However, Table 4 reveals the highest concentration of countries occurs among those with medium-high policy effectiveness and a medium-low performance in material recycling (16), followed by 10 nations that achieve a medium-low level in both variables. These results underscore the importance of promoting governmental actions aimed at minimizing waste generation along with recycling as best practice for waste treatment.

EU waste policies have the highest priority in which waste prevention, followed by preparing for reuse, recycling and other recovery and finally disposal as the least desirable option (Directive 2008/98/EC, Directive 2018/851). Even though, the amount of municipal waste being recycled has been steadily increasing in Europe thanks to investments in appropriate collection and handling, financial incentives to move away

from landfilling of waste and landfill bans (EEA, 2018). Germany, Austria, Slovenia, Belgium, Netherlands, and Switzerland recycled at least half of their municipal waste in 2017.

Although, the outlook to 2030 is less optimistic, waste management is improving, with increasing recycling rates and less reliance on landfilling. Several countries have already adopted strategies to develop the circular economy, Belgium, Denmark, Finland, France, Italy, Netherlands, Portugal, Slovenia and Scotland in the United Kingdom, whereas several countries are developing them (EEA, 2020).

In Spain, for example, waste generation does not show a common pattern of behavior. The regions that greatly depend on tourism show the highest values, Alcay et al (2020) propose the adoption of methods for reduction of the waste levels generated by these activities. As for Bueno and Valente (2019) evaluate the causal effect of a unit pricing system on a disposal of municipal solid waste in Trento, Italy. They show that this policy is effective, with a significant decrease of the priced waste stream, unsorted waste, by 37.5%. Also, Valente (2021) introduces waste prices on waste demands and social welfare, concluding that social welfare effects became positive when this policy cause significant waste avoidance.

4. Conclusions

Rapid economic development needs to be accompanied by sustainable practices that allow the proper preservation of natural resources without causing irreparable damage. At the international level, numerous treaties have been signed, establishing lines of action that commit those responsible for productive activities to the implementation of new technologies aimed at preventing pollution and excessive waste generation. However, countries' degree of commitment varies, with serious differences that jeopardize the

overall outcome. What is needed is a coming together of countries to mitigate environmentally harmful actions.

In this context, the research carried out provides valuable knowledge about the international situation regarding countries' level of participation in establishing shared environmental regulations and compliance with the stated objectives. Moreover, evidence is provided of the relationship between the effectiveness of environmental policies and two indicators of sustainable practices that could mitigate the problems generated by global warming.

The results obtained show that not all countries are moving in the same direction in terms of their environmental standards, leading to a lack of correlation between economic development and degree of compliance with international policies. The most obvious case is the major economic power of the USA, which achieves similar scores for its environmental policies as Turkey and Israel. It is thus shown that political interests can generate a disregard for climate change, bringing down sustainability indicators to minimum values. This behaviour creates a dismal pattern in WM, with heavy reliance on landfills, generating gases that are harmful to the environment and to human health.

Conversely, other highly developed European economies such as Sweden, Finland, Denmark and the Netherlands, among others (cluster 5), register high levels of participation in environmental policies. This in turn has an influence on their waste treatment, with a predominance of incineration and recycling. For example, Estonia, Latvia, Lithuania, Slovakia—even though they were among the last countries to join the EU—achieve high levels of compliance with the KP and medium participation in policies, accompanied by good WM.

The contingency tables show that no country achieves a High rating in EP - WG nor in EP - MR, only 36.6% and 39% obtain Medium-high, respectively. This shows the need

to adopt environmental policies that promote the introduction of innovative technologies focused on reducing waste generation and facilitating recycling. These activities avoid annually over 700 million tons of CO2 around the world and have participated in the slowdown of GHG emissions from OCDE countries. Recycling leads to a lower energy consume, saving natural resources, allowing the decontamination of the environment and filtering particles of urban pollution. This study has attempted to address one of the most controversial issues associated with economic development: waste generation and management. However, there are other issues, such as the use of renewable energies, which could also provide relevant information for an assessment of different countries' actions. As the database used is limited to 41 OECD and/or EU countries, it has not been possible to determine the actions of developing countries.

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Table 1. Results of each indicator for all countries and descriptive statistics.

	GEP	MEA	KPA	EP	WG	MR
Australia	5	6.2	4.34	4	4.82	5.65
Austria	6	5.5	4.78	6	4.60	5.21
Belgium	4	8.7	6.41	6	6.49	6.77
Bulgaria	5	8.7	8.18	5	6.36	5.63
Canada	7	4.2	4.20	7	4.91	4.23
Chile	6	6.4	1.00	6	6.17	1.22
Croatia	6	8.6	6.82	5	6.25	4.73
Cyprus	4	5.8	1.84	4	3.95	3.37
Czechia	5	8.6	7.31	5	7.17	5.49
Denmark	9	9.3	6.18	9.0	2.50	6.20
Estonia	6	8.4	8.23	8	6.56	5.02
Finland	8	10.0	6.93	8	4.92	5.85
France	9	8.9	6.67	7	5.19	5.16
Germany	7	10.0	6.18	6	4.20	9.23
Greece	4	3.5	7.80	4	5.44	3.44
Hungary	5	8.2	7.93	5	6.83	5.83
Iceland	7	1.2	4.55	7	3.73	4.16
Ireland	7	4.8	5.86	7	4.63	6.21
Israel	5	1.0	1.00	5	3.52	2.12
Italy	6	5.8	6.29	7	5.50	5.79
Japan	7	8.6	5.30	6	7.33	4.29
Latvia	6	6.4	8.65	8	6.54	4.18
Lithuania	6	8.4	8.69	7	5.89	5.04
Luxembourg	9	9.6	5.17	8	4.25	5.65
Malta	6	4.6	6.33	4	3.91	2.09
Mexico	6	6.6	1.00	5	7.19	1.83
Netherlands	6	9.6	6.13	6	5.37	5.48
New Zealand	6	6.2	4.26	7	2.33	3.54
Norway	9	9.6	5.62	9	2.80	6.14
Poland	4	4.4	7.10	4	7.41	5.34
Portugal	6	6.9	6.37	6	5.40	3.02
Romania	5	6.8	8.98	5	8.05	2.28
Slovakia	5	8.6	7.72	5	6.46	5.45
Slovenia	6	6.9	6.07	8	5.65	8.07
South Korea	6	7.8	1.00	4	6.77	10.00
Spain	7	8.0	5.68	7	5.77	4.04
Sweden	10	9.3	7.52	9	6.23	5.97
Switzerland	9	9.1	5.90	9	3.21	6.12
Turkey	4	1.0	1.00	3.00	6.34	2.84
The UK	9	5.7	7.38	8	5.91	5.52
USA	2	1.3	1.00	4	2.76	5.16
Media	6.22	6.81	5.59	6.17	5.35	4.96
Maximo	10.00	10.00	8.98	9.00	8.05	10.00
Minimo	2.00	1.00	1.00	3.00	2.33	1.22
Desv Tip	1.74	2.56	2.38	1.67	1.47	1.83

Table 2. Kruskal-Wallis test and the mean values of the indicators for the 5 clusters

	GEP	MEA	KPA
Cluster 1	6.08	5.07	5.79
Cluster 2	5.50	6.66	1.21
Cluster 3	3.67	1.11	1.00
Cluster 4	5.22	8.08	8.01
Cluster 5	8.00	9.22	6.17
Total mean	6.22	6.81	5.59
χ^2	22.011	33.332	27.852
p-value	0.0002	0.0001	0.0001

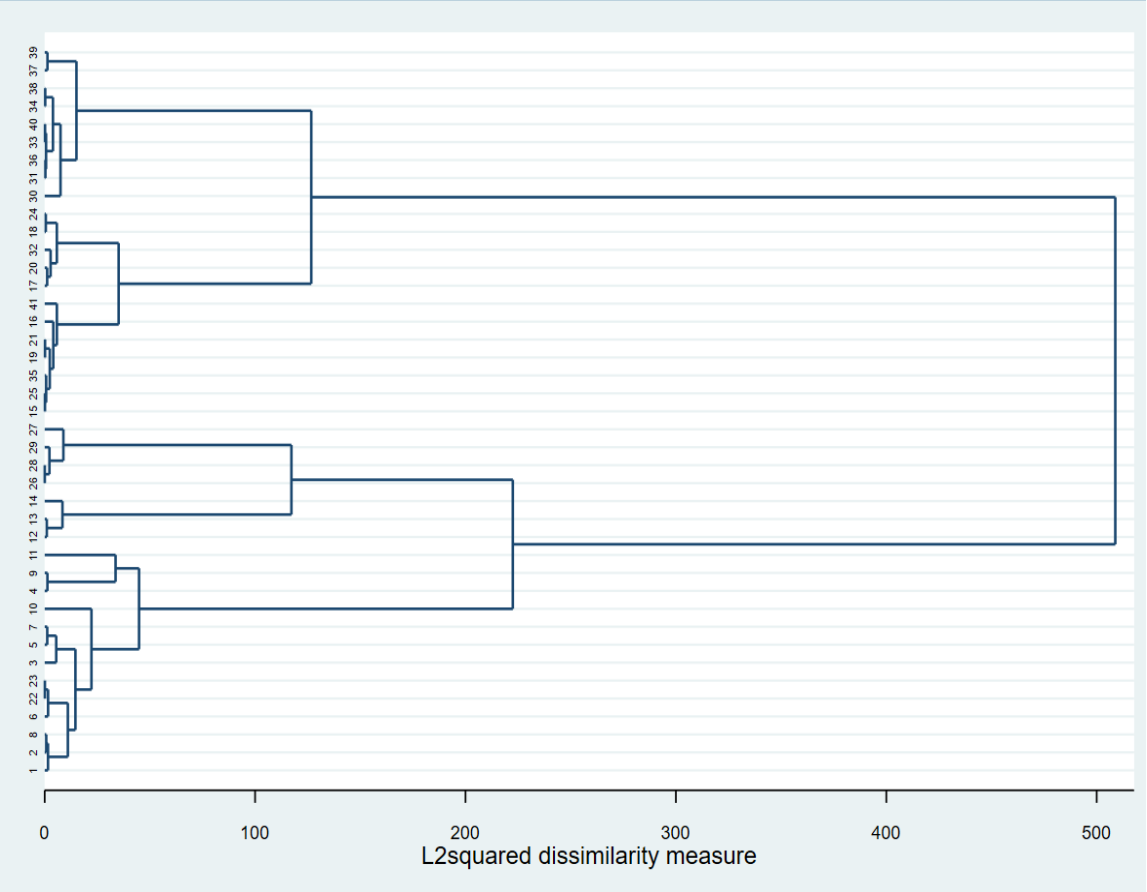
Table 3. Contingency table between environmental policy and waste generation

		ENVIRONMENTAL POLICY PERFORMANCE				
		High	Medium-high	Medium-low	Low	Total
WASTE GENERATION PERFORMANCE	High	0	0	0	0	0
	Medium-high	1 (2.4%)	5 (12.2%)	10 (24.4%)	0	16 (39%)
	Medium-low	1 (2.4%)	15 (36.6%)	5 (12.2%)		21 (51.2%)
	Low	2 (4.9%)	1 (2.4%)	1 (2.4%)	0	4 (9.8%)
	Total	4 (9.8%)	21 (51.2%)	16 (39%)	0	41 (100%)
	Pearson's Chi-squared: χ^2 = 14.543 (p-value: 0.006)					

Table 4. Contingency table between environmental policy and material recycling

		ENVIRONMENTAL POLICY PERFORMANCE				
		High	Medium-high	Medium-low	Low	Total
MATERIAL RECYCLING PERFORMANCE	High	0	1 (2.4%)	1 (2.4%)	0	2 (4.9%)
	Medium-high	3 (7.3%)	3 (7.3%)	0	0	6 (14.6%)
	Medium-low	1 (2.4%)	16 (39%)	10 (24.4%)	0	27 (65.9%)
	Low	0	1 (2.4%)	5 (12.2%)	0	6 (14.6%)
	Total	4 (9.8%)	21 (51.2%)	16 (39%)	0	41 (100%)
	Pearson's Chi-squared: $\chi^2 = 18.945$ (p-value: 0.004)					

Figure 1. Clustering dendogram according to indicators of environmental policies



Note: The numbers in the dendogram represent the countries in the sample in the following order.

1	Australia	11	Iceland	21	Norway	31	Bulgaria
2	Austria	12	Israel	22	Portugal	32	Croatia
3	Canada	13	Turkey	23	Slovenia	33	Czechia
4	Greece	14	USA	24	Spain	34	Estonia
5	Ireland	15	Denmark	25	Switzerland	35	France
6	Italy	16	Finland	26	Chile	36	Hungary
7	Malta	17	Germany	27	Cyprus	37	Latvia
8	New Zealand	18	Japan	28	Mexico	38	Lithuania
9	Poland	19	Luxembourg	29	South Korea	39	Romania
10	The UK	20	Netherlands	30	Belgium	40	Slovakia
						41	Sweden

Figure 2. Clusters of countries according to their compliance with and participation in environmental policies with respect to the total mean

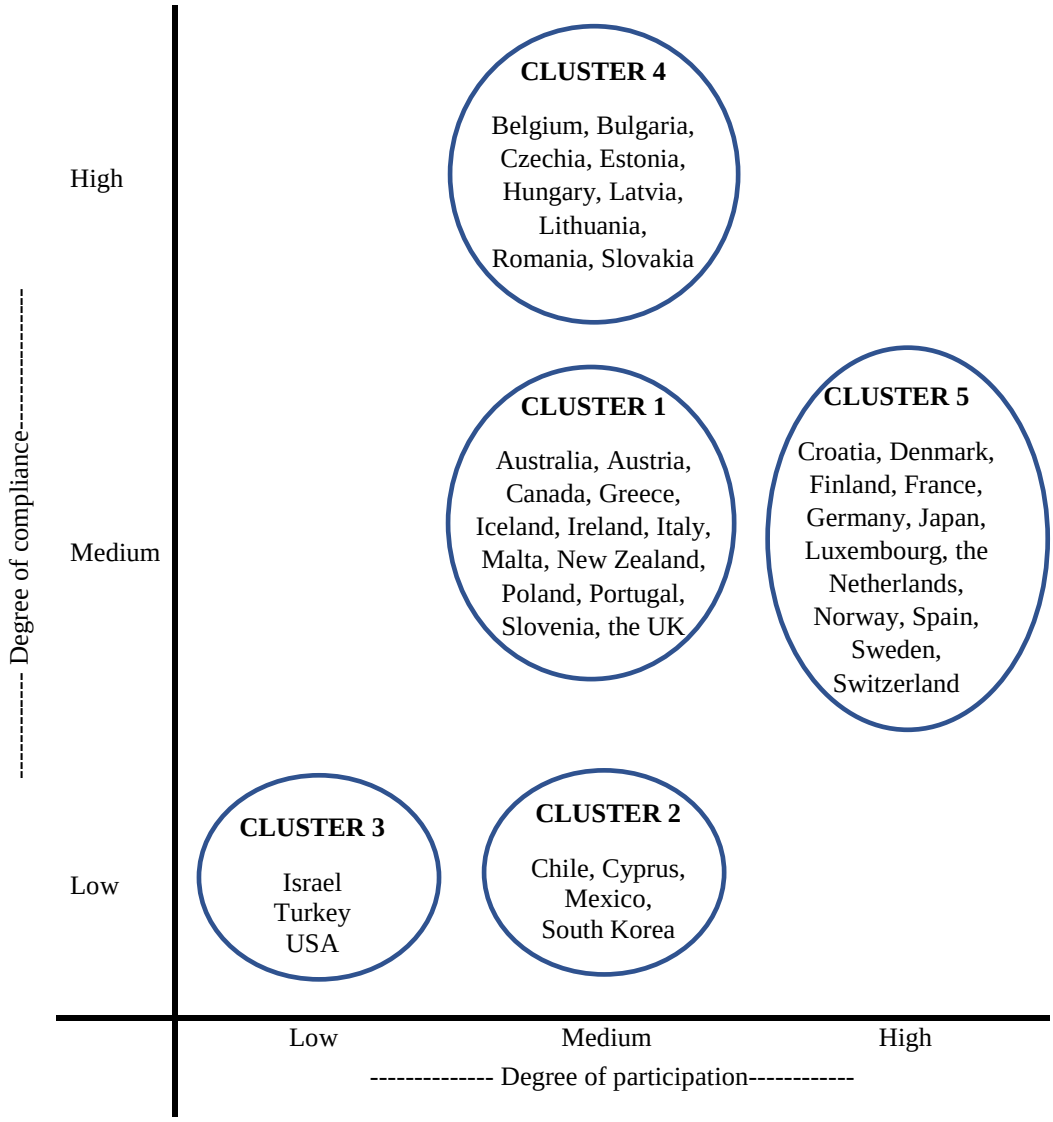
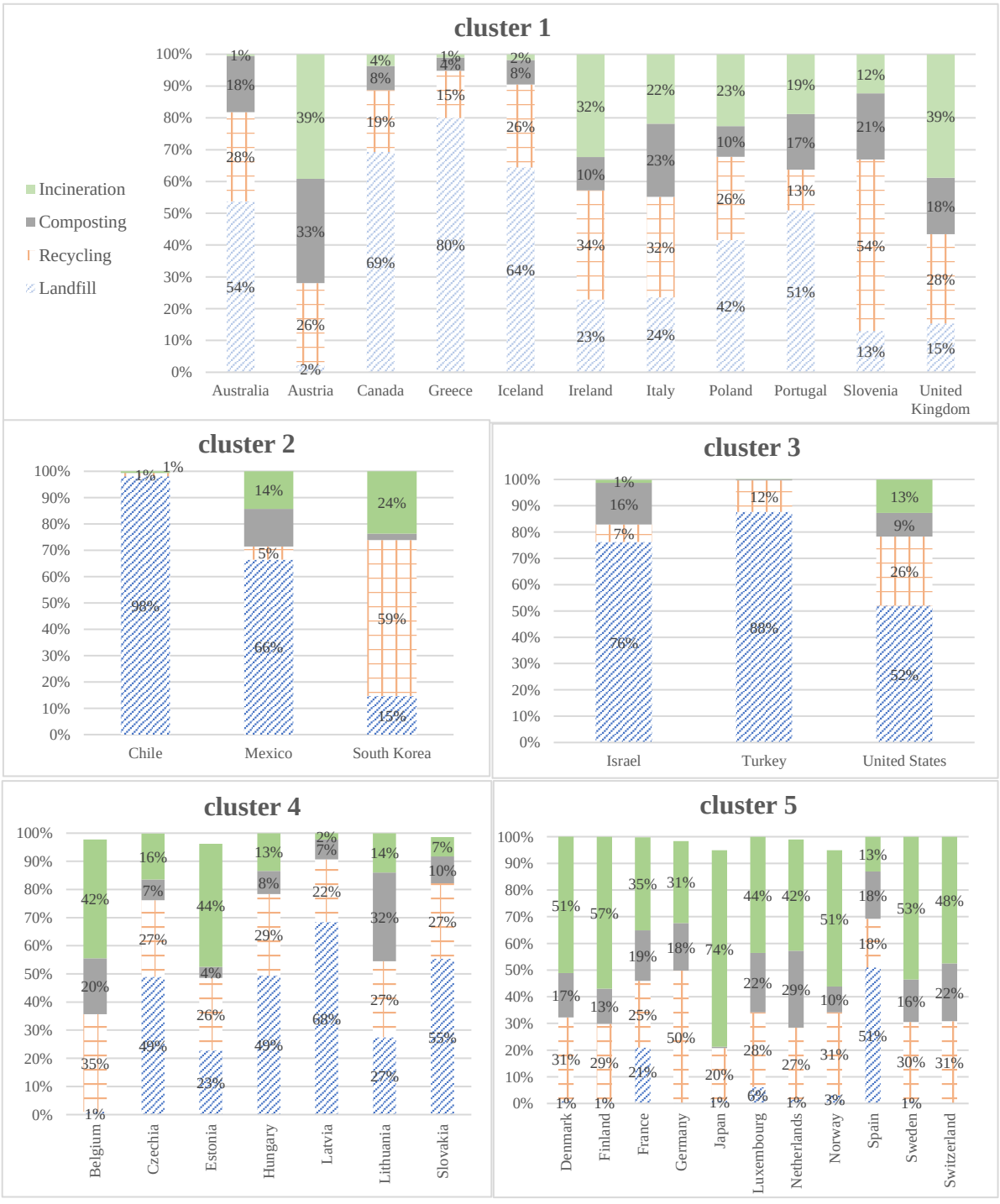


Figure 3. Waste treatment in countries by cluster



Note: No OECD statistics on waste treatment are available for Malta, New Zealand, Cyprus, Bulgaria, Romania or Croatia.