Analysis of the Waste Kuznets Curve and of the success factors in waste management strategies:

Evidence from European countries and analysis of the Danish case

Master's Thesis

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Abstract

The Environmental Kuznets Curve (EKC) is a hypothesized relationship between various indicators of environmental degradation and economic growth. A specific application of the EKC, the Waste Kuznets Curve (WKC), restricts the focus to the environmental degradation caused by waste. In the present paper, a first model is develop in order to investigate the existence of a U-shaped relationship between economic growth and waste–related environmental degradation. In order to account for the latter, two different indicators are employed: the amount of waste landfilled and the amount of waste generated. The econometric analysis provides some evidence of the existence of a curve in the case of waste landfilled, while for waste generation there was a linear direct relationship. The existence of the curve in the first case is supported by the evidence of an improvement of the waste management performance of the countries, after having reached a certain stage of economic growth. The second model is dedicated to investigate how countries can contribute to improving their waste management performance causing the downward shift in the curve. This is done taking into account four possible drivers, investigating which is their impact on waste management performance. A panel data containing the European Countries is created and an empirical model is developed in order to carry out the two analysis. The study concludes explaining the specific position of Denmark in the right part of the EKC, highlighting it as a virtuous example considering their continuous progress towards better waste management practices and towards the implementation of a circular economy.

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1.Introduction

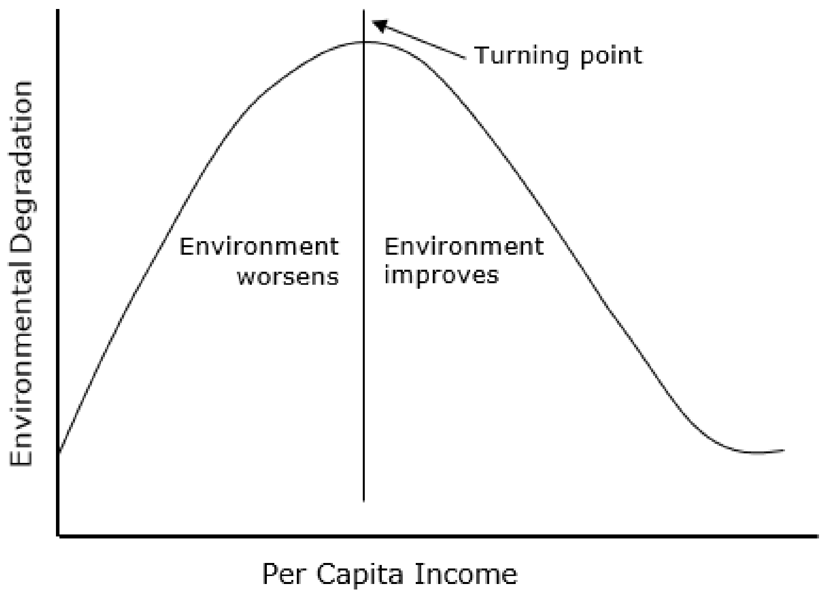
The transformation of waste into a valuable resource is a key process for the sustainability of our planet. For this reason, in the recent years waste management has become a prominent issue all over the world. Though landfill diversion has increased, waste generation still represents a major problem for the sustainability of our planet and is gaining ever more the public attention. Waste volumes are expected to keep growing unless something concrete is done in order to tackle the problem. Within this scenario, economists have started to study this sector and have developed models to help policy makers choosing the efficient mix of policy levers.

Waste can be managed mainly through three different processes: recycling, which include composting, incineration and landfilling. Incineration represents an intermediate option among the three in terms of performance and in turn can be split in two parts, incineration with and without energy recovery, with the first being better for the environment. The management and disposal of waste can have serious environmental impacts. In the case of landfill, it may result in air, water and soil pollution. In the case of incineration , the risk is of emissions of air pollutants. Those are just one part of the issue related with these practices, indeed the environmental impacts are massive (Pearce, 2004; Eshet, Avalon and Shechter, 2004).

However, overall landfilling is still an important option in the European municipal waste management, but with significant differences among the European countries. In fact, in many countries landfilling is still a predominant choice, while others have made sensible progress in the field of incineration or recycling. However, there has been a positive trend in the recent years, with a declining trend of landfilling.

The attention given to waste management practices is on the increase, fostering people to separate refuses and creating a new market for the recycled materials. The growth in the interest about waste management has coincided with a growth of interest into the topic of decoupling or delinking. These can be defined as the effort to block the correlation between the growth of the economy and the increase in environmental degradation. Indeed several researchers hypothesize that higher levels of income coincide with an increase in environmental degradation (Georgescu-Roegen 1971; Hall, Cleveland and Kaufmann, 1986). However, not all the researchers agree on this assumption, providing countervailing evidence that higher levels of income reduce environmental degradation (Beckerman, 1993). The question that emerges is whether the relationship between income and environmental quality behaves strictly monotonic or it takes other shapes. Because of this question, numerous studies went further putting into play the Environmental Kuznets Curve (EKC), a hypothesized relationship between various indicators of environmental degradation and economic growth[1].

Exhibit 1.1: Environmental Kuznets Curve



Source: Agarwal (2017)

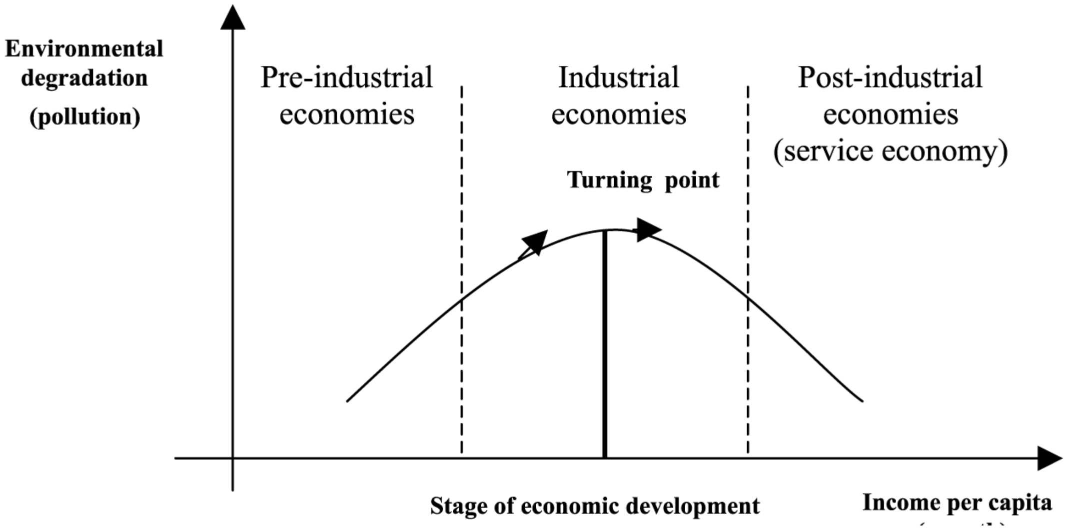
[1] In the existing literature in order to account for economic growth indicators of income has been used. Just few studies has used instead indicators of consumption (Mazzanti and Zoboli, 2008)

The environmental Kuznets curve (EKC) hypothesis is that environmental degradation first increases with income, then after having reached a peak, it declines. The second part of the curve provides an important insight, in fact following the EKC, economic growth is not a threat to global sustainability and there are no environmental limits to growth. (Stern, Common and Barbier, 1996)

The assumption behind the EKC is the following: at low levels of development, environmental degradation is confined to the impacts of subsistence economic activity on the resource and to limited quantities of wastes. As economic development accelerates with the growing impact of agriculture, with the increasing resource extraction and the inception of industrial economy, the pace of resource depletion begins to exceed the rate of resource regeneration, pollution increases and at the same time, waste generation increases in both quantity and toxicity. At higher levels of development, several factors including, structural change [2], rising environmental awareness, enforcement of environmental regulations, better technology and higher environmental expenditures, level off and gradual start to reduce environmental degradation (Panayotou, 1993).

[2] That is, changes in the output mix of economy that arise from economic growth. First the transformation from an agricultural to an industrial economy that cause an increase in pollution, second the shift to a service economy which generate a reduction in pollution.

Exhibit 1.2: Environmental Kuznets Curve with the different phases



Source: Panayotou (1993)

All the countries seem to follow the curve during their process of growth, the condition of their environment worsens until it reaches the so-called "turning point", where the inclination of the slope changes and the quality of the environment starts to improve. If some countries have already reached the right part of the curve, showing an increase in their environmental quality, others are lagging behind and they still do not have reach the turning point.

A specific application of the EKC, the so-called Waste Kuznets Curve (WKC), considers only the waste in lieu of a broader indicator of the environmental degradation. As a result, in this context the environmental degradation could be either waste generation, waste landfilled or waste incinerated.

It is important to emphasize that delinking and WKC are not two unrelated and complete adverse theories. Delinking is observed in the descending part of the WKC while no delinking is observed when we are on the ascending part of it.

Income, even if crucial and the main variable for the analysis of delinking and the WKC, must not be analyzed in isolation as the only determinant of waste management performance. In fact, other numerous socio-political factors come into play. It then becomes crucial to spot which are those factors considered as "enablers" for an improvement in waste management performance and how strong is their impact on it.

In fact, the reduction of the impact on the environment achieved after a certain threshold, is strictly related to the countries' improvement in the environmental performance. Narrowing down the analysis to the case of the present paper, the environmental performance is the waste management performance of the selected countries. For the purpose of this study, the countries are considered as good performer if they show higher percentage of recycling than of incineration and landfilling[3].

Lastly, in the paper the case of Denmark is analyzed, as a best practice example in terms of sustainability. The impact of the enabling factors in the Danish context is further investigated. Denmark is a top class performer in this field, especially in the almost complete absence of landfilling in its disposal process[4]. For this reason, a specific section is dedicated in the paper, namely an in-depth analysis of this Scandinavian country in order to understand how Denmark has succeed to put in place an effective system of waste management and how the country is working in order to target the achievement of the most ambitious goal: the development of a circular economy.

[3] Indeed, as it will be shown in the section regarding the analysis, in both the indicators of performance employed in the paper recycling and composting are included, since they are the best possible method of disposal. The second indicator is broader, including also incineration with energy recovery

[4] In 2008, last year of the analysis landfilling of the municipal waste was only 3.86% and in 2015, last year available was very close to zero.

2.Subject Area

2.1 Problem Identification

This thesis is characterized by a threefold aim. First of all, it wants to investigate the existence of a WKC in the European framework. Second, it has the aim of spotting which are the so-called "enabling factors", drivers that have a positive impact on the waste management performance of the countries. In this way, the study aims to give to the countries that are far behind in terms of waste management performance a comprehension of which are the factors to be improved, in order to catch up with the most sustainable countries. Finally, there is a focus on Denmark, one of the best performer in this field, in order to understand which are the lever of its success and which are the ambitious goals posed by the Danish government. In order to accomplish this threefold task, the study provides a comprehensive analysis of waste generation, incineration, recycling and landfill dynamics based on a panel of European countries.

2.2 Reason of the Study

Within this study, the aim is to bridge several gaps that have emerged in the existing literature. Research on delinking for waste is far less developed than research on air pollution and greenhouse gas emission. In spite of the significant environmental, policy and economic relevance of waste management issues, there is very little empirical evidence on delinking for waste. Empirical evidence on WKC dynamics is also rather scarce. In light of this, the contribute of this paper is to deepen the understanding of WKC with a specific application to the European Framework. Moreover, Mazzanti and Zoboli (2008) state the need for study which combined WKC with studies of policy effectiveness and of the other drivers, these are extensively covered in the present paper.

Another important contribution and motivation of the paper is the lack of an all-encompassing study of the factors that influences waste management for a vast regional area like EU, in fact the majority of the research already performed focus on the relation between one or two factors at maximum. Only single-country case studies using data at regional, provincial or municipal level has recently emerged in the literature. The approach of this thesis is broader, considering the European Countries as the area of investigation. A panel data containing the European countries has been created and an empirical model has been developed in order to assess the effects of the different factors on waste performance.

It is an original contribution also to separately and specifically analyze a leading country in this field. In fact, in the final part of the work a deep-dive analysis of Denmark, one of the countries at the forefront in this field, has been carried out. This is done with the aim of understanding how Denmark has reached its target and how it has developed and perfected its waste management practices. Moreover, the future ambitions and the goals that Denmark have set for its future are analyzed, in order to understand which path the country is following, briefly mentioning also the concept of circular economy.

2.3 Literature Review

The concepts of delinking and decoupling has been analysed by several institutions. The OECD appears to have been the first international body to have adopted the concept of resource decoupling, treating it as one of the main objectives in their policy paper "Environmental Strategy for the First Decade of the 21st Century". The OECD defines decoupling simply as "breaking the link between environmental bads and economic goods" (Unep, 2011). The European Union (EU) policy thematic strategies on both resources and waste entail reference to absolute and relative delinking indicators (Jacobsen, Mazzanti Moll, Simeone, Pontoglio and Zoboli , 2004).

The inception of the literature regarding EKC dates back to 1955, when Kuznets (1955), hypothesized the existence of an inverted U shape relationship between a measure of inequality in the distribution of income and the level of income. The growth in the interest regarding the EKC literature is related to the report of the World Bank (1992), which explores the links between economic development and the environment, even if using data of the 1980s no waste Kuznets curve was founded. From that year, a strand of literature has emerged. To similar outcome of the World Bank gets the study of Cole, Rayner and Bates (1997) which, examining the relationship between per capita income and a wide range of environmental indicators using cross-country panel data sets, found the existence of an EKC only for local air pollutants. One of the first studies that found evidence of the curve is the work of Grossman and Krueger (1994), which for various environmental indicators found that "economic growth brings an initial phase of deterioration followed by a subsequent phase of improvement". In the same year, other authors provide the existence of an increasing monotonic relationship between waste generation and income, while for other indicators there was a U-shaped relationship (Shafik, 1994)[5]. The paper of Chavas (2014) tries to explain the dynamics of the EKC while Andreoni and Levinson (2001) suggested that the basis of the EKC are related to technological micro-foundation. Brooks and Taylor (2004) argued that the EKC and the Solow model are deeply related and provide an alternative method to estimate the EKC. Just few studies include also waste policy analysis (Karousakis, 2009). However, there was a strong prevalence of quantitative analysis at the expenses of theoretical studies which remain scarce.

Huhtala (1997) and Highfill and Mc Casey (2001) were among the first research that provides a theoretical explanation for the WKC. Some authors argue that stock pollution externalities, as it is waste, generally does not show curve but just increasing monotonically with income. (Lieb, 2004). Mazzanti, Montini and Zoboli show empirical evidence about delinking and about existence of an Environmental Kuznets Curve for the waste generation in Italy (2007). Another study develops a theoretical model that highlights a U-shaped path of income-refuse relationship depending on the environmental effort of household in recycling and consumption. (Abrate and Ferraris, 2010).

Various streams of literature have investigated the factors correlated with waste performance, ranging from waste generation, waste management, at the micro and macro levels. (Mazzanti and Montini, 2009; D'Amato, Mazzanti and Montini, 2013). The dynamic relationship between the stringency of environmental regulation and innovation has been analyzed (Cecere and Corrocher, 2016) and there has been also a growing attention for the role of innovation and policies on waste performance (Nicollli et al., 2012). The literature suggests that several social, economic and policy factors contribute to explaining waste performance and possibly also driving related innovation (Mazzanti and Zoboli, 2009; Mazzanti, Montini

[5] Shafik, has indeed through an empirical model has provided evidence of the EKC for some pollutants , in particular air pollution. Sulphur dioxide (SO_2), carbon monoxide (CO), ground level ozone (O_3) and nitrogen oxides (NO_x) were among the pollutants analyzed.

and Zoboli, 2008). Within this literature, there are several studies of waste generation and disposal and their drivers that focus on the analysis of regional frameworks (Hage and Soderholm, 2008).

As already said, it is not common in the literature to analyze individually the case of one country. Hjelmar (1996) present an overview of the waste management in Denmark analyzing waste legislation and waste policies. The Danish initiatives are included in many documents published by the Danish Government and by the Ministry of the Environment. "Denmark without Waste" (2013) and "Denmark without waste II" (2015) are nowadays the mainstays of the Danish efforts towards the improvement of waste management performance.

3.European Framework

The background of this study is the European framework, analyzed in terms of policy and directives being enacted and the influence that the European Union exerts on the member states in terms of waste management. The Directive 2008/98/EC [6] define waste as "any substance or object which the holder discards or intends or is required to discard". It potentially represents an enormous loss of resources in the form of both materials and energy. EU waste management policies aim to diminish the environmental and health impacts of waste and to improve the EU's resource efficiency. Recent EU waste policies have begun defining policy settings defining waste generation and treatment targets.

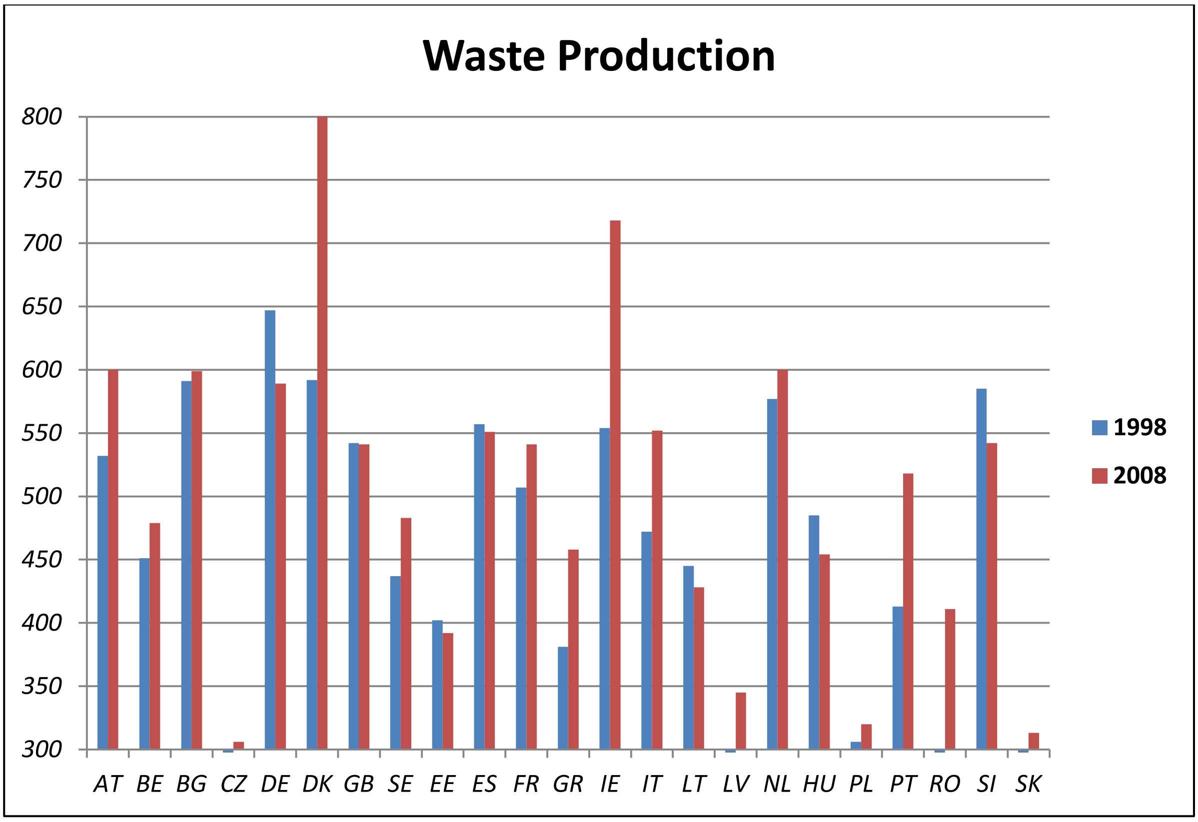
Policies are implemented with the aim of reaching two performance targets: the first consists in hampering the utilization of landfilling as a form of disposal and in giving incentive to the alternative methods, especially recycling and composting; the second is aimed to prevent from the generation of an excessive amount of waste. Indeed, according to the European waste hierarchy, landfill diversion and waste prevention are the two main priorities in the new waste management strategies. Two important directives, the so-called "Landfill directive" in 1999 and the above mentioned "Waste framework directive" in 2008 have been enacted and are the two mainstays of European waste policies (Nicolli and Mazzanti, 2008). The Waste Framework Directive of 2008, as the previous one, discourages the EU member state to locate waste in the landfill site, increasing the cost related to this practice. It also introduced a waste hierarchy where prevention is the best option and the utilization of landfill is the last one. In line with this hierarchy the 7th Environment Action Programme (2014), which is a roadmap for a resource efficient EU, has set, among the others, the following priority objectives for waste policy:

[6] Widely known as the "Waste Framework Directive"

- diminish the quantity of waste produced;
- maximise recycling and re-use;
- phase out incineration to non-recyclable materials;
- limit landfilling to non-recyclable and non-recoverable waste.

A previous study of Mazzanti and Zoboli (2009) has shown that the set of guidelines imposed by the European Union has been able to have an impact on waste landfilling, but the impact on waste prevention has been negligible, indeed, they found that policies do not provide backward incentives for waste prevention. As it is shown in the graph below, where the first and the last year of the analysis are compared in terms of waste production per capita, there are not clear declining trends regarding waste production in Europe, instead in the 10 years analyzed there are more countries which have increased their waste generation, in some case exponentially, than the countries which have reduced it.

Exhibit 3.1: Overview of waste production in EU Member States[7]



Elaboration of the author on Eurostat data

[7] Only the states included in the analysis are included in the graph

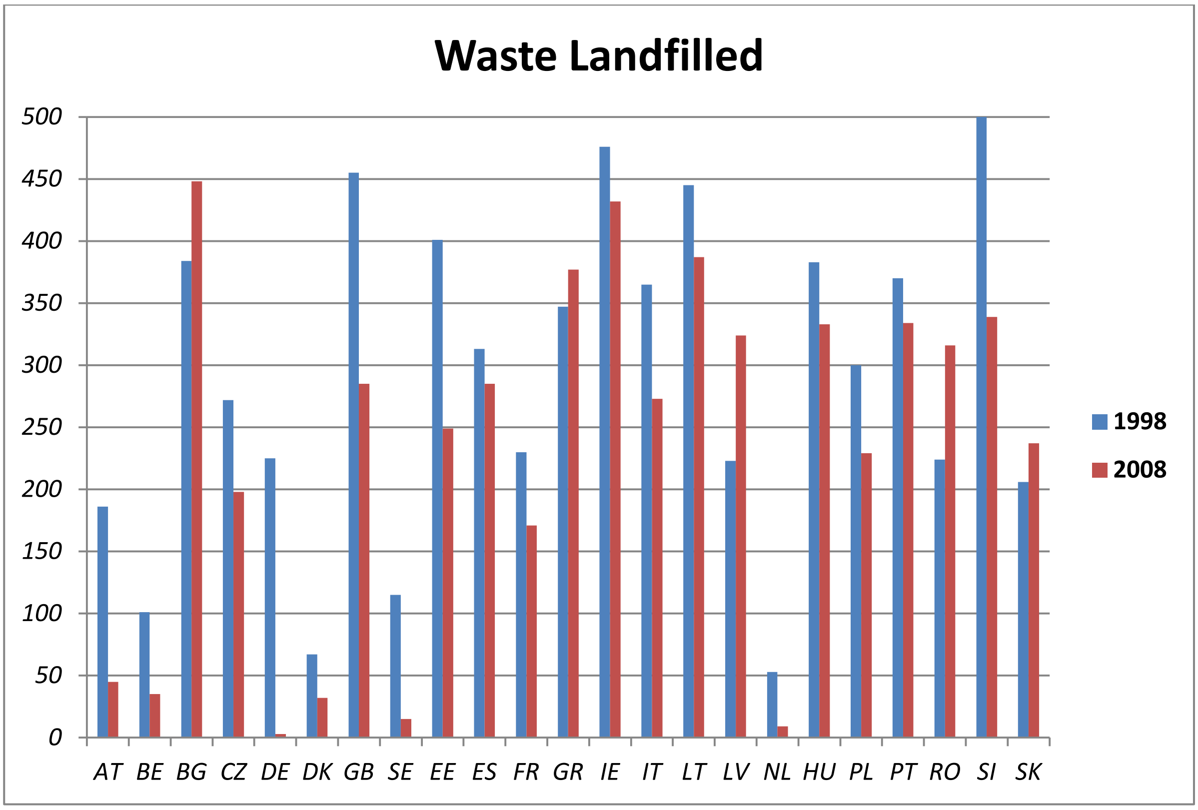
On the other hand, regulation has been able to affect the amount of waste landfilled across EU Member States. One of the provisions that had a deep impact in waste management is the landfill tax, which has played a pivotal role in the reduction of waste landfilled. Twenty European countries have decided to introduce a tax on waste which is disposed in landfill sites.[8] In 2009/2010, the total revenue generated from the landfill tax was around 2.1 billion of Euros (ETP/SCP 2012) for the countries that adopted it. The tax has contributed to achieve the target of diverting waste away from landfill sites. The majority of countries have imposed a tax for the most common waste typology, which amounts to around 30 euro per ton. Furthermore, many countries are already increasing their tax level. The impact of this, together with the impact of the Landfill directive, are testified and corroborated by the data gathered about the European countries. In fact in all the countries there is a declining trend of landfilling, in favour of better waste management methods like recycling, composting and incineration.

The graph below shows the year 1998 and 2008, in this particular case in terms of waste landfilled per capita. The results are very different from the previous graph highlighting the decline of waste landfilled across Europe[9].

[8] Some countries introduce also a tax on the waste sent to incineration plants, varying the amount of the taxes according to the presence or absence of energy recovery in the incineration process. However the tax on waste incinerated is always less than the landfill tax. Recycling and composting are instead often tax-free.

[9] The amount of landfilling is diminishing, even though the amount of waste produced is increasing. Since both graph present absolute data, this provided even stronger evidence on the declining impact of landfilling in the waste management process of EU Member State

Exhibit 3.2: Overview of waste landfilled in EU Member States



Elaboration of the author on Eurostat data

However, all the EU Directives have a major weakness, indeed similarly to the majority of the European guidelines in the area of waste, they have to be accepted and implemented at country level. As a consequence of this, the process of ratification of those European Guidelines has been various both in stringency and timing of the different national legislation. If some countries have promptly reacted to those stimuli coming from the EU, in other countries this have been much more problematic.

European directives have decided to focus on the outcome, imposing specific performance targets, leaving the countries flexible to reach those targets following different paths. Focusing on the final result, these directives were also conceived with the aim of stimulating the development of innovations in this sector, because through innovation the countries can generate more economically efficient ways to reach the target posed by regulation. In fact, the development of innovations aimed at improving waste management innovation is a key priority for the EU.

3.1 Delimitation

The study analyzed 23 European Countries[10] and spans from 1998 to 2008, including therefore the period after the enforcement of the "Landfill Directive" and before the "Waste Framework Directive". In this period, it is possible to group the European countries in three very different groups on the basis of which the impact of landfilling is.

The first group is composed of those countries which strongly rely on recycling, composting and incineration with the near complete absence of landfilling. This lack of landfilling is achieved or through a high percentage of waste recycled and composted or through a predominant impact of incineration. Germany, Austria and Denmark are included in this group[11]. The second group is characterized by those countries which, even if still rely on landfilling for a part of their waste disposal, show an encouraging percentage of recycling too. Italy and Great Britain are part of this group, in fact even if they still rely on landfilling with a percentage of around 35% (that is reducing year by year), they show good results in terms of material recovery. Finally, the last group is composed of the laggard countries, where landfilling is still the predominant waste management option. The countries included in this group are mainly the eastern European countries, with Romania and Bulgaria as a perfect case.

[10] Of the total number of 28 EU Countries, five are omitted. Malta, Cyprus and Luxembourg have been omitted due to their relative small size, while Finland and Croatia have been omitted due to problem in the availability of some data (in the case of Croatia is due to the relative recent entry in the European Union, just in 2013)

[11] Even if these countries are different in terms of how they drove waste away from landfills. Germany and Austria rely mainly on recycling while in Denmark the incineration of waste have completely substituted the use of landfill sites.

3.2 Future Orientation

The long-term goal is to turn Europe into a recycling society, reducing the environmental impact. In order to do so, policies are conceived with the aim of reducing the quantity of waste produced and when waste generation is unavoidable achieve higher levels of recycling and composting. Implementing appropriate system of waste management is crucial to guarantee resource efficiency and achieve a sustainable growth of European economies.

The most significant problem which has not been adequately faced is the role of prevention, the directives in theme remain non-binding and prevention is still far from being the cornerstone of waste policies. In the near future waste prevention will became the primary and necessary target of waste regulatory efforts. Waste prevention targets and innovative benchmarking should be the ways to shape waste policies. In fact, even if waste prevention is at the top of the EU waste hierarchy, no concrete action geared towards waste prevention has been object of formal directives so far. This is probably due to the fact that achieving compliance to waste management and landfill diversion policies presents lower implementation cost.

The Horizon 2020[12] Work Programme for 2016-2017 includes a major initiative on "Industry 2020 in the circular economy", with funding of over €650 million (EU Commission, 2015).

In the same year, the European Commission adopted an ambitious Circular Economy Package, which comprises revised legislative proposals on waste in order to accelerate Europe's transition towards a

[12] Horizon 2020 is the flagship initiative aimed at securing Europe's global competitiveness. Seen as a means to drive economic growth and create jobs, Horizon 2020 has the political backing of Europe's leaders and the Members of the European Parliament. They agreed that research is an investment in the future and so put it at the heart of the EU's blueprint for smart, sustainable and inclusive growth and jobs. (EU Commission, 2016)

circular economy. The Circular Economy Package consists of an EU Action Plan for the Circular Economy that establishes a concrete and ambitious program of action, with specific measures: from production and consumption to waste management. The proposed actions will contribute to "close the loop" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy. According to the EU Commission website (2017), key elements of the revised waste proposal include:

- Recycling 65% of municipal waste by 2030;
- Recycling 75% of packaging waste by 2030;
- Reduction of landfill to maximum of 10% of municipal waste by 2030;
- A ban on landfilling of separately collected waste;
- Promotion of economic instruments to discourage landfilling ;
- Concrete measures to promote re-use and stimulate industrial symbiosis, making one industry end product the raw material of another industry;
- Economic incentives for producers to put greener products on the market and support recovery and recycling schemes.

4. Analysis of the Waste Kuznets Curve

The first analysis that is performed in the present paper is the investigation about the possible existence of a Waste Kuznets Curve taking into account the European Countries.

There are several major generic issues related to the generic estimation of the Environmental Kuznets curve that remains dealing with the WKC: the assumption of unidirectional causality from economic growth to environmental degradation is surely the major. If the EKC hypothesis were confirmed, this would suggest that growth maximization could be considered as the solution to improve the quality of life in the least developed countries. In other words, instead of being a threat to the environment, as argued in the work of Meadows, Randers and Behrens "The Limits to Growth" (1972), economic growth can be the means to achieve environmental improvement. However, trying to accelerate the process of growth in the early stages of development can become a double-edge sword. There is clear evidence of this from the case of many developing countries (Barbier, 1994)

The paper of Stagl (1999), talking about the EKC state that “possible explanations for this pattern are seen in the progression of economic development, from clean agrarian economies to polluting industrial economies to clean service economies”. This assumption could hold also in the case of WKC and not only for EKC. This could also contribute to explain the presence of the above mentioned curve.

In order to perform this kind of analysis a panel data is created, including 23 European countries. As already mentioned, two different measures of waste-related environmental degradation are employed: waste landfilled and waste generated[13], both having their strengths and weaknesses that are evaluated in the text. If waste produced has been often used in literature for this scope, the use of waste landfilled is a rather novel approach[14]. The main covariate is the richness of the countries, measured as the GDP per capita. This variable is included also in the quadratic term with the aim of spotting the existence of the U shape relation. In the model, other control variables are included in order to refine the analysis.

The database is related to 23 European countries which are observed from 1998 to 2008. Publicly available data from EUROSTAT were used as demographics and socio-economic indicators.

4.1 Description of Variables and Methodology

All the variables included in the model are summarized in the table below and then examined individually in the present section:

Table 4.1 Description of the variables

Waste Landfilled	Quantity of waste landfilled per capita (kg)
Waste Produced	Quantity of waste produced per capita (kg)
Income	GDP per capita
$Income^2$	Quadratic terms of the GDP per capita
Regulation	Value of Environment Stringency Index

[13] In the present paper for waste the total amount of municipal waste has been considered.
[14] Even if not completely new, indeed other scholars used waste landfilled as indicator of environmental degradation in the analysis of WKC, for instance Mazzanti and Zoboli (2008) investigate the existence of a WKC performing the analysis with several dependent variable among which there was also waste landfilled.

Household Size	Average number of people for household
Population Density	Number of inhabitants per km^2

The first dependent variable is Waste Landfilled. It is defined as the quantity of municipal waste that every year is disposed in landfill sites. It is measured per capita and expressed in kilograms. Landfilling is almost unanimously considered as the worst method of dealing with refuses. Nonetheless, it has still a wide adoption, since solid waste disposal in landfills remains the most economic form of disposal (Thompson and Zandi, 1975). The environmental problems caused by this method are several, gas and leachate generation are inevitable consequences of this practice. "The migration of gas and leachate away from the landfill boundaries and their release into the surrounding environment present serious environmental concerns including potential health hazards, fires and explosions, damage to vegetation, unpleasant odors, landfill settlement, ground water pollution, air pollution and global warming". (El-Fadel, Findikakis and Leckie, 1997). On the grounds of this, waste landfilled seems to be a suitable indicator of environmental degradation. Still this indicator presents its downside, for example underestimating the environmental impact of countries which have very low landifilling rate obtained through a massive use of incinerators, especially when the incinerators does not allow to recover energy. Indeed, this coupled with the obsolescence of some incineration plants can result in a harmful impact for the environment not so different from locating waste in landfill sites.

The variable has an average value of 258 kg per capita of refuses. This value ranges from 3 (minimum value taken by Germany in 2008) to 550 (Ireland in 2000). The virtuous countries are Germany, Denmark and Netherland whose values in the last period covered by the analysis are below 50 kg of waste landfilled per capita per year. On the other hand, there are countries like Bulgaria, surprisingly Ireland and Great Britain who have the highest quantity of refuses landfilled per capita. Almost all the countries analysed reach their peak values in the first year of the analysis, probably the following reduction in the amount of waste landfilled occur thanks to the effort driven by the European Policies especially through the already mentioned Landfill Directive.

The second and alternative dependent variable is Waste Produced, that is to say the quantity of waste produced every year in the selected countries per capita. It is still expressed in kilograms. Measuring waste generation is the alternative way of estimation of environmental degradation adopted in the paper. Differently from the previous measure, the waste management process carried out by the countries does not have an influence on the value of this indicator. The use of this indicator is supported by the assumption that whichever method of treating refuses is harmful, even if some are more dangerous than others, so the main problem is in the exaggerate production of refuses and not in how they are managed. This method is rather unpolished, since waste generation does not imply per se environmental degradation. In fact, countries that produce more refuses sometimes have very effective system of waste management. This allows, thanks to high rates of material recovery obtained through very efficient recycling system, to remarkably reduce their environmental impact. Brilliant examples in this sense are Austria and Germania.

The average value of the dependent variable Waste Produced is 483 kg. The minimum value is 239, registered in Slovakia throughout the year 2001. Slovakia is together with Czech Republic the country with the lowest production of refuses. The countries which produce more waste are Denmark (in 2008 it produced around 830 kg per capita) and Ireland. Those are two complete opposite cases, Denmark has put in place a very effective system of waste management, in fact even if they are the biggest producers of refuses per capita in Europe they are also, as mentioned above, one of the countries with less refuses per capita that are landfilled. On the other side in Ireland, the huge waste production ends up primarily in the landfill sites.

For the explanatory variable Income, the value of GDP per capita has been taken, since it is the standard way of measuring the richness of a country. The choice of using GDP per capita, in lieu of GDP, is clear-cut, it allows to avoid overestimation of bigger countries. The unit of measure used is the thousands of Euro. It has been included also the quadratic terms of GDP per capita in order to spot for the existence of the theorized U-Shape, indeed, if this second variable is significant and with a negative coefficient, there are evidences for an inversion in the direction of the slope. Mazzanti and Zoboli (2008) perform the analysis using as main economic driver, an indicator of consumption, that is to say the household expenditure consumption per capita, instead of an indicator of GDP per capita[15]. However, they show that the outcome of the analysis does not change replacing consumption with GDP.

In the next page the table containing the summary statistic, both for the dependent and the independent variables:

Table 4.2: Descriptive statistics

Variable	Obs	Mean	Median	Std. Dev.	Min	Max
Waste Landfilled	253,00	258,92	285,00	134,92	3,00	550,00
Waste Production	253,00	483,80	482,00	126,36	239,00	830,00
Income	253,00	18,32	16,66	12,01	1,51	45,46
$Income^2$	253,00	479,38	277,54	490,07	2,28	2066,44
Regulation	253,00	1,79	1,88	0,74	0,52	3,28
Household Size	253,00	2,52	2,50	0,27	2,03	3,24
Population Density	253,00	132,07	100,30	104,10	21,50	487,20

[15] They follow the hypothesis that consumption is a better independent variable for economic growth for waste related analysis as supported by Rothman (1998) and Gawande, Berrens and Bohara (2007).

The value of GDP per capita in the countries analysed does not provide new insights to the common knowledge, it ranges from 1.50 to 45 (thousands of Euro) with an average of 18. The richest countries are Denmark and Ireland while the poorest are Bulgaria and Romania.

All the control variables that are employed are almost time-invariant, or at the most, they change only slightly across the years.

The first control variable is regulation. It has been used the Environmental Stringency Index, an index developed by the OECD[16]. The second control variables is Household Size and it controls for the average size of the household in the examined countries. The assumption behind the inclusion of this variable is that larger household has a lower production per capita of refuses.[17] The third control variable is the Density of Population. It has been included because countries with a higher population density usually relies less on landfilling because of a reduction in the space available to locate the landfill sites. In other words, countries with a high density of population should present a prevalence of recycling and incineration over landfilling, which is traditionally more land consuming.

The last comment of this section regards the table of correlation among the variables:

Table 4.3: Correlation matrix

		1	2	3	4	5	6	7
Waste Landfilled	*1*	1,000						
Waste Production	*2*	-0,046	1,000					
Income	*3*	-0,440	0,721	1,000				
Income^2	*4*	-0,437	0,722	0,969	1,000			
Regulation	*5*	-0,345	0,419	0,468	0,430	1,000		
Household Size	*6*	0,590	-0,181	-0,349	-0,378	-0,252	1,000	
Pop. Density	*7*	-0,442	0,250	0,404	0,351	0,089	-0,292	1,000

[16] A detailed discussion of this variable is provided in the following chapter, where regulation has been evaluated as one of the drivers influencing waste management performance

[17] The assumption is that, for instance an household of four people produces less than four times the quantity of refuses produced by a person living alone

From the starting model, some variables have been omitted due to collinearity problem[18]. Putting aside the obviously very high correlation between GDP and GDP^2 , the table of correlation does not show particular criticalities. There is no relation among the independent variables higher than 0.5. The relation of the two variable of income (GDP and GDP^2) with the control variable Regulation takes the higher values. This is somehow expected since richer states have usually tougher regulation in terms of the environmental problems. This is also the case of Denmark, which presents high values on these two indicators.

4.2 Empirical Findings

After having specified all the variables and having analyzed the descriptive statistic and the table of correlation, the statistical results of the analysis are presented in this section.

Before starting with the analysis, Hausman Test has been performed for the two models with the two alternative dependent variables. All the regressions are first estimated by both random and fixed effects. The results are opposite for the two models. In the case of Waste Landfilled as dependent variable, the p-value obtained with the Hausman Test is 0.0756, suggesting the adoption of the Random Model. In the case of Waste Produced, the indication is opposite, the p-value is 0.0012, therefore in this case the Fixed Model is clearly suggested. In light of these results, in the present paper the two models are estimated using the two different methods, following the Hausman Test outcomes.

Here below the statistical findings for the two models:

[18] The presence of collinearity has emerged analyzing the variance inflation factors and the correlation among the coefficients of the independent variable of the regression. As a consequence, the variables urbanization degree and population have been removed.

Table 4.4: Results of the linear regressions:

VARIABLES	(1) Waste Landfilled per capita	(2) Waste Production per capita
Income	1.579	3.044*
	(2.096)	(1.823)
$Income^2$	-0.0806**	0.123***
	(0.0330)	(0.0292)
Regulation	-15.73***	-6.761
	(5.710)	(4.674)
Household Size	81.49**	66.72**
	(37.96)	(32.33)
Population Density	-0.483**	-4.123***
	(0.213)	(0.871)
Constant	155.4	758.0***
	(110.5)	(159.7)
Observations	253	253
R-squared	0.255	0.424
Number of Country1	23	23

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In the first model the equation is the following:

$Y_{it} = X_n\beta_n + \alpha + U_{it}$

Where *i* denotes the individual countries, *t* denotes the year, β_n are the coefficients estimated for every single explanatory variable X_n, α is the intercept and *u* is the error terms. *Y* is the dependent variable, in this case the quantity of waste landfilled. The r squared of 0.255 is not very high, however the purpose of the analysis is to understand the relation between GDP and the waste landfilled and not understanding all the variables related to the increase or decrease in the use of landfill sites. In light of this, the absence of other variables, which could explain better the dependent variable, does not have a negative on the analysis.

In order to have the hypothesis of the Kuznets curve verified, two conditions must hold in this model and in the next one: the coefficient of the variable GDP per capita should be positive while at the same time the quadratic term of GDP per capita should be negative.

What turns out is that apparently both the conditions hold, so there is a clear evidence supporting the existence of the Kuznets Curve. The problem with this model is that even if it is sure that there is a change in the inclination of the curve given the p-value of the GDP^2, it is not possible to rely on the coefficients of GDP, since the p-value is too high. The problem that has arisen could be related to the specific subset of countries analyzed. In fact the risk that has been incurred, focusing our analysis only on the European countries, is that in comparison to the same analysis performed globally the left side of the curve has been neglected, giving that even the more laggard European countries (e.g. Romania, and Bulgaria) are more developed than the underdeveloped world countries. In light of this, performing the same analysis on a wider and more heterogeneous set of countries, could provide less contrasting and clearer results.

As far as the control variables regulation is concerned, as expected, it has been found to be significantly negatively correlated with the quantity of waste landfilled. This comes as no surprise since several countries are enforcing national laws in order to stop the offspring of new landfill sites, often mainly driven by European Directives, for instance the Landfill Directive, a cornerstone of the European Waste Strategy. Population Density as well follows the expectation; it is negatively related to waste landfilled. This is expected since countries that are smaller have less space to put landfill sites, increasing the cost opportunity[19]. The only control variable which is somehow against expectation is Household Size, there is a positive relation, namely an increase in the average household size coincides with an increase in the quantity of waste landfilled. This finding

[19] A perfect example is again Denmark, which has around 125 inhabitants per square kilometers and almost does not dispose waste in landfill

could be explained by an issue of reverse causality, that is to say the eastern European countries (e.g. Romania and Bulgaria), which are laggard in terms of method of waste disposal are characterized by household size that are above average.

In order to perform a more complete analysis, waste generation has been analysed in the present paper as another possible measures of environmental degradation. This is to avoid to reject or to accept the existence of a Kuznets curve only due to the use of a wrong indicator of environmental degradation. In this case the hypothesis is that, initially income and waste produced increased until a certain level of income is reached, after which an increase in income corresponds to a reduction of waste produced.

As already mentioned, in this second case the Fixed Model has been used, so the equation is the following:

$Y_{it} = X_n\beta_n + \alpha_i + U_{it}$

Where again *i* denotes the individual countries, *t* denoted the year, β_n are the coefficients estimated for every single explanatory variable X_n, α is the intercept and *u* is the error terms. In this case the dependent variable *Y* is the quantity of waste produced per capita in the selected countries. The r squared is much higher than in the previous case, being around 0.42, showing a good explanatory power of the model.

In this case the coefficient of GDP is positive with a p-value that is lower than the previous one (0.09 in this case, 0.7 before), but still if 0.05 is considered as threshold for a p-value to be significant, it is unacceptable. What is strikingly different from the previous model is the coefficient of the squared term of GDP; here the coefficient is significant and positive rejecting the hypothesis of the existence of a Waste Kuznets Curve in the European countries.

In this variant of the model, the control variable Household size is not significant while Population Density is significant with a negative coefficient. Regulation is not significant. This last finding is expected and in line with several previous studies (Mazzanti and Zoboli, 2009) (Mazzanti et al., 2008), which do not found any impact of environmental policies on waste generation and waste prevention. Regulation, as it is shown also in the next chapter, has been found to be correlated only to how to manage the waste, not to how to prevent and reduce it.

Summing up the models, what comes out is that, changing the proxy for waste-related environmental degradation (our dependent variable), the results and the following findings strikingly change. The first model seems to allow for the possibility of the presence of the hypothesize curve, even if the p-value of GDP is not significant and makes a further investigation necessary. This model also theoretically has stronger basis than the other. In fact, the assumption is that less developed countries do not produce a high quantity of waste, so even if waste is in majority landfilled, it does not have a relevant impact on the environment. Successively, the development and the growth of richness of the population increase remarkably the quantity of waste produced, without a proper system of managing them. This causes the upward shift of the curve. When the environmental situation worsens showing a lack of sustainability, the countries focus their attention on how to manage and reutilize this huge quantity of waste produced. People start to be more aware of the environmental problems and more concerned about their health and, as a consequence, of the potential harmful impact of a polluted environment on their health. Therefore, even if there is a continuous increase in waste produced, as shown by the model using the other dependent variable, the improvement in the waste management practices more than offset it, resulting in a decrease of waste landfilled.

Indeed, waste landfilled is not an exogenous indicator for countries, it is not just related to waste produced, but an increase in this value is often related to a mismanagement of waste at the country level. Being related to the waste performance of a country, the downward shift of the curve is boosted by the improvement of waste management process, which occurs in the countries after having reached the turning point. This improvement is not automatic, but it is the result of the sum of many drivers, which can be consider as enabling factors for waste management process. In the next section the relation of those drivers with two indicators of performance[20] is investigated.

All the above suggests a stark difference from the other indicator of waste-related environmental degradation, where the only impact that the countries could have is on preventing waste, which has found problematic in almost all the countries. As a results waste produced does not provide the same results of the previous indicator. This is also somehow expected, because several studies have demonstrated the absence of delinking between waste produced and the increase of income. (Mazzanti and Zoboli, 2008). In fact what is seen from real case is that the more vigorous is the economy, the more refuses are generated. So it is rejected one of the underlying hypothesis behind the presence of the curve with waste generated, namely that the increase of the richness of a country can provoke a structural change that results in a decrease of waste intensive sectors in favor of service sectors, which traditionally produce less waste. This effect is not as big to offset the increase in waste generation linked with the increase of income. So in this case there is only a linear relation between the two variables, the increase of richness is positively related with an increase in waste produced. This is in line with has been found in literature, in fact stock pollution externalities, as it is the production of waste, generally does not show curve but just increases monotonically with income (Lieb, 2004).

[20] For reason of refinement of the analysis two positive and relative indicators willl be used, instead of the absolute value of waste landfilled

5. Analysis of the Success Factors in Waste Management Strategies

This section is dedicated to analysis of the enabling factors that are considered as possible drivers for an improvement in waste management performance. Four possible factors are tested in the next models. This is done with the aim of analyzing the strength of the relation between waste management performance and the enabling factors, which are first enlisted and then carefully analysed below. The period of years of the analysis spans from 1998 to 2008. The starting point in time is very close to the enforcement of the "Landfill Directive", giving us also an idea about the impact that this directive had on EU member states. In fact, all the countries show a declining trend of landfilling probably spurred and accelerated by the adoption of this directive.

5.1 Description of Variables and Methodology

The table below summarize the meaning of all the analyzed variable:

Table 5.1: Description of the variables

Waste Performance 1	% of Waste Recycled and Composted over the quantity of waste produced by each country
Waste Performance 2	% of Waste Recycled, Composted and Incinerated with energy recovery over the quantity of waste produced by each country
Innovation	Quantity of patents in the field of waste management granted each year per capita (patents per

	hundred thousands of inhabitants)
Regulation	Value of Environmental Stringency Index
Structure of the Economy	% of Value Added of the so-called dirty sectors[21] over the value added of all sectors for each country
Education	Share of students in tertiary education as a percentage of the population aged 20-24 years
Propensity to Patent	% of R&D expenditure over the GDP of each country

The dependent variable of this analysis is the Waste Management Performance. For the context of this paper, there are two suitable indicators that are adopted. The first one takes into account the percentage of municipal waste recycled or composted over all the municipal waste produced in one year by the different countries. The second one is broader, because it is the percentage of the municipal waste that is recycled, composted or incinerated (considering only incineration with energy recovery) over all the municipal waste produced in one year by the different countries. The latter indicator is similar but not equal to a concept that is widely used, known as "Landfill Diversion". The difference is that this indicator that has been adopted does not consider the incineration without energy recovery, differently from the concept of "Landfill Diversion". The table below schematically represents the difference between the two indicators.

[21] For Dirty Sectors we refer to the paper of Many and Wheeler (2008). This is extensively covered later in this section

Table 5.2: Breaking down of the two indicators of performance

	Recycling	Composting	Incineration with energy recovery	Incineration no energy recovery	Landfilling
Waste performance 1	✓	✓			
Waste performance 2	✓	✓	✓		

Using two different models that explain those two indicators of performance separately, allows distinguishing the different impact of the variables on these two different ways of estimating waste performance. In fact, the two models are not substituted but complementary. The first model focuses only on the impact of the four factors on the most preferred and more innovative way of treating waste (recycling and composting). The second model analyzes the impact of the variables on avoiding the utilization of the worst methods, that is to say landfilling and incineration without energy recovery. Several countries have quite a large difference in the performance according to the two indicators because of a deep impact of incineration with energy recovery in their waste management process[22]. The two waste performance indicators are expressed in percentage and in this sense are more reliable than indicators that shows the amount of waste recycled pro capita, because the amount of waste produced in the different countries does not have an impact on the quality of our data.

The first dependent variable, Waste Performance 1 ranges from 0% to 64% with an average of approximately 21%. The minimum values are taken by some East European Countries (Bulgaria, Romania and the Baltic Republic) in the first years of our analysis. The only exception is Romania, which retains very low value also in the last years considered. In this indicator the best performers are Austria and Germania.

[22] As an example, Sweden and Denmark present a very high percentage of refuses incinerated (with energy recovery), as a consequence of this the two Scandinavian present a good performance on the first indicator and an outstanding performance on the second one

The second indicator presents a higher variance, in fact if the minimum value is the same of the one considered above (0%, so complete landfilling), the maximum as obvious presents higher value, driven up by the inclusion of incineration with energy recovery in the index. Interestingly, if the worst performers are more or less the same with the two indicators, the best performers change. If Austria retains a high rank, Belgium and the Scandinavian countries Sweden and Denmark overcome Germany. Those countries in the last year covered by the analysis shows the almost completed removal of landfilling by their waste management process.

Both the two alternative independent variables however present a high variability not only across countries but also across years. This is because some countries have not even started a serious recycling program or have launched it only in the last period of the analysis. Here below the summarizing statistic for the two dependent variables and for the independent that will be explained in the rest of this section:

Table 5.3: Descriptive statistics

Variable	Obs	Mean	Median	Std. Dev.	Min	Max
Waste Performance 1	253	20,96%	16,11%	18,44%	0,00%	64,47%
Waste Performance 2	253	32,16%	20,41%	28,34%	0,00%	96,89%
Innovation	253	0,67	0,39	0,87	0,00	5,20
Regulation	253	1,79	1,88	0,74	0,52	3,28
Structure of the Econ.	253	5,06%	5,03%	1,72%	1,98%	9,81%
Education	253	55,53%	55,00%	13,23%	18,50%	95,30%
Propensity to Patent	253	1,30%	1,09%	0,79%	0,35%	3,91%

The first factor is Innovation, interpreted as innovation in the field of waste management. The importance of innovation is confirmed also by the European legislation, which has defined it in the field of waste management as a “key priority”. Innovation plays a pivotal role and can offer new and better ways of treating refuses, reducing costs and increasing effectiveness, in other words making the recycling alternative more viable and cost effective. Existing studies have adopted different methods of estimating innovation, for instance through indicators of input such as R&D per capita (Jaffe and Palmer, 1997).

A measurement of output has been used in this work, taking into account the patents granted in this sector. Patents seem to be a reasonably good indicator of innovation in a country and display a good availability both in terms of time and country coverage. Moreover, as Dernis and Khan (2004) suggested, patents protects all the economic relevant innovations, this is the reason why patent data are considered as a useful proxy of innovation for economic research. All the patents that fall within the category "Waste Management" have been taken into account. In order to spot them, PATSTAT database has been used [23], considering the IPC classes which refer to "Waste Management" technologies. A list of those classes is contained in the Wipo Green Inventory. We included all the five subclasses of Waste Management which are:

- Waste Disposal
- Treatment of waste
- Consuming of waste by combustion
- Reuse of waste materials
- Pollution control

For a more detailed list and a further breakdown of the classes, see the appendix 1. This inventory has been developed with the aim of simplifying the searches for patent information related to the so-called Environmentally Sound Technologies (ESTs)[24]. In the present analysis, the patents are classified on the basis of the country's authority where the application is filed and of the filing date[25].

[23] The online database can accessed via https://www.epo.org/searching-for-patents/business/patstat.html#tab1.
[24] ESTs are currently scattered widely across the IPC in numerous technical fields. The Inventory attempts to collect ESTs in one place.
[25] The first search on the database was conducted on 15 November, 2016. The search date is important because of the dynamics of the database. A new search at another time could yield more patents

Nonetheless, using patent as a proxy for innovation presents its downside. First, it is difficult to know the value of each patents. There are patents that has a broader and deeper impact and other patents with almost no technological impact. Counting them without account for their values shows some weaknesses. In addition, the propensity to patents of the different countries matters, there are countries where the inventors are more confident in the patent system while in other they prefer to keep the secret around their invention. This is the reason why in the present work a control variable is included in order to account for this second problem.

Innovation, differently from the majority of the other variables does not present an upward trend with the years. In fact, the waste sectors seem to have reached a degree of technological maturity, and it is now experiencing a decreasing trend of patenting activities as already noted by other studies (Nicolli and Mazzanti, 2011). The index ranges from a minimum of 0 to 5.2 patents per hundred thousands of inhabitants with an average of 0.67. The countries that are characterized by the higher number of patents per capita across the time span analyzed are Austria, and Germany. Instead, the worst performer in this field are the Baltic Republic together with East-European countries such as Bulgaria, Greece and Romania. Also Ireland presents a quite low number of patents during the time span covered by the analysis.

The second factor taken into account is the stringency of regulation, namely the governmental engagement in spurring better environmental performance and in our specific case better waste management practices. In fact, since pollution is a form of economic waste and inefficiency, regulation can represent for firms an opportunity to follow environmental friendly project that otherwise could have been avoided and a signal of the governmental commitments towards the environmental problems. Furthermore, policy can be implemented at country level in order to incentivize the adoption of the most preferred methods of disposal such as recycling and composting and for the promotion of landfill diversion.

Stricter regulation can consist in polluters pay more for several reasons, as an example polluters have to bear expenses for pollution control equipment. Moreover, they have to convert their process in a more environmentally friendly way, in order to avoid penalties for their infringement.

Finding a good measure for regulation has been a very debatable and controversial discussion among researchers. There are several different approaches and each method presents its strengths and its weaknesses. In the present study an external approach to assess regulation has been used and the Environmental Policy Stringency Index (EPS) has been considered as a proxy for regulation. The EPS is defined as "a country-specific and internationally-comparable measure of the stringency of environmental policy" (Botta and Kòzluk, 2014). Stringency is defined as the degree to which environmental policies put an explicit or implicit price on pollution or environmentally harmful behaviour. The index ranges from 0 (not stringent) to 6 (highest degree of stringency) and includes 28 OECD and 6 BRIICS countries from 1990 to 2012. This method presents only two problems. First, the fact that is not just related to waste regulation, but it covers all the environmental area. Second, few countries included in our analysis do not have this index computed, so the value of comparable countries, which have been found similar in terms of political, economic and cultural background, have been allocated.

There are several other external approaches investigated in the literature. One of these is the agreement of the countries to the international treaties. However, those agreements are often not abiding for the countries and are not respected in practice. This makes this indicator not very reliable. Other researchers adopted the commitment to the Kyoto Protocol together with other regulations (Kounetas, 2015). Cagatay and Mihci (2006) develop an interesting and promising index that accounts for regulation in different sectors, but this indicator has the problem of referring to a very short timeframe and still is not just related to waste management regulation.

Other studies have adopted internal approach, for example using the "Pollution Abatement Cost" (Jaffe and Palmer, 1997) (Bhatnagar and Cohen, 1997), monitoring the expenses that the companies have to sustain for achieving compliance. The assumption behind the use of this estimation is that, the higher are the outlays incurred by the firm, the more stringent is the country where they are locate. This method has the big weakness of being subjective, in fact those expenditure are self-reported by the firms through survey. There are also other issues linked with this method. First in defining which are the borders of those costs and second because higher cost can be seen as inefficiency at the firm level rather than signal of toughness of regulation.

Regulation varies from 0.52 to 3.27, as obvious within the range of the Environmental Stringency Index (which, as already mentioned, ranges from 0 - not stringent regulation, to 6 - very stringent). The average is 1.78. For this indicator there is a trend of growth, that is to say the country analyzed are implementing regulation which cause an increase in the value of the index across the years. The lower values are taken by the eastern European countries and the highest by the northern European countries, especially Denmark and Sweden.

The third factor is the Structure of the Economy of each country; the economic activities are different in terms of amount and type of waste generated (e.g. hazardous, not hazardous). The balance of those economic activities in each country is with no doubt an important fact to be considered when analyzing the performance of the different countries. One possible approach could have been to analyze the ratio of profit of the manufacturing, construction, mining and quarrying sectors divided by the number of firms, as has been done in the paper of Cecere and Corrocher (2016). In the present paper a similar path has been followed, but in order to more accurately classify the so called "Dirty Sectors", the classification in the paper of Many and Wheeler (2008), which ranks the sectors according to how harmful are for the environment in general[26], has been used. In order to detect them, the two researchers adopt a direct approach, monitoring the emission intensity (emission per unit of output) of the sectors. Using this criterion five sectors emerged[27]:

- Iron and Steel
- Non Ferrous Metals
- Industrial Chemicals
- Pulp and Paper
- Non-Metallic Mineral Products.

After having spotted the five dirty sectors for each of the European Countries, the cumulated share in terms of Value Added of those "Dirty Sectors" over all the sectors is computed, in order to obtain an accurate measure of the impact of the aforementioned sectors in the economy of the analyzed countries.

This factors varies from approximately 2% to 10%. As already mentioned, structure of the economy is the percentage of value added provided by the so-called dirty sectors. Therefore, a low value is desirable for the countries. If the low value of countries like Denmark and France is somehow expected, it is surprising to spot the low value of bad waste management performers such as Latvia and Lithuania. Instead, countries such as Czech Republic, Slovakia and Slovenia show a predominant impact of those "dirty industries", scoring very high in this indicator.

[26] The researchers identify those sectors through two different paths. They first search the sectors which have presented high levels of abatement expenditure per unit of output in the US and other OECD economies. Second they identify the sectors which rank first on emission intensity (emission per unit of output). In order to use the second method they have analyzed the detailed emission intensity by medium for US manufacturing at the 3-digit Standard Industrial Classification (SIC) computed by the World Bank together with the US Environmental Protection Agency and the US Census Bureau. Using both the method the same five sectors emerged.

[27] The absence of petroleum sector could surprise, but this has been motivated in the paper of Many and Wheeler (2008) by the fact that just few countries are actually involve in the production of petroleum

The fourth factor is the level of education. The assumption is that a higher level of education is linked to a deeper awareness of the environmental problems and a stronger involvement of people into the waste management programme driven by the government. Several possible alternatives of indicators for education have been considered, all of which emerged to be broad and not only related to the education and awareness of the problem related to the environment. In the present model, education has been estimated as the share of students in tertiary education as a percentage of the population aged 20-24 years.

The reliability of this indicator has been questioned because it shows an unexpected really high variance, ranging from 18% to 95% with an average of 55%. Romania, Czech Republic and Slovakia show really low values. On the other hand, surprisingly together with Sweden, Greece and Slovenia show extremely high values, which cast further doubts on the reliability of this indicator.

In the analysis, other variables have been tried as control variables. In the end, the only kept control variable is the percentage of R&D over GDP with the aim of controlling the propensity to patents of the countries, since it can create bias in a regression model (Johnston, et.al 2010). Moreover, with this control variable, also the richness of the countries has been indirectly checked; indeed countries that invest more in R&D are on average also richer.

Having specified all the variables included in our models and the summary statistic, here below there is the table of the correlation:

Table 5.4: Correlation matrix

		1	2	3	4	5	6	7
Waste performance 1	*1*	1,000						
Waste performance 2	*2*	0,878	1,000					
Innovation	*3*	0,652	0,639	1,000				
Regulation	*4*	0,480	0,496	0,254	1,000			
Structure of the economy	*5*	0,098	0,060	0,268	-0,004	1,000		
Education	*6*	0,112	0,182	-0,007	0,335	-0,394	1,000	
Propensity to Patent	*7*	0,706	0,851	0,532	0,422	0,044	0,243	1,000

This is the table encompassing the variables included in the model, after that some variables have been omitted due to collinearity problem[28]. The two measure of performance as obvious are highly correlated[29] . The four factors do not present particularly high correlation among each other. There is a correlation of 0.563 between the factor Innovation and the control variable Propensity to Patent, this is expected since the control variable has been included in the analysis to take into account that the number of patent in waste management is influenced by the propensity to patents of the different countries.

5.2 Empirical Findings

In the present section, the empirical findings are presented for the two analysis. First of all, is provided the descriptive statistic for the relevant variables, then the output of the statistical analysis has been commented.

Before starting with the analysis, Hausman Test has been performed, in order to appropriately choose between random and fixed model. With the Hausman Test, in both cases the p values are not significant. In the first

[28] The issue of collinearity will be analyzed in the next section, together with the results of the analysis
[29] This because the second measure of performance is equal to the first plus the percentage of waste incinerated with energy recovery

case the value is 0.0391, while in the second is even less, 0.001. In light of these results, the Fixed Model has been suggested in both cases.

The basic function of both models is the following:

$Y_{it} = X_n\beta_n + \alpha_i + U_{it}$

Where *i* denotes the individual countries, *t* denotes the year, β_n are the coefficients estimated for every single explanatory variable X_n, α is the intercept and *u* is the error terms. *Y* are the independent variables, which vary between the two models.

The models aim to test the relation between the aforementioned factors and the two measures of performance. All the factors were expected to have a positive relationship with the dependent variables with the exception of Structure of the Economy, here the expectation was the opposite, the intuition is that a decrease in the percentage of the impact of the "dirty sectors" should coincide with an increase in waste management performance.

The two models are tested separately. Both models initially present issues of collinearity[30] and heteroskedasticity[31].

In order to account for the first issue, the number of independent variable has been reduced, in particular diminishing the number of control variables. The control variables GDP per Capita and the variable Population have been omitted. Omitting the variable GDP per Capita does not reduce the power of the model, because the other control variable R&D as a percentage of income is highly correlated with income and indirectly control for the richness. Furthermore, Dasguspta, Mody, Roy an Wheeler (1995) detect a striking correlation between national income and the strictness of environmental regulation, one of the main covariate in

[30] This has been found analyzing the variance inflation factors and the table of the correlation of the coefficients of the regression.
[31] Heteroskedasticy has been spotted performing the Breush Pagan test on the dataset. The resulting p-value was 0.00, rejecting the hypothesis of the absence of heteroskedasticity

the analysis, strengthening the collinearity and the need to omit the income variable from the model.

In addition, the variable Population has not been considered in the model because of the same problem. The omission of this variable does not reduce the power of the model since all the variables are percentage, index or variable already computed per capita, so controlling for population is not particularly relevant.

In its definitive shape, the model still presents some minor issues of collinearity for the variable Education and Regulation[32]. However, since the relation of these factors with the dependent variable are at the primary scope of the analysis, it has been decided to keep both the factors in the model.

In order to solve the problem of heteroskedasticity, both models are estimated twice, in the second case using the robust standard error, the use of this methodology should mitigate the heteroskedasticity. With respect to the model with the standard error, some variables reduce their significance. However mainly the statistic with the robust standard error are presented in the model, because, as already mentioned, it fixes for the problem of heteroskedasticity and as a consequence of this is more reliable.

After having corrected both heteroskedasticity and collinearity the results for the two model using robust standard error are the following:

[32] The VIF of the two factors were around eight, suggesting the possibility to omit one of the two. The rather high VIF of those two factors can be explained by the correlation between their coefficients of the regression which is of about 0.5.

Table 5.5: Results of the linear regressions:

VARIABLES	(1) Waste Performance 1	(2) Waste Performance 2
Innovation	0.02092	-0.00872
	(0.0171)	(0.0240)
Regulation	0.0461***	0.0561***
	(0.0107)	(0.0129)
Structure of the Economy	-2.302	-4.059**
	(1.490)	(1.518)
Education	0.0669	0.0351
	(0.0662)	(0.0783)
Propensity to Patent	4.859	8.616
	(4.663)	(5.907)
Constant	0.129	0.301**
	(0.109)	(0.124)
Observations	253	253
R-squared	0.431	0.455
Number of Country1	23	23

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

The first model analysed is the one which has the variable Waste Performance 1[33] as independent variable.

The model has an r square value of 0.43, showing a good explanatory power. Below the table that summarizes the main findings of this model.

[33] The measure that takes into account only recycling and composting

Table 5.6: Expectation and results of the factors in relation to the first indicator of performance

Dependent Variable: Waste Performance 1	Expected Relation	Results	Significance with Robust Standard Error	Significance with Standard Error
Innovation	+	+	No (0.235)	Yes (0.05)
Regulation	+	+	Yes (0.00)	Yes (0.00)
Structure of the Economy	-	-	No (0.137)	Yes (0.001)
Education	+	+	No (0.323)	No (0.086)

In the table, there are two columns which compare the p-value in the case of standard error and robust standard error. As expected, there are no variation in the sign of the various coefficients. What changes is the significance of the p-values. In fact, only regulation does not vary in significance, even using the robust standard error the relation remains highly significant. In the present paper mainly the results with the robust standard error have been scrutinized.

As expected, the relation with innovation and our dependent variable is positive, an increase of one unity in the number of patents per thousand hundred inhabitants corresponds to an increase of 2% in the percentage of refuses recycled or composted. The p-value is high, so the findings are not reliable, even if using the standard error the p-value is significant. Also for regulation, as expected, the relation is positive. A growth in the Environmental Stringency Index causes an increase in the waste performance. The significance of this relation is very high. The variable Structure of the Economy has a negative relation with the independent variable. This is in line with what was expected since a decrease in the percentage of the "dirty sectors" is related to an improvement in waste management process, but similarly to innovation, this variable is significant only in the case of standard error. Finally, the last variable

Education presents a positive relation with waste performance, but the p-value is rather high showing an unreliability of this indication.

What turns out from this model is that regulation is the factor that has a deeper impact on waste management performance - without any doubt. Innovation and Structure of the Economy provide countervailing results, the relation is of the same sign of what was expected but when the robust standard error is adopted to mitigate the problem of heteroskedasticity, the two variables lose their significance. Education is always not significant.

As already said, the second model changes only in the choice of the dependent variable, namely in the measure of waste performance utilize. The dependent variable in this case includes also the percentage of incineration with energy recovery. What emerges is that this variation of the model presents results very similar to the previous one. The r square is 0.45, slightly higher than before. Again, the table resuming the expected relation and the result with the standard error and the robust standard error is provided:

Table 5.7: Expectation and results of the factors in relation to the second indicator of performance

Dependent Variable: Waste Performance 2	Expected Relation	Results	Significance with Robust Standard Error	Significance with Standard Error
Innovation	+	-	No (0.720)	No (0.529)
Regulation	+	+	Yes (0.000)	Yes (0.000)
Structure of the economy	-	-	Yes (0.014)	Yes (0.000)
Education	+	+	No (0.659)	No (0.478)

Still, the attention will be focused on the model using the robust standard error, because it is considered as the most reliable model.

The factor Innovation presents opposite sign with respect to the previous one, and opposite sign to what was expected. However, again the variable is not significant presenting a very high p-value (0.720). Moreover, differently from the previous model, innovation is not even significant if we consider only the standard error and not the robust one. The variable Regulation is in line with what was expected and to what has been found in the previous model. Again the p-value is very low (0.000) allowing to reject the null hypothesis. The variable Structure of the Economy is in line with the expectations and with the previous model. However, in this case the variable is always highly significant. Education presents again a very high p-value, therefore its positive sign cannot be considered.

Summing up, even if the two models are apparently similar, the change of the measure of performance coincides with the change of some of the findings of the model.

The change of the sign of Innovation between the two model is not relevant, since in both model Innovation is not significant[34]. The major change is in the variable Structure of the Economy. Using the second waste management performance, a strong and significant negative relation has been found differently from the other model, where this variable was not significant[35]. In other words, including incineration with energy recovery in the performance variable, a reduction in the percentage of the so-called dirty sectors in the economy of a country causes a positive variation of the percentage of refuses that are recycled, composted or incinerated. A possible explanation is that when the impact of those dirty industries is high, there is a large production of refuses which are very hard to dispose, difficult and not cost-effective to manage, especially with the standard incineration process because they are hazardous.

[34] Even if in the first model using only the standard error and not the robust one the relation is positive and significant

[35] To be more precise, it was not significant using the robust standard error

Regulation is positive and highly significant in both models, underlining the crucial role of this factor in fostering the adoption of better waste management practice. A good system of national laws, together with the directives that comes from the European Union, should be the starting point for every country which wants to improve its waste management process.

Education is the unique variable which is never significant in both models. This can be related to two aspects, the inadequacy of the variable used as a proxy for education or the minimal importance that the education variable has on the waste management performance of the countries.

6.The Danish Case

In the present chapter the case of Denmark will be analyzed, one of the best performer in terms of waste management. In the first section a general overview of the country and of the environmental policies will be provided, in the second one the Danish waste management system is analyzed, the third one will analyze in which part of the Kuznets Curve Denmark can be located, the fourth focuses on how Denmark performs taking into account both the measures of performance and the drivers previously analyzed and finally the fifth section covers the ambitions and the target which the country has posed for its future.

6.1 Denmark and the Environment

Until the 1980s, Denmark has not been particularly concerned about environmental matters.

It is in 1983 that the Danish Federation of Industri, Dansk Industri, has stated "Industry has reached the regulatory limit, and could take no more" (Dansk Industri, 1983). This has been corroborated ten years later by the same federation with the following statement: "Industry’s stance has since changed to a more proactive approach that acknowledges that international competitive advantage can be achieved through stringent regulations" (Dansk Industri, 1993).

Danish regulation has focused primarily on direct regulation, rather than on market based instruments (Miljøministeriet, 1988). All the environmental related policies have been influenced by the publication of the government's Action Plan for the Environment and Development "Our Common Future 1988", which proposed the change to a strategic environmental policy approach. As a consequence of this, numerous policies has been modified, culminating in 1991 in the revision of the original 1974 Environmental Protection Act. In 1994, it has been modified again, to form the Consolidated Environmental Protection Act 1994 (CEPA). This remains one of the cornerstone of all the policies, posing pollution prevention as one of the main priority by means of permitting and licensing procedures.

Denmark is a unitary state where the central government retains the control of the situation and exerts a relevant influence, thanks to the rather small size of the country in comparison to numerous other European Countries. Nonetheless, the practical implementation of environmental policy is characterized by a decentralization of responsibility and authority from the Minister of Environmental Protection (EPA) to regional and municipal levels of government. In fact, municipalities account for about 65% of public expenditure on environmental matters. "Municipalities have a lot of discretionary power, which results in municipal enforcement by consultants/service partners or by policemen" (Georg, 1995). As a consequence of this, enforcement of regulations is carried out, mainly, at the level of the single municipality. "This process is characterized by a low level of conflict and low involvement of the judiciary system" (Ministry of the Environment, 1985).

Denmark is characterized by a tradition of negotiations related to environmental matters. All the costs required to comply with the environmental regulations are borne by the firms. As a unique case in the EU, in Denmark there are provisions which empower the Minister to make binding agreements with firms and trade association with the aim of reducing pollution and preventing the generation of an excessive amount of waste. However, those agreements have to be negotiated with national trade, environmental organization and local and state authorities [36].

[36] Only in exceptional circumstances has the Minister for the Environment insisted on unilaterally imposing his will.

Several of these agreements have achieved important environmental results.

6.2 Denmark and Waste Management

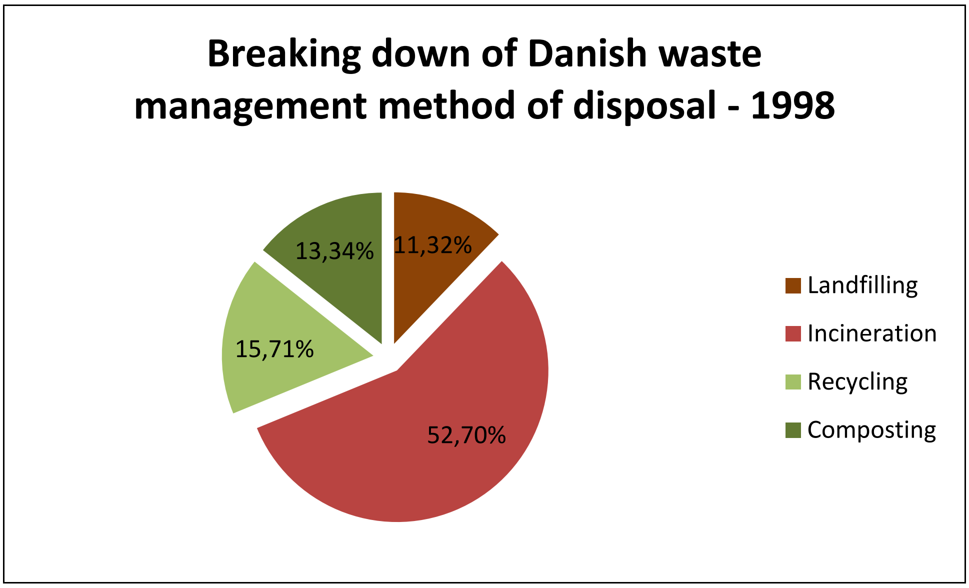
Denmark has made remarkable progress in environmentally responsible waste management in the last years. If at the beginning it was focused only on the protection of human health, now the attention has shifted to the recovery of the resources which are hidden in waste.

Nowadays Danish waste policy comprises both prevention and handling of waste. The authority in this field is the Danish Environmental Protection Agency. In Denmark, differently from many other countries, household, industrial and commercial wastes are treated in a unique waste management system.

In 1970s landfilling without any kind of environmental protection was still the most common way of handling waste. As a consequence of this, in 1980 the landfilling capacity of the Copenhagen area was exhausted. It is only in 1985, after the first mapping of waste disposal, that Denmark has begun to modify its regulations with a wave of reforms, covering both waste management and waste prevention. In line with this, Denmark has also enforced several environmental agreements, adopted technology promoting laws and given monetary incentive in order to reduce the emissions. The first waste plan at national level was developed in 1992. It included targets for all kind of waste in terms of landfilling, incinerating and recycling. It covered the period 1993-1997. From then several other similar waste plans have been implemented.

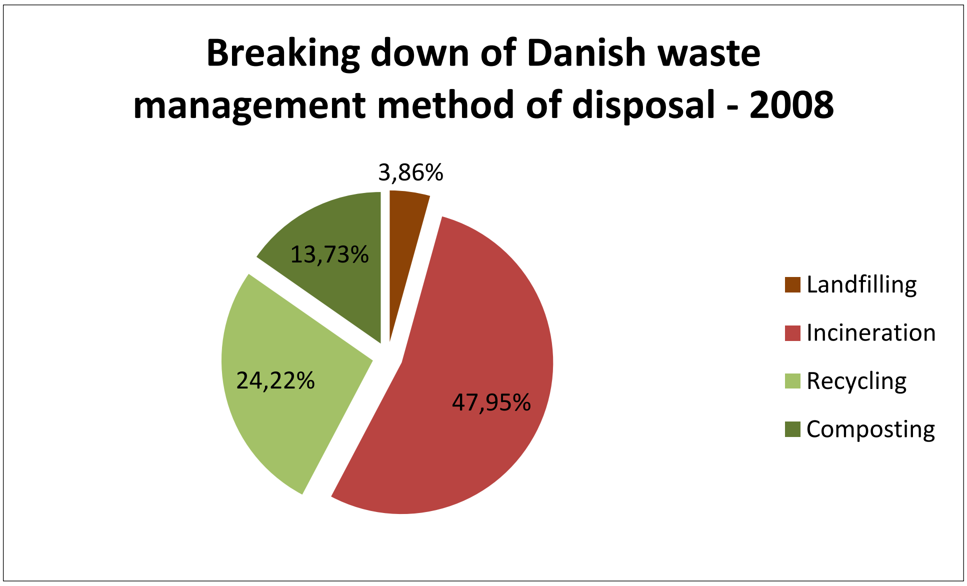
All these provisions led to successful outcome, especially in phasing out landfilling. Nowadays some landfill sites receive so little amount of waste that is being questioned their economically viability (Fischer, Kjaer and Mc Kinnon 2012) .

Exhibit 6.1: Overview of Danish Waste Management[37] – 1998



Elaboration of the author on Eurostat Data

Exhibit 6.2: Overview of Danish Waste Management – 2008



Elaboration of the author on Eurostat data

The above graphs compare the results obtained by Danish Government throughout the period covered in the analysis. The reduction of landfilling

[37] The sum of the percentage is not 100% because the single percentage are computed over the total amount of waste produced, not all the waste produced is treated.

in favor of recycling is very clear. What proportionally has not diminished very much is incineration, which retain a very high percentage. It is right the shift from the incineration towards recycling one of the goals of the Danish Government is focusing. This topic will be covered extensively in the last section of this chapter, where the future ambitions of Danish government are discussed.

6.2.1 Waste return system

One of the pillars of waste treatment in Denmark consists in the separation of waste at source. This method is well-accepted by the Danish citizens. One of the most typical and effective example is the system of recovery of empty bottles that has been put in place. The deposit and return system for beer and soft drinks has indeed allowed preventing management of around 390,000 tons of waste every year, corresponding to around 20% of the total amount of domestic waste from households. (Ministry of Environment, 2009). For several years, Denmark has had a system of return, but initially it was only related to refillable bottles. Many shops and supermarket had a machine where the empty container could be given back. At that time, the use of non-refillable bottles was limited and the use of aluminum trays forbidden. Eventually due to the EU legislation Denmark was forced to modify the laws, therefore a similar system for the non- refillable bottles was put in place.
Dansk Retursystem A/S, a Danish no profit organization, was established by the Ministry of the Environment with the aim of implementing, administering and operating the deposit/refund system in Denmark.

When a producer or importer sells a beverage to a retailer in Denmark, he charges together with the price of the beverages the deposit related to the beverage containers. All the deposits are given to the Dansk Return System A/S. The empty containers are usually brought back to the "Reverse Vending Machine" or manually, where the final customer, which have paid temporarily the charge to the shops or supermarket, gets a refund. Eventually those empty containers are transported to the centre where they are counted and registered. As a result of this process, the no profit organization pays the refund back to the shops and supermarket.

If the final customer does not bring the bottles back to the point of collections, the association keeps the money to improve the quality of this program or to fund other similar environmental initiatives. All the producers and importers of beverage containers are obliged to sign up with Dansk Retursystem A/S otherwise they are not allowed to distribute and sell their products in Denmark.

Dansk Retursystem A/S is financed through three ways:

- Signing-up fees
- Logistic fees
- Collection fees

In addition to these fees, producers and importers pay a so-called “packaging fee”, which is a sort of environmental tax. This tax has to be paid for each beverage container marketed[38].

Crucial in the Danish deposit and return system is the ABC deposit system, because different amounts are refunded for “Pant A”, “Pant B” and “Pant C”. The amount refunded depends on three characteristics of the empty container:

- Material used
- Volume of the bottle
- Whether the bottle or can will be recycled or reused

[38] All the above fees, with the exception of the packaging fee are regulated by Dansk Retursystem A/S yearly after the approvali by the Danish Environmental Protection Agency

For more details of the amount refunded for each type of packaging, see the Appendix 2.

6.2.2 Waste tax

Central in Danish waste system is also the general tax on waste. The Danish waste tax is a special tax that is levied on the majority of the household and industrial waste delivered to the country's landfills and incinerators. It was enacted by the Danish parliament in February 1986 and became effective on the first of January 1987 .This tax, which is an important part of the country's "Action Plan for Waste and Recycling", aims to reduce the amount of waste deliver to landfills and incinerator plants.

Throughout the years, the tax has been increased numerous times, the tax base has been enlarged and refined in some aspects. Initially, all taxable wastes delivered to municipal waste facilities were taxed at a uniform rate of 40 kroner (approximately 5.40 Euro) per ton (Andersen, 1998). In 1992 there was a crucial development in the composition of the tax, indeed, the tax on incinerated and landfilled waste became different. Furthermore in 1997, another distinction was made between waste incinerated with and without energy recovery (with both heat and electricity recovery). Moreover recycling remains exempt from taxes.

The results of the Danish waste tax has been encouraging, as the quantity of waste being brought to landfills and incinerators has fallen of around 26 percent and recycling has been fostered (Andersen, 1998). In the year 2010 the tax on waste landfilled amount to 475 DKK (Euro 63,3)[39]. Furthermore, there are particular taxes for plastic bags, disposable tableware and nickel cadmium batteries.

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[39]The tax is levied on waste delivered to registered plants and a refund is granted for waste that is subsequently removed. In this way, tax is paid only over the net amount (ETP/SCP, 2012).

6.3 Denmark on the Waste Kuznets Curve

Denmark is one of the countries in Europe producing more waste per inhabitant. In 2011, only Danish households produced 447 kg of waste per person. This corresponds to every Danish people throwing away more than 8 kg of waste every week. (The Danish Government, 2013). The high quantity of waste produced by the country, which in the year covered in our analysis is well above the average, has put under pressure the countries and has pushed the countries to develop a proper and efficient system of waste management. Denmark has shown an increase of waste generation together with its richness, without showing any sign of inversion of the tendency. As a result of this, the country is in line with the findings of the analysis of the possible existence of WKC using waste production as dependent variable performed in the previous chapter. In fact, it does not appear any sign of delinking between income and waste production.

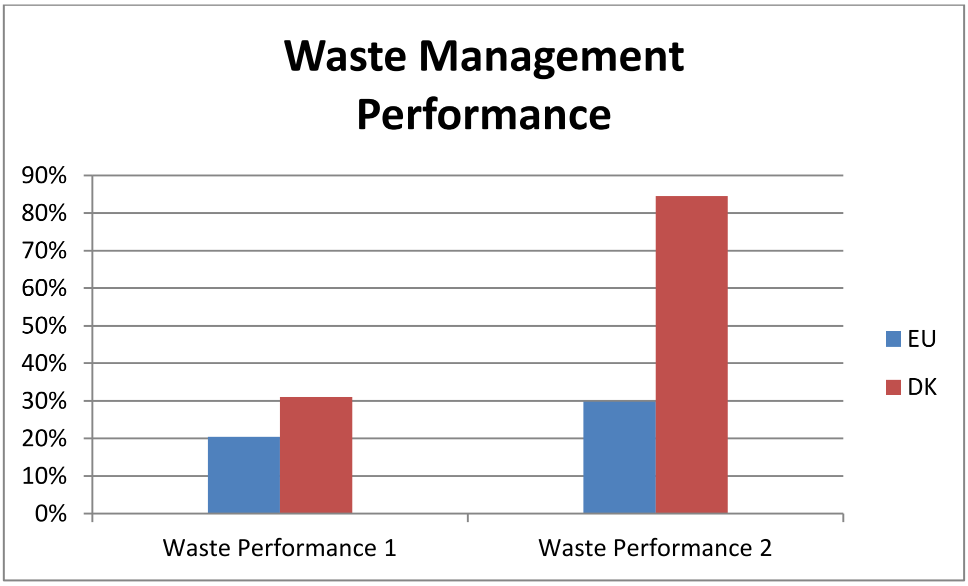
Considering instead the other model, with the amount of waste landfilled as dependent variable (in which instead some evidence of the existence of a WKC were discovered in the previous analysis), Denmark is still an interesting case. In fact, it is one of the country with the highest income (it has an average GDP per capita in the year analyzed that is twice the average of the European Countries) and the lowest amount of waste landfilled across European Countries (obtained mainly thanks to the massive use of incinerator, which in Denmark has been extensively used to divert waste away from landfills). During its process of growth the country has increased its amount of waste landfilled until 1985, when as a consequence of the problems related to the excess of landfill sites, has started to invert the trend. In light of this, Denmark seems to have followed the whole trajectory hypothesize by the WKC and having reached the right end part of the curve.

6.4 Denmark in the Analysis of the Success Factors

The present section aims to present the results of Denmark in the analysis of the drivers analyzing both the indicators of performance taken into account and the enabling factors.

The graph below compares the waste management performance of Denmark with the performance of the other European Countries. For both a mean of the performance in the years analyzed is computed:

Exhibit 6.3: Comparison of Waste Management performance between Europe and Denmark

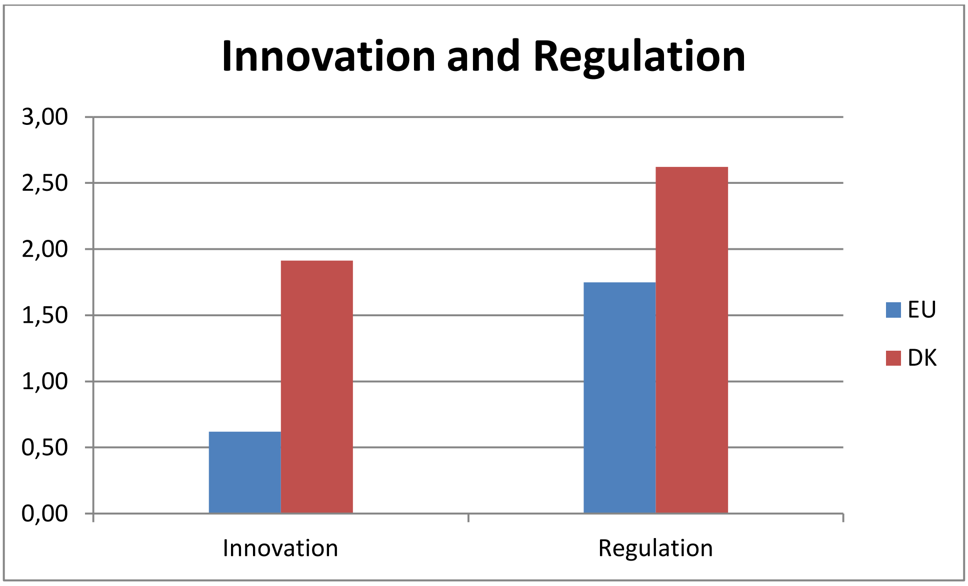


Elaboration of the author on Eurostat data

In both indicators, Denmark is above the EU average, but in the second one the difference is striking. The mean of Denmark in the first indicator of performance is 31.6%, above the average of the European Countries covered in the analysis. However, other virtuous EU countries rank even higher on this indicator. As it is clear to see from the extremely high percentage shown instead on the second indicator, Denmark does not score extremely high on the first indicator not because it still relies on really obsolete techniques of disposal like landfilling, but due to the very high percentage of incineration with energy recovery. In fact, it has the highest percentage in the European countries. As a consequence of this, in the second indicator, Denmark has a value that ranges from 81.8% to 87.2% that puts the country on the top position among the European countries. This is related to the near total absence of landfill sites in the country. In fact, Denmark has chosen a different path from other European countries: mainly exploiting the energy that arises from waste through incineration (Ministry of the Environment, 1999). One of the regulation that went in this direction was the ban of landfilling on those materials which can be incinerated. Both the measures of performance indicate a trend of improvement in Danish performance, this is mainly driven by the increase in recycling. Furthermore, Denmark has achieved the target posed by the EU Landfill Directive of reducing the amount biodegradable municipal waste landfilled.

It is now interesting to analyze how Denmark scores on the factors, in order to verify in practice, the relation previously discovered. The values of Denmark are again compared to the EU average, as it is shown in the next graphs:

Exhibit 6.4: Comparison of the first two factors between Europe and Denmark



Elaboration of the author on Eurostat data

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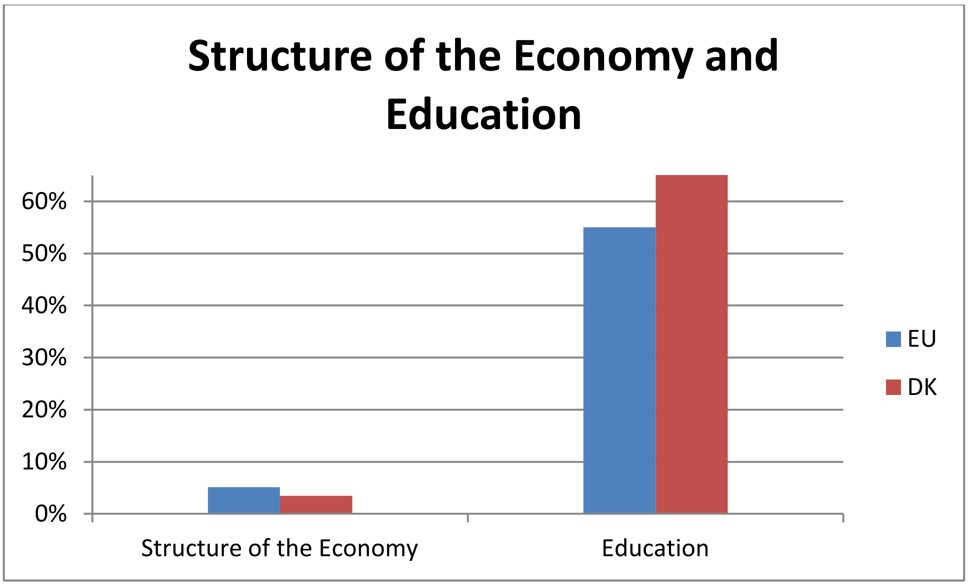
The average value of the Environmental Stringency Index is 2.65, which is not far from the maximum value registered in the European countries in the set of year under study and is above the average. This is in line with the previous findings, a high value in the factor Regulation coincide with a high values in the two measures of performance analyzed (in this case especially in the second). This rather high value reflects also the regulatory and legislative efforts that Denmark is carrying out in these years, which are extensively covered in the previous section.

The second factor Innovation presents values that are above the mean but less than the best performers in this field. However, in both the analysis Innovation has been found as being not significant [40]. The Danish Government has tried to foster innovation through several measures: for instance the introduction of state subsidy schemes for projects on clean technology that target on the reduction of the impact from products, considering its whole life cycles. In addition, subsidies have been granted to project which aim to develop novel method of waste treatment.

Exhibit 6.5: Comparison of the second two factors between Europe and Denmark



Elaboration of the author on Eurostat data

[40] With the exception of the first measure of performance using the standard error

The third factor Structure of the Economy has been, in the previous analysis, founded to be negatively related and highly significant only with the second measure of waste performance analyzed[41], the measure in which the Danish performance is very high. In light of this, it is not surprising that Denmark has value below the average for the variable Structure of the Economy in all the years analyzed. Of the sectors already enlisted as "Dirty Sectors", the unique that has a relevant size are the manufacture of chemical and chemical products and the manufacture of non-metallic mineral products, but still in comparison to the whole Danish economy they represent just a very little fraction.

In the fourth factor Education, Denmark is slightly above the average, but this factor has shown to be not significant in both analysis, so it does not deserve a particular attention.

6.5 Denmark Future Goals and Ambitions

Denmark has almost completely phased out landfilling from its process of disposal, so in this sense there is not room for possible further improvements. What Denmark can and should improve is what we have previously called in our analysis the indicator of Waste Performance 1. In fact, the percentage of waste recycled has to grow at the expenses of the percentage of waste incinerated. The Danish government has understood this and its Ministry of the Environment has stated that "recycling is the highest ranking waste treatment form – it ensures better exploitation of resources in waste" (Ministry of the environment, 1999). Even if incineration has been exploited in order to produce green energy, there has been a loss of resources which could have been reused. An increase in recycling will imply a high quantity of materials that will be reintroduced in the economic cycle with sizeable benefits for the environment. The

[41] With the first measure indeed, using the robust standard error lost its significance

changing approach toward waste of the Danish Government is summarized in the presentation "Denmark without waste".

The goals that Denmark has posed are ambitious: in 2022 it aims to recycle 50% of the household waste. As typical of the Danish Economy the Government's new waste policies will be supported by an interplay of different actors, but with the crucial role that will be played by the municipalities. Together with the growth of quantity of material recycled, Denmark has posed also the target of improving the quality of the recycling process, recovering more and purer materials from the products than what is actually done.

At the same time, Denmark is focusing the effort on waste prevention. The definition of waste prevention is broader than the simple reduction of waste generated, but it includes all the economic activities that occur before a product become waste. It starts with the conception of the product, which can have characteristic that will make it easier to dispose at the end of its utilization. The enterprises can also enhance the durability of the product or make it possible to use some components of it at the end of its life cycle. These initiatives are conceived to meet two goals, generate less waste and make the waste generated easier to dispose.

Furthermore, the Danish Government is pushing firms to think differently about their products, taking into account the final disposal already in the process of production of the final product. Products can be designed from the beginning with the aim of reducing the resources and the hazardous substances employed in the manufacturing process. They can be made modular, in order to easily divide the different parts at the end of the utilization. In this sense, Denmark is making the first step in the direction of circular economy. This is fostered primarily by the Danish Ministry of Environment and known with the expression "from cradle to grave".

In the government view, business can also enhance their competitiveness by utilizing resources more efficiently and effectively and by designing their products so that products and materials can re-enter the production chain (Ministry of the economi, 2015).

As a result of its effort, Denmark is starting to change the conception of its entire economy. In fact, traditionally, goods have been produced and consumed following the standard linear model that begins with the extraction of resources and ends with the production of waste. This is changing. In a circular economy[42], resources that would traditionally be used only once and then discarded, re-enter the production chain and thus restart the cycle. Everything starts from the design of the product, in fact, it is in the first phase that the environmental impact of the product is generated.

Furthermore, the government aims to support citizens in indicating the products and services which are less resource intensive, that contain fewer hazardous material and that generate less refuses. This will be done through several initiatives which comprise among the others: information campaigns, increased use of eco-labels, and guidance about green public procurement.

Another path that the country is following is to prioritize the access over the ownership of the products, moving towards a service economy. The aim is still to reduce the amount of waste increasing the utilization of the products through, for instance, initiatives of sharing economy.

Overall, the initiatives of the government will be focused on five key areas of intervention:

- Food Waste
- Construction sector
- Textile sector

[42] A circular economy is defined as ”an industrial system that is restorative or regenerative by intention and design. (Ellen MacArthur Foundation, 2004)

- Electrical and electronic equipment
- Packaging

“Denmark without Waste II” has recently been published as a continuation of “Denmark without Waste”. Together, these two strategies aim to contribute to decouple the link between economic growth and environmental impact caused by waste. These Waste Prevention Strategies meets the requirement of the EU Waste Framework Directive for national waste prevention programs. This Strategy applies for a 12-year period (2015-2027) and will be revised every six years, together with an evaluation of the outcome reached (Ministry of the Envronment, 2015),

7. Conclusion

This last chapter provides some conclusive remarks regarding this work. Furthermore, the chapter is thought to recollect the limitations of this analysis and to provide food for thought for further researches.

In the present work two different empirical analysis providing some interesting insights have been performed. The first analysis has been performed with the aim of spotting the possible presence of the Waste Kuznets Curve in the European scenario. The results are different according to the proxy of environmental degradation employed in the model. Choosing waste landfilled as proxy for environmental degradation, evidence has been provided that supports the existence of the WKC across European Countries, highlighting the existence of a turning point for the landflling of waste, obtained mainly thanks to the growing attention devoted in the last decades towards recycling and waste sorting policies. As a matter of fact, the data show that after a certain threshold delinking is observed, with the amount of waste landfilled diminishing in relation to the increase of income.

If, on the contrary waste generated is used as indicator, no delinking between economic growth and our proxy of environmental degradation is observed. In fact, in the analysis a positive linear relation emerges rejecting the hypothesis of the existence of WKC. Some additional factors, such as density of population and household size appear to play a role.

The second analysis aims to understand on which levers the countries have to focus their efforts in order to improve their waste management process. In this way the study wants to give to the countries, especially the laggard in terms of sustainability, a comprehension of which are the factors to be improved, in order to catch up with the most sustainable countries. In order to do so, the strength of the relation between four drivers and the waste management performance of the countries has been analyzed. Two different estimations of waste performance of a country has been employed, one covering the percentage of waste recycled and composted, the second that adds to the latter indicator also the percentage of incineration with energy recovery.

First, from the analysis emerge the importance of regulation, in fact whichever indicator is considered the relation is strong. Regulation such as landfill bans for particular material can oblige the utilization of the best method for treating the refuses. Furthermore the imposition of taxes on waste disposed, regulating the amount of the tax according to the method of disposal used, for instance making recycling tax free and landfilling very costly, as it is also in the Danish case, can spur the enterprises and the households to change their attitude towards refuses. Waste from businesses and households contains materials and parts which could be crucial to recycle. For instance, paper and cardboard can become brand-new products; aluminum trays can be melted down and recycled for other purpose, and organic waste can be used as fertilizer.

Furthermore, comparing with the previous analysis, another very interesting finding emerges, regulation has not shown any impact over waste prevention and in fact, in the first analysis the coefficient of regulation was not significant. This means that the countries have been able to improve the method of waste through the above mentioned regulation but they were not able to reduce the quantity of waste produced at source; in other words, addressing the thematic of waste prevention with regulation has been proven hard.

Therefore, the impact of regulation can keep on increasing through many ways. First tackling waste prevention more seriously with programs that address all the different producers of waste indifferently, from household to large enterprises. Secondly, imposing to the business to design products that last longer and already thinking about the environmental impact of the final disposal. Third pushing all the states to promptly implement the EU directive, avoiding unbalance of regulation through the EU member states. All the above mentioned should be done through the cooperation of EU with the member states, following the virtuous example of the partnership that occur between Danish government and the different municipalities.

The other factor discovered to have an impact on waste managing performance is the "Structure of the Economy". It is interesting that this factor is relevant only if we consider the second indicator of waste performance, the one that includes incineration with energy recovery. The explanation lies in the fact that an increase of hazardous waste has mainly an impact on incineration; in fact it increases remarkably the amount of waste that cannot be burnt without severely affecting the environment (think of the waste resulting from chemical process). As a result, the member states have two possible solutions. First to reduce the impact of those bad sectors, even if it is not often possible, since they are pivotal for the economy of the member states. Second and more feasible to invest heavily on innovation in order to make the disposal process of the refuses produced by these "bad sectors" less harmful for the environment.

The other factors have been founded to be not relevant, the low impact of innovation could surprise and it could be interesting to analyze the impact of innovation on the quality of the recovery process instead of on the quantity of waste recycled. One way of doing this could be to investigate the amount of material on average recovered from a product recycled.

Our analysis presents some limitations. As already said, the use of Europe as a background is interesting for some aspect, even if it reduces the applicability of the findings. In fact, Europe is a rather homogeneous set of countries, a broader analysis can provide different results. Still enlarging the area of the study can provide problems of availability and uniformity of data collected. This problem has been overcome for the European case through the use of Eurostat database for several variables.

For reasons of quality and reliability, the data used in the analysis span from 1998 to 2008, period after the enforcement of the EU of the Landfill Directive and before the Waste Framework Directive. Analysis collected on more recent data could provide other interesting insights and better understand the impact on EU Countries of the last directives. It could be also interesting to use a delayed variable for waste performance, assuming that the impact of the factors are delayed in time (for instance in the case of Innovation, for a patents to be exploited could passed some years), in order to strengthen the findings of the paper.

Another possible avenue of analysis, once the existence of the curve is ascertain, is to investigate at which point the environment starts to improve in relation to the increase of income. In other words, at which level of GDP is collocated the turning point.

Denmark has proved to be a perfect example of what has been found in our analysis. The mix of the European Directive and the national legislation has allowed the country to achieve one of the lowest landfilling rate not only among the European Countries but in the entire world. Initiative such as the "Landfill ban" has been proved crucial for the development of the Danish system of waste management.

Nowadays however the reduction of landfill sites is not anymore enough. Making progress just related to the last part of the life cycle of the product, that is to say when it becomes waste, is not sufficient. Denmark has recognized this, its last policies has decided to place top priority on waste prevention, being the reduction of waste produced at source the best possible outcome for the environment.

This should be done stimulating more efforts by firms, which because of the regulatory pressures, could change products features, reducing its environmental impact (Glachant, 2004). In addition, the household has to be influenced in order to change consumption habits, being for instance more careful about waste generation.

Together with waste prevention targets, innovative benchmarking (for example stating that waste cannot growth more than a share of GDP each year) could concur to shape waste policies in the short-term future.

In the last years, Denmark has started to embark on the long and ambitious path towards the implementation of circular economy. This new paradigm can have a profound impact on the countries, generating numerous benefits, also not strictly environmentally related contributing positively to the whole economy. Indeed, it can foster global competitiveness, promote sustainable economic growth and generate new jobs.

All the governments should push in order to provoke a change in the mindset of the citizens and of the whole society, stop considering waste just as something to throw away but thinking of waste as a valuable resource that can be reused. Not only Denmark, but all the European countries must embrace the new paradigm of circular economy, because in the long run will be the only way of dealing effectively with waste. The resource of the planet are depleting at a quick pace, the time to act is now.

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Appendices

Appendix 1 - List of the the IPC classes related to waste management included in the the Green Inventory[43]:

- Waste Disposal
- Treatment of waste
    - Disinfection or sterilization
    - Treatment of hazardous or toxic waste
    - Treating radioactively contamined material; decontamination arrangements
    - Refuse separation
    - Reclamation of contaminated soil
    - Mechanical treatment of waste paper
- Consuming waste by combustion
- Reuse of waste materials
    - Use of rubber waste in footwear
    - Manufacture of articles form waste metal particles
    - Production of hydraulic cements from waste materials
    - Use of waste materials as filler for mortars, concrete
    - Production of fertilizers from waste or refuse
    - Recovery or working-up of waste materials
- Pollution control
    - Carbon capture and storage
    - Air quality management
    - Control of water pollution
    - Means for preventing radioactive contamination in the event of reactor leakage

[43] All the category are detailed until the second level of classification, for some voices exist also a third level of classification

Appendix 2 - Overview of the refunds for different type of container in Denmark

Bottles and cans with a deposit mark are one-way (disposable) packaging that can be recycled, melted and turned into new bottles and cans. The refunds on one-way packaging are:

- Pant A = DKK 1.00 (glass bottles and aluminium cans less than 1 litre)
- Pant B = DKK 1.50 (plastic bottles less than 1 litre)
- Pant C = DKK 3.00 (all bottles and cans of 1–20 litres)

Bottles without a deposit mark are refillable packaging that can be cleaned and refilled: for example, the green beer bottle. The deposit you pay on refillable packaging at the point of sale is refundable as follows:

- Glass bottles under 0.5 litres = DKK 1.00
- Glass bottles over 0.5 litres = DKK 3.00
- Plastic bottles under 1 litre = DKK 1.50
- Plastic bottles over 1 litre = DKK 3.00