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**L'impatto della severità delle politiche ambientali sull'occupazione nel Settore dei beni e servizi ambientali: Evidenze dall'Europa**

**[En] The Impact of Environmental Policy Stringency on Employment in the Environmental Goods and Services Sector: A European Perspective**

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## Riassunto

Le variazioni nella severità delle politiche ambientali possono influenzare i modelli occupazionali nei diversi settori dell'economia. Questa tesi esamina in che modo tali cambiamenti di politica siano associati agli esiti occupazionali nei paesi europei tra il 2014 e il 2020. L'analisi combina l'indice EPS dell'OCSE con i dati occupazionali settoriali di Eurostat e distingue tra le attività classificate nel Settore dei beni e servizi ambientali (Environmental Goods and Services Sector - EGSS) e quelle al di fuori di esso. Utilizzando un pannello paese-settore-anno e un modello a effetti fissi a due vie, lo studio stima le relazioni contemporanee e ritardate di un anno tra l'EPS e l'occupazione e valuta risposte non lineari tra i quartili della severità delle politiche.

I risultati indicano che politiche ambientali più restrittive sono associate a significative diminuzioni dell'occupazione nei settori non appartenenti all'EGSS. Un aumento di un punto dell'indice EPS corrisponde a una riduzione di circa il 9-10 per cento in tali attività. Al contrario, i settori EGSS reagiscono positivamente: la combinazione dei coefficienti di base e di interazione implica un aumento dell'occupazione di circa il 16-18 per cento per un incremento di un punto dell'EPS. La specificazione non lineare mostra che le associazioni positive più forti si verificano nella metà superiore della distribuzione dell'EPS, dove la severità delle politiche è relativamente elevata.

Sfruttando la variazione dettagliata tra paesi, settori e anni, lo studio fornisce nuove evidenze su come la severità delle politiche sia correlata agli aggiustamenti del mercato del lavoro a livello settoriale. I risultati suggeriscono inoltre diverse direzioni per ulteriori ricerche, tra cui l'utilizzo di periodi temporali più lunghi e di dati a livello micro per esaminare le risposte a livello di impresa e specifiche per competenze.

## Abstract

Changes in environmental policy stringency may influence employment patterns across different sectors of the economy. This thesis examines how such policy changes are associated with employment outcomes in European countries between 2014 and 2020. The analysis combines the OECD EPS index with Eurostat's sector-specific employment data and distinguishes between activities classified in the Environmental Goods and Services Sector (EGSS) and those outside it. Using a country–sector–year panel and a two-way fixed effects framework, the study estimates contemporaneous and one-year lagged relationships between EPS and employment and assesses nonlinear responses across quartiles of policy stringency.

The results indicate that stricter environmental policies are associated with notable employment declines in non-EGSS sectors. A one-point increase in the EPS index corresponds to a reduction of roughly 9 to 10 percent in these activities. In contrast, EGSS sectors respond positively: combining the baseline and interaction coefficients implies an employment increase of about 16 to 18 percent for a one-point rise in EPS. The nonlinear specification shows that the strongest positive associations occur in the upper half of the EPS distribution, where policy stringency is comparatively high.

By drawing on detailed variation across countries, sectors, and years, the study provides new evidence on how policy stringency relates to sectoral labour-market adjustments. The findings also suggest several directions for further research, including the use of longer time periods and micro-level data to examine firm-level and skill-specific responses.

# Contents

Riassunto .....	II
Abstract.....	III
Contents.....	IV
List of Figures .....	VI
List of Tables.....	VI
1 Introduction .....	1
2 Literature Review .....	4
2.1 Environmental Policy Stringency, Firms, and Employment .....	4
2.2 Skill-Biased and Structural Labour Market Effects.....	5
2.3 Green Jobs, EGSS, and Policy Case Studies.....	7
2.4 Summary and Research Gap .....	8
3 Theoretical Framework.....	10
3.1 Labour-Market Implications of Environmental Policy Stringency .....	10
3.2 Mechanisms Through Which EPS Influences Employment.....	10
3.2.1 Compliance Cost and Output Adjustment Channel.....	10
3.2.2 Sectoral Reallocation and Competitiveness Channel .....	12
3.2.3 Innovation, Technology Adoption, and Productivity Channel.....	13
3.2.4 Labour Adjustment Dynamics and Skill-Biased Transition Channel	15
3.3 Implications for the Empirical Strategy .....	17
4 Data and Methodology .....	19
4.1 Data Sources and Variable Construction .....	19
4.2 Descriptive Statistics and Data Patterns .....	24
4.3 Empirical Strategy and Model Specification. ....	32
4.3.1 Modelling Framework .....	32
4.3.2 Baseline Regression Model .....	33
4.3.3 Lagged Regression Model.....	34
4.3.4 Nonlinear (Quartile) Regression Model.....	35
5 Empirical Results and Discussion .....	38

5.1	Baseline Model Results.....	38
5.2	Lagged Model Results.....	40
5.3	Nonlinear (Quartile) Model Results.....	42
6	Conclusion .....	48
	Bibliography.....	51
	Statement of Authorship.....	55

## List of Figures

Figure 1 - Structure of the Environmental Policy Stringency (EPS) Index (OECD, 2022).....	20
Figure 2 - EPS over Time: Mean and Min–Max Rang .....	25
Figure 3 - EGSS Employment by Country (2014 = 100).....	26
Figure 4 - Non-EGSS Employment: Mean and Min–Max Range (2014 = 100) ...	28
Figure 5 - EGSS vs. Non-EGSS Employment Index (2014 = 100), by Country ....	29
Figure 6 - EPS Quartile Distribution by Country and Year (2014–2020).....	46

## List of Tables

Table 1 - Baseline Two-Way Fixed Effects Estimates for Employment .....	38
Table 2 - Lagged Two-Way Fixed Effects Estimates for Employment.....	40
Table 3 - Nonlinear EPS Quartile Effects on Employment.....	44

# 1 Introduction

The world is experiencing rising environmental pressures that affect both human well-being and economic systems, including issues such as climate change and air pollution (OECD, 2022). According to the World Health Organization, almost the entire global population lives in areas where air-quality levels exceed recommended health limits, highlighting the magnitude of current environmental concerns (World Health Organization, 2024). Air pollution is also linked to millions of premature deaths each year, illustrating the significant public-health dimension of environmental degradation (World Health Organization, 2018).

In response to these challenges, many countries have announced more ambitious environmental goals and expanded the range of policy measures aimed at reducing environmental risks (OECD, 2022). The OECD Environmental Policy Stringency (EPS) index shows that environmental regulations in OECD countries have tightened substantially over the past two decades, with the average index more than doubling between 2000 and 2020 (OECD, 2022). This tightening reflects the increasing use of market-based instruments, which raise the opportunity cost of pollution, and command-and-control measures that impose specific environmental standards (Albrizio, Kozluk, & Zipperer, 2017).

At the same time, the structure of employment in Europe has been changing. Employment in the Environmental Goods and Services Sector (EGSS) increased by 68.9% in the European Union between 2010 and 2022, compared to less than 10 percent growth in total EU employment over the same period (European Environment Agency, 2025). This expansion raises important questions about how environmental policy relates to employment patterns, including whether policy stringency is one of the factors linked to the differences between EGSS

activities and those outside this sector. Understanding these relationships is important, since tightening environmental regulation may contribute to shifts in economic activity and labour demand across different parts of the economy.

Despite growing interest in these issues, several aspects remain insufficiently understood. Existing studies often examine broad employment outcomes or focus on individual countries, and there is limited evidence on how employment responses differ between EGSS activities and those outside the sector using harmonised European data. Another gap concerns the form of the relationship between environmental policy stringency and employment. Many studies assume a linear association, while less is known about how employment may respond across different levels of policy intensity.

This thesis addresses these gaps by examining how environmental policy stringency is associated with employment outcomes in EGSS activities compared to activities outside the EGSS in European countries. The analysis covers 16 EU member states over the period 2014 to 2020 and combines the OECD EPS index with employment data from Eurostat. The empirical framework uses a country-sector-year panel estimated with a two-way fixed effects model. Three specifications are considered: a baseline contemporaneous model, a model with a one-year lag in EPS to test for short adjustment delays, and a nonlinear specification that replaces the continuous EPS index with quartiles to assess whether employment responses differ across lower and higher levels of policy stringency.

The main findings can be summarised as follows. Stricter environmental policies are associated with reductions in employment in activities outside the EGSS, while the opposite pattern is observed for EGSS activities. A one-point increase in the EPS index corresponds to a decline of roughly 9 to 10 percent in employment for activities outside the EGSS, but an increase of around 16 to 18

percent in EGSS employment when combining the baseline and interaction terms. The nonlinear model indicates that the largest differences appear in the upper half of the EPS distribution, where policy stringency is comparatively high.

This thesis contributes to the literature in several ways. It provides new evidence on how environmental policy stringency relates to employment in two broad and economically relevant sector groups using harmonised European data. It also introduces a nonlinear perspective by analysing quartiles of policy stringency, showing that the association between EPS and employment varies across different policy levels. In addition, the inclusion of a one-year lag offers insight into short adjustment delays.

The remainder of the thesis is structured as follows. Chapter 2 reviews the related literature on environmental policy, labour-market outcomes, and the role of the EGSS. Chapter 3 presents the theoretical framework and discusses the mechanisms through which environmental policy may influence employment. Chapter 4 describes the data, variable construction, and empirical methodology. Chapter 5 reports and discusses the empirical results. Chapter 6 concludes with a summary of the main findings and suggestions for future research.

## 2 Literature Review

### 2.1 Environmental Policy Stringency, Firms, and Employment

Research on the labour market effects of environmental policies has expanded strongly over the past decade. A central question in this field is whether stricter regulations reduce employment or merely shift jobs across sectors and firms. Most empirical findings suggest that, rather than destroying jobs, environmental policy stringency mainly triggers structural reallocation and productivity adjustments.

Mohammad (2021) estimates a multi-way fixed effects model with firm, country, and year dummies using Worldscope data for 31 countries from 2000 to 2015. The study finds that tighter environmental policies reduce labor demand in high-emission firms while raising it in cleaner ones, yielding modest net effects overall. Market-based instruments show positive employment impacts, whereas command-and-control regulations are associated with job reductions. These findings indicate that environmental policy stringency mainly reallocates jobs toward low-emission activities, consistent with the mechanisms identified in this thesis.

Albrizio, Kozluk, and Zipperer (2017) analyse the relationship between environmental policy stringency and productivity using both industry-level and firm-level data for OECD countries. They find that tightening environmental policies stimulates productivity growth in more technologically advanced and pollution-intensive firms, whereas less efficient firms experience declines. The authors conclude that well-designed environmental regulations can raise average productivity and encourage innovation, rather than simply imposing costs.

Bijnens, Hutchinson, Konings, and Saint Guilhem (2021) explore how rising electricity prices, often driven by environmental policy measures, affect manufacturing employment. Using data on European firms between 2008 and 2017, they find that higher electricity prices reduce employment and investment in electricity-intensive industries, particularly among financially constrained firms. The impact is not uniform across countries or sectors, indicating that differences in industrial structure and financial capacity determine who bears the costs of green policies.

Together, these papers show that environmental policy stringency does not generate uniform employment outcomes. The overall effect depends on firm characteristics, the type of policy instrument, and the ability to innovate or adapt. Employment tends to decline in pollution-intensive sectors but expand in cleaner industries, confirming that reallocation and innovation are central mechanisms linking environmental policy to labour outcomes.

## 2.2 Skill-Biased and Structural Labour Market Effects

Another strand of literature examines how climate and environmental policies influence the composition of jobs across skill levels and occupations. These studies highlight that the transition to a low-carbon economy is not neutral: it favours some workers and sectors over others.

Marin and Vona (2019) analyse labour market dynamics in 14 European countries between 1995 and 2011, using energy prices as a proxy for environmental policy stringency. They find that higher energy prices, interpreted as tighter environmental regulation, do not reduce total employment but shift labour demand from manual to technical and professional occupations. Technicians benefit most, while manual workers experience lower demand. This pattern, described as a skill-biased employment effect, reflects the growing importance of innovation and clean technologies under stricter policies.

Javed & Usman (2025) study the link between environmental policy stringency, green energy transition, and skill-biased employment in Italy from 1992 to 2020. Using a dynamic autoregressive distributed lag (ARDL) model, they show that stricter policies and renewable-energy expansion increase high-skilled employment and reduce low-skilled employment in the long run. Short-run effects are weaker but move in the same direction. The authors conclude that green transition policies are associated with higher skill demand and that training policies are essential to prevent inequality between skill groups.

Vandeplass, Vanyolos, Vigani, and Vogel (2022) take a broader European perspective and discuss possible labour market implications of the EU's green transition. Their study highlights that most jobs are in emission-neutral activities, while employment declines are expected mainly in emission-intensive sectors. At the same time, new opportunities will arise in green activities that tend to require higher qualifications. The paper emphasises the need for active labour market policies and education measures to ensure that the transition remains inclusive. Although descriptive rather than econometric, this analysis clearly supports the idea of structural labour market adjustment driven by environmental policies.

These studies consistently show that environmental policy stringency contributes to the transformation of labour markets. The effect is not primarily a loss of jobs, but a change in their nature and distribution. Stricter environmental regulations and the move towards renewable energy increase demand for skilled and technical labour while reducing employment in low-skill and pollution-intensive occupations.

### 2.3 Green Jobs, EGSS, and Policy Case Studies

A further group of studies examines how green employment is defined, how it can be measured, and how specific policy instruments have affected labour markets.

Apostel and Barslund (2024) present a comprehensive overview of how green employment is defined and measured across different national and institutional contexts. They distinguish between output-based measures, which capture employment in the production of environmentally beneficial goods and services, and process-based measures, which identify jobs that involve environmentally sustainable production methods. The authors show that the large variation in green employment estimates across studies arises from differences in these conceptual and methodological approaches. Within the European Union, they note that the Environmental Goods and Services Sector (EGSS) framework serves as the main approach to measure green employment, focusing on firms whose activities are directly related to environmental protection or resource management.

Markandya, Arto, González-Eguino, and Román (2016) evaluate employment effects of the European Union's transition towards low-carbon technologies in the energy sector between 1995 and 2009. Using a multi-regional input-output model, they estimate that the energy transition created about 530,000 jobs across the EU, with positive effects in 21 of 27 member states. Roughly one-third of these gains resulted from spill-over effects through trade linkages. The results indicate that low-carbon policies can generate modest but positive employment growth, particularly in countries and sectors investing in clean technology.

Yamazaki (2017) investigates the employment impact of British Columbia's revenue-neutral carbon tax using industry-level data for Canadian provinces from

2001 to 2013. The study finds that employment declined in emission-intensive and trade-exposed industries but increased in service sectors that benefited from the redistribution of tax revenues. Overall, the carbon tax had a small but positive effect on employment, corresponding to an average annual increase of about 0.74 percent between 2007 and 2013.

Wei & Yip (2025) also study the British Columbia carbon tax but use individual-level Labour Force Survey data from 2005 to 2015. They find that the tax caused a short-term increase in unemployment and a gradual decline in wages of about 2.5 per cent, mostly through lower wages for new hires. The unemployment effect was temporary, while wages for existing workers remained stable. These results suggest that carbon pricing involves transitional labour market adjustments, with effects depending on labour mobility and wage rigidity.

Overall, these studies indicate that environmental policies generally lead to modest net employment effects while triggering clear structural and distributional changes across sectors. They also highlight that how “green employment” is defined strongly influences the conclusions drawn.

The EGSS framework offers a consistent and comparable way to measure green jobs across countries, making it a suitable basis for analysing the impact of policy stringency on employment in Europe.

## 2.4 Summary and Research Gap

The reviewed studies generally agree that stricter environmental policies do not cause major employment losses but instead reshape the composition of labour markets. Most empirical evidence shows modest or neutral aggregate effects combined with significant reallocation of jobs from emission-intensive sectors to cleaner and more innovative activities. At the same time, the green transition

tends to be skill-biased, increasing demand for technical and high-skilled workers while reducing employment for low-skilled groups. Overall, the literature indicates that environmental policy stringency acts more as a driver of structural and technological change than as a source of net job decline.

Despite these insights, several aspects remain underexplored.

Existing research mainly examines aggregate or firm-level outcomes and provides limited evidence on differences between environmental and non-environmental sectors. Dynamic or lagged employment responses to policy stringency are analysed only in a few national studies, leaving little cross-country understanding of adjustment patterns. In addition, no study explicitly tests whether the relationship between environmental policy stringency and employment is linear or varies across different levels of policy intensity. Furthermore, the definition of green employment differs across studies, while the EGSS framework provides a consistent output-based approach for identifying environmental activities. These gaps motivate a closer investigation of how environmental policy stringency relates to employment patterns in EGSS and non-EGSS sectors across Europe.

## 3 Theoretical Framework

### 3.1 Labour-Market Implications of Environmental Policy Stringency

Environmental policy influences labour markets because it changes the production conditions under which firms operate. Stricter rules alter the cost structure of economic activities, leading to gains for some sectors and losses for others (OECD, 2022). Empirical work shows that tighter environmental regulation affects the use of energy- and material-intensive inputs, making these inputs less responsive to price changes and encouraging firms to adjust their production mix over time (Feng, McLaren, Yang, Zhang, & Zhao, 2021).

These adjustments also affect labour demand. Studies find that environmental policy can act as a cost shock that reduces employment in emission-intensive activities, since these firms face higher compliance costs and more constrained production decisions (Yamazaki, 2017). At the same time, the same policies can create favourable conditions for sectors with lower emission intensity, where demand for labour may rise as cleaner technologies and services expand (Mohammad, 2021).

Together, these mechanisms show that environmental policy reshapes employment by altering costs, incentives, and the relative competitiveness of different activities. Changes in input use, technology adoption, and sectoral demand create differentiated labour-market outcomes, laying the foundation for the channels discussed in the following sections.

### 3.2 Mechanisms Through Which EPS Influences Employment

#### 3.2.1 Compliance Cost and Output Adjustment Channel

Environmental policies can influence employment by altering firms' cost structures through the choice of policy instruments. Market-based instruments raise the price of pollution, while command-and-control rules impose mandatory

standards, and both mechanisms change firms' production decisions in measurable ways (Albrizio, Kozluk, & Zipperer, 2017). Higher compliance costs tend to reduce productivity for firms operating far from the technological frontier, because these firms struggle to adapt their processes efficiently when environmental rules tighten (Albrizio, Kozluk, & Zipperer, 2017).

Empirical studies also show that the type of pollutant being regulated plays an important role in shaping cost and output responses. Regulations aimed at reducing ozone and particulate emissions have been linked to declines in productivity, while carbon monoxide regulations show more favourable effects, indicating that compliance burdens differ across pollutants (Greenstone, List, & Syverson, 2012). Evidence from polluting industries further suggests that negative productivity effects arise when firms face additional environmental constraints, especially when these constraints increase the cost of essential inputs (Becker, 2011).

Energy prices provide another channel through which compliance costs influence employment outcomes. Research shows that increases in energy prices, often used as proxies for environmental taxes or carbon pricing, have modest negative effects on employment, concentrated in energy-intensive industries that face the strongest cost pressures (Greenstone, List, & Syverson, 2012). Similar findings indicate that higher energy costs reduce labour demand in sectors with the highest pollution intensity, reinforcing the link between compliance costs and employment adjustment (Kahn & Mansur, 2013).

The ability of firms to pass compliance costs onto consumers also shapes the magnitude of output reductions. In industries with greater market power, evidence shows that the scale effect of environmental regulation is relatively small because higher costs can be transferred through prices with limited impact on

demand (Morgenstern, Pizer, & Shih, 2002). This dynamic implies that employment losses from compliance costs may be less severe in markets where firms face weaker competitive pressures.

Overall, the compliance cost channel highlights that environmental policies influence employment through changes in regulated input prices, pollutant-specific compliance burdens, and industry-level market structures, with the strongest short-term effects observed in pollution- and energy-intensive sectors.

### 3.2.2 Sectoral Reallocation and Competitiveness Channel

Environmental policy stringency can shift employment across sectors by changing which industries remain competitive under tighter environmental constraints (Albrizio, Kozluk, & Zipperer, 2017). Evidence shows that energy-intensive manufacturing industries are more likely to experience declines in production and increases in net imports than less energy-intensive industries when climate and energy policies tighten, indicating a relative loss of competitiveness for the most energy-intensive sectors (Aldy & Pizer, 2015). These sectoral responses reflect broader reallocations of activity as industries adjust to higher energy prices and regulatory requirements, with production gradually shifting toward cleaner or less energy-intensive activities over time (Vandeplas, Vanyolos, Vigani, & Vogel, 2022).

A clearer sign of sectoral reallocation emerges in the expansion of cleaner energy industries. As environmental policies encourage investment in renewable technologies, employment shifts toward these activities, but the location and magnitude of these gains vary across projects. Evidence shows that jobs created by renewable-energy developments do not always remain in the areas where projects are built, and that technologies such as solar power tend to generate larger employment and unemployment multipliers than wind installations because of differences in task structures and skill requirements (Fabra, Gutiérrez,

Lacuesta, & Ramos, 2024). These patterns indicate that labour demand can grow in low-emission sectors while becoming more uneven or mobile across regions.

Spillover effects further shape the direction of labour reallocation. Studies show that a considerable share of new employment generated by the green transition occurs outside the sectors directly receiving environmental investment, indicating that indirect linkages play a substantial role in determining where jobs ultimately emerge (Markandya, Arto, González-Eguino, & Román, 2016). This spillover mechanism means that sectors supplying intermediate goods or specialised services can gain employment even when they are not the primary target of environmental policies.

Finally, longer-term analyses show that environmental regulation is associated with a growing demand for high-skilled workers in cleaner and renewable-energy sectors, while traditional energy industries may experience declining employment prospects (Javed & Usman, 2025). Such developments reinforce the idea that environmental policy not only reallocates labour between sectors but also reshapes which industries maintain competitive advantages under more stringent environmental standards.

### 3.2.3 Innovation, Technology Adoption, and Productivity Channel

Environmental policy can influence employment by stimulating cleaner technologies and innovation activities that alter firms' competitiveness (Horbach & Rennings, 2013). Firm-level evidence shows that command-and-control regulations can raise innovation expenditures, which in turn contribute to higher productivity growth in regulated industries (Hamamoto, 2006). Other research finds that environmental rules impose initial compliance costs, but that these

costs may be followed by productivity improvements as firms reorganise production processes or adopt more efficient technologies (Lanoie, Patry, & Lajeunesse, 2008).

Innovation related to cleaner production can also support job creation when it enhances firms' competitiveness. Studies show that environmental process innovations that reduce material and energy use tend to increase employment because cost savings strengthen firms' market position and stimulate demand (Horbach & Rennings, 2013). These findings indicate that innovation in cleaner production can generate employment gains within firms that successfully adopt these technologies.

Research on broader eco-innovation further suggests that transitions from end-of-pipe technologies to cleaner production methods are associated with net job creation, particularly among highly skilled workers (Pfeiffer & Rennings, 2001). However, the employment benefits of these innovations are not evenly distributed across firms, as gains tend to be concentrated among enterprises that are technologically prepared to adopt advanced environmental measures.

The link between innovation and employment is also evident in studies that examine the impacts of renewable energy and green technologies. Long-run analyses show that an expansion in renewable energy production can increase employment across European countries, with estimates suggesting that a 1% rise in renewable energy output leads to measurable job growth (Azretbergenova, Syzdykov, Niyazov, Gulzhan, & Yskak, 2021). Additional evidence indicates that the transition to renewable energy may add around 50,000 new jobs to national economies, highlighting how innovation in clean energy systems can support labour demand (Bulavskaya & Reynés, 2018).

Green innovation more broadly is found to have a stronger positive effect on long-term job creation than non-environmental forms of innovation, underscoring the specific labour-market contribution of environmentally oriented technological change (Gagliardi, Marin, & Miriello, 2016). Although general innovation often supports employment growth, the evidence for green innovation suggests particularly pronounced positive effects when new products or production methods relate directly to environmental improvements (König, Buscher, & Licht, 1995; Garcia, Jaumandreu, & Rodriguez, 2004; Harrison, Jaumandreu, Mairesse, & Peters, 2014).

Together, these results show that innovation and technology adoption can transmit environmental policy effects into the labour market. Cleaner technologies, energy-efficient production methods and renewable energy systems generate new employment opportunities, especially in firms and sectors capable of integrating these innovations effectively. At the same time, the distribution of benefits remains uneven, depending on technological readiness, skill requirements and the nature of the environmental innovations being adopted.

#### 3.2.4 Labour Adjustment Dynamics and Skill-Biased Transition Channel

Environmental policy affects labour markets not only through immediate cost or competitiveness pressures, but also through gradual adjustment processes that unfold over the medium to long run. Evidence from economies undergoing the green transition shows that stringent environmental regulation and the expansion of renewable energy are associated with long-run changes in employment patterns, including higher demand for high-skilled labour and declining opportunities for low-skilled workers in traditional energy sectors (Javed & Usman, 2025). These findings indicate that the full labour-market impact of environmental policy emerges progressively as energy systems and production

structures adapt, rather than being fully visible in the short term (Javed & Usman, 2025; Vandeplas, Vanyolos, Vigani, & Vogel, 2022).

The green transition also reshapes labour demand by altering the skills required in both expanding and contracting sectors. Evidence indicates that climate and energy policies have contributed to a decline in manual occupations and a rise in technical roles, reflecting a shift toward more skill-intensive production processes (Marin & Vona, 2019). Long-term increases in energy prices, linked to climate policy, explain part of this adjustment, suggesting that regulatory signals gradually influence occupational structures rather than generating abrupt changes (Marin & Vona, 2019).

A similar pattern is observed in renewable-energy transitions. Studies find that the growth of renewable energy increases demand for medium- and high-skilled labour, while traditional energy sectors face declining opportunities for low-skilled workers over time (Černý, et al., 2024). Research examining broader labour-market trends in environmentally regulated economies also shows that stringent climate policies and the shift toward cleaner technologies lead to rising demand for high-skilled labour, accompanied by long-run reductions in low-skilled employment (Javed & Usman, 2025).

Taken together, this evidence suggests that environmental policy produces dynamic and skill-biased adjustments rather than uniform or instantaneous effects. Labour demand evolves as firms adopt cleaner technologies, reorganise production, and reallocate tasks, resulting in a transition that favours occupations with advanced or specialised capabilities. These gradual, skill-oriented shifts help explain why the effects of environmental policy on employment may strengthen over time and vary across different levels of policy stringency.

### 3.3 Implications for the Empirical Strategy

The theoretical mechanisms discussed in the previous sections inform the empirical approach used in this thesis. Since environmental policy can influence employment through changes in costs, competitiveness, technology adoption and longer-term skill adjustments, the empirical strategy must capture variation within countries and sectors over time while allowing for systematic differences across sector groups. The modelling choices described below reflect these requirements.

The two-way fixed effects framework is suitable because employment levels differ across countries and sectors for reasons that remain stable over time. Country-sector fixed effects account for these time-invariant characteristics, while year fixed effects absorb common shocks that affect all observations in a given year. With this structure, the empirical model focuses on how changes in policy stringency are associated with changes in employment within the same country-sector unit, which aligns with the theoretical focus on within-unit adjustment rather than cross-sectional comparisons.

The distinction between the Environmental Goods and Services Sector (EGSS) and non-EGSS activities follows from the theoretical expectation that these groups may react differently to changes in policy conditions. Including an interaction between EPS and the sector indicator allows the model to quantify how the association between policy stringency and employment varies across the two groups. Using a unified regression framework ensures that both sectors are examined within the same policy environment.

The lagged specification reflects the possibility that employment responses do not occur immediately. Adjustments such as restructuring, changes in input use

or the adoption of cleaner technologies may take time to materialise. Introducing a one-year lag of the EPS index makes it possible to assess whether the effects of policy stringency appear with delay, which is consistent with the theoretical channels related to dynamic adjustment. The lagged model therefore complements the baseline results and provides evidence on the timing of employment responses.

The nonlinear quartile model is motivated by the possibility that the effects of policy stringency are not linear. Several theoretical arguments imply the presence of threshold effects. Sectoral reallocation and innovation responses, for example, may become more pronounced only when policy stringency reaches a certain level. Dividing the EPS distribution into quartiles allows the empirical model to capture these nonlinearities. Interaction terms between the quartiles and the sector indicator provide information on whether the two sector groups react differently at higher levels of policy stringency.

Overall, the use of a two-way fixed effects framework, the separation of EGSS and non-EGSS sectors, the lagged specification and the nonlinear quartile approach are directly motivated by the theoretical mechanisms described earlier in this chapter.

## 4 Data and Methodology

### 4.1 Data Sources and Variable Construction

This subchapter provides an overview of the data employed in the empirical analysis. Its purpose is to define the variables of interest, explain their construction, and outline the temporal and geographical coverage of the dataset. The dataset takes the form of a balanced panel comprising 16 European Union member states observed over the period 2014–2020. The countries included in the analysis are Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Luxembourg, the Netherlands, Poland, Portugal, Slovenia, Spain, and Sweden.

All data originate from official and harmonised statistical sources to ensure reliability and cross-country comparability. The following paragraphs present each variable in detail, outlining its source, coverage, and the specific steps undertaken for its construction.

- Environmental Policy Stringency (EPS)

The Environmental Policy Stringency (EPS) Index, developed and maintained by the Organisation for Economic Co-operation and Development (OECD, 2024), serves as the principal measure of cross-country differences in environmental regulation. It is compiled directly by the OECD and is available for all years of the study period from 2014 to 2020.

The EPS Index is reported on a 0–6 scale, where higher values indicate more stringent environmental policies. It aggregates a broad range of policy instruments, including both market-based measures (such as taxes, emission trading schemes, and certificates) and non-market-based measures (such as emission limits and performance standards), as well as technology support policies (such as R&D and renewable energy adoption subsidies).

Figure 1 illustrates the structure of the EPS index (EPS21), showing how individual policy instruments are grouped and weighted to form the composite indicator (OECD, 2022). Each major policy domain—market-based, non-market-based, and technology support—receives an equal weight of one-third in the final index.

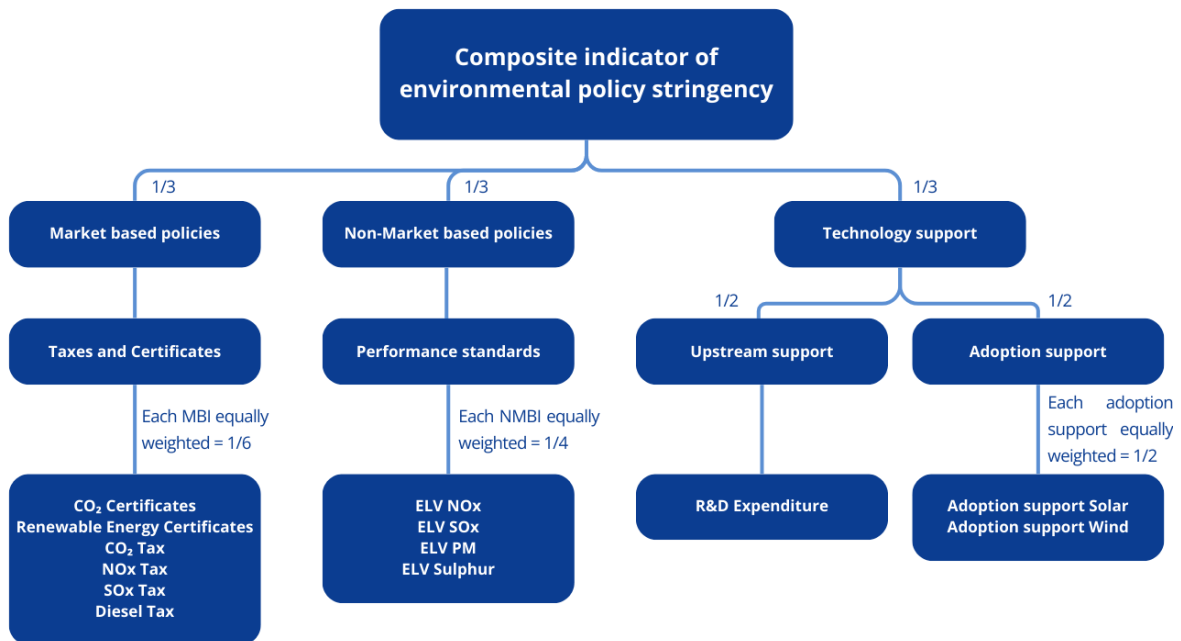


Figure 1 - Structure of the Environmental Policy Stringency (EPS) Index (OECD, 2022)

- Employment in the Environmental Goods and Services Sector

Data on employment in the Environmental Goods and Services Sector (EGSS) are obtained from Eurostat’s dedicated EGSS accounts (Eurostat, 2025), which provide harmonised and internationally comparable statistics across European Union member states. The dataset records employment levels in activities officially recognised as part of the EGSS, covering both environmental protection and resource management services.

In line with the Classification of Environmental Protection Activities (CEPA) and the Classification of Resource Management Activities (CReMA), the analysis in-

cludes total environmental protection and resource management activities. According to the Statistical Classification of Economic Activities in the European Community (NACE Rev. 2), the data are aggregated at the level of total economic activities (all NACE categories). Employment is expressed in full-time equivalents (FTEs), ensuring comparability across countries and over time.

The dataset provides annual observations for all countries included in the analysis and covers the entire study period, offering consistent and comprehensive information on environmental employment dynamics.

- Employment in the Non-Environmental Goods and Services Sector

A comparable measure of employment outside the Environmental Goods and Services Sector (EGSS) was constructed using data from Eurostat's national accounts series "Employment by main industry (NACE Rev. 2)" (Eurostat, 2025). This dataset, compiled under the European System of Accounts (ESA 2010), reports total employment by industry on a domestic concept and covers all economic activities (total NACE categories). Employment is expressed in thousand hours worked, with annual observations available for the same countries and years as the EGSS data.

Because this source measures employment in hours worked rather than in full-time equivalents (FTEs), a conversion was necessary to ensure consistency with the EGSS figures. For this purpose, Eurostat's dataset "Average number of usual weekly hours of work in main job, by sex, age, professional status, full-time/part-time and economic activity (NACE Rev. 2)" (Eurostat, 2025) was used. From this dataset, values were selected for employed persons aged 15–64, men and women, working full-time across all NACE activities. Since these data are available quarterly, an annual average was calculated for each country and year. Multiplying the resulting average weekly hours by 52 provided the estimated annual full-time working hours.

Equation 1 then converts total employment, reported in thousand hours worked, into full-time equivalents (FTEs):

$$FTE = \frac{\text{Total annual hours worked (in thousand hours)} \times 1000}{\text{Average weekly full – time hours} \times 52} \quad (1)$$

This conversion produced a harmonised measure of total employment (in FTEs) that is directly comparable to the EGSS employment data. Subsequently, non-EGSS employment was calculated as the difference between total and EGSS employment:

$$\text{Non EGSS employment} = \text{Total employment} - \text{EGSS employment} \quad (2)$$

The resulting series provides a balanced annual panel of non-EGSS employment in FTEs for all countries and years included in the study.

- Gross Domestic Product (GDP) per Capita (PPS)

As a control for income levels, this analysis employs gross domestic product (GDP) per capita expressed in purchasing power standards (Eurostat, 2025). The indicator represents the volume index of real expenditure per capita (PPS, EU27\_2020 = 100) as reported in Eurostat's national accounts. It is based on gross domestic product within the analytical framework of the purchasing power parity (PPP) calculation.

The dataset provides annual observations for all countries included in the study and offers complete coverage for the analysis period. This variable reflects cross-country differences in real income, adjusted for price level variations, and serves as a standard macroeconomic control in the regression models.

- Unemployment Rate

The unemployment rate is included as a control variable to account for overall labour market conditions across countries (Eurostat, 2025). The indicator

measures the share of the labour force that is unemployed, expressed as a percentage. It refers to the population aged 15 to 74 years and includes both sexes (total).

The dataset is compiled by Eurostat as part of its annual labour market statistics and provides complete coverage for all countries and years considered in the analysis. This variable serves as an important macroeconomic control, reflecting cyclical conditions that may influence employment dynamics in both EGSS and non-EGSS.

- Manufacturing Share of Value Added

To account for structural differences in economic composition across countries, the manufacturing share of value added was constructed using official data from Eurostat’s national accounts database “Gross value added and income by main industry (NACE Rev. 2)” (Eurostat, 2025). This dataset reports annual value added at basic prices (in million euros) by main industry groupings following the NACE Rev. 2 classification.

For each country and year, two series were selected: (1) Manufacturing (C) and (2) Total – all NACE activities. Both variables are expressed in current prices (million EUR). The manufacturing share was then calculated as shown in Equation 3, using the ratio of manufacturing value added to total value added, multiplied by 100:

$$Share = \frac{Value\ Added\ (Manufacturing)}{Value\ Added\ (Total,\ ALL\ NACE)} \times 100 \quad (3)$$

This indicator represents the percentage contribution of manufacturing to total value added in each country–year observation. The dataset was filtered to include only the 16 European countries considered in the main analysis and covers the same time period as the other variables.

- Population

The population variable is included as a control to account for differences in market size across countries. The indicator used is “Population on 1 January – total,” obtained from Eurostat’s database (Eurostat, 2025) under “Demography, population stock and balance” (Population at national level). It reports the total resident population in each country at the beginning of the calendar year. The dataset provides annual observations for the same countries and years as the other variables, ensuring full consistency within the panel structure.

## 4.2 Descriptive Statistics and Data Patterns

This section provides a descriptive overview of the variables used in the empirical analysis. Its purpose is to highlight the main characteristics and patterns observed in the dataset before moving to the econometric estimations. The discussion begins with the evolution of environmental policy stringency (EPS) and the corresponding employment developments in the Environmental Goods and Services Sector (EGSS) and the non-EGSS sector, followed by a concise description of the control variables. All descriptive figures and statistics are based on the balanced panel covering 16 European countries over the study period and were generated in R.

- Environmental Policy Stringency (EPS)

The analysis begins with an overview of environmental policy stringency (EPS), measured on a scale from 0 to 6. Figure 2 displays the annual mean and the corresponding minimum–maximum range of the EPS index across the 16 European countries over the study period. The cross-country mean value increased gradually from 3.20 in 2014 to 3.47 in 2020, indicating a moderate tightening of environmental regulations. The range of values also widened slightly, with the minimum rising from 2.11 to 2.50 and the maximum from 4.22 to 4.89. This

pattern suggests that although policy stringency strengthened in most countries, higher-performing countries advanced more rapidly than those with initially weaker regulatory frameworks.

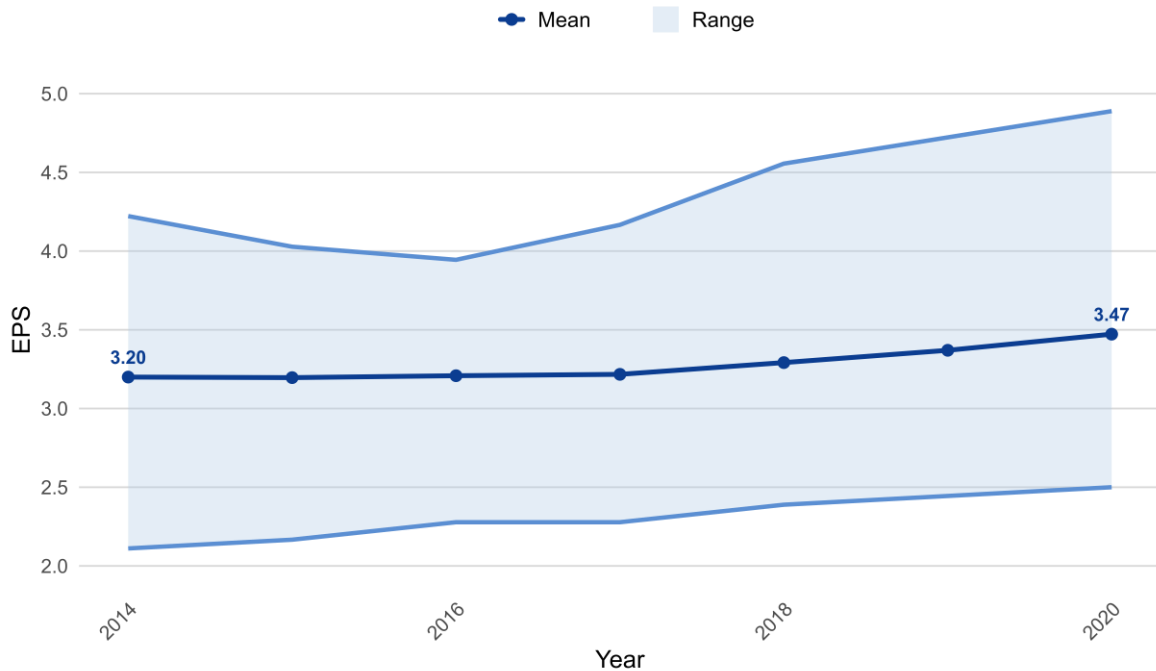


Figure 2 - EPS over Time: Mean and Min-Max Rang

- Employment in the Environmental Goods and Services Sector

To capture the evolution of employment in the Environmental Goods and Services Sector (EGSS) across Europe, Figure 3 presents country-specific trends between 2014 and 2020. A small-multiples layout is used to enable clear visual comparison across sixteen countries while avoiding scale distortions. All values are normalised to 2014 = 100, allowing the analysis to focus on relative changes in employment rather than absolute magnitudes. This representation highlights cross-country differences in employment growth within the EGSS.

Overall, Figure 3 indicates that EGSS employment expanded in most countries over the study period, but the pace and smoothness of growth differ markedly across national contexts. Several countries show steady, almost monotonic increases (e.g., Germany, France, Denmark, Portugal, and Sweden), consistent

with a sustained and gradual scaling-up of EGSS-related activities. Other countries exhibit more pronounced catch-up dynamics, where employment rises strongly after a relatively flat start (e.g., Poland and the Netherlands). In a few cases, the trajectory is visibly less smooth, with noticeable mid-period dips or reversals (e.g., Estonia and Greece), suggesting that year-to-year movements can be more sensitive to short-run conditions.

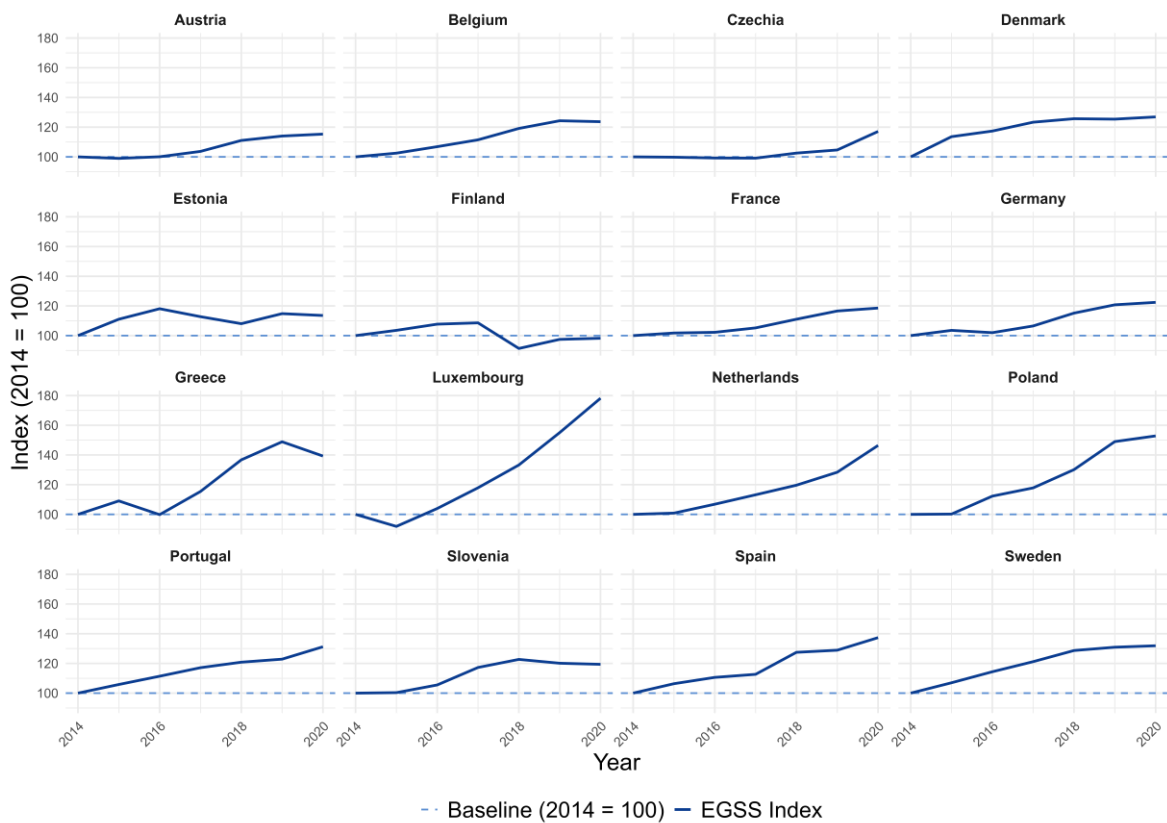


Figure 3 - EGSS Employment by Country (2014 = 100)

Notably, by 2020 the employment index exceeds 110 in most countries, indicating that relatively strong employment growth is observed across a broad set of countries. At the same time, the magnitude of expansion varies widely: some countries remain closer to the baseline, while others record substantial increases, such as Luxembourg’s strong and sustained rise over the period. Beyond illustrating cross-country differences, the heterogeneity in these trajectories is also relevant from an empirical perspective. The coexistence of smooth

upward trends in some countries, sharper accelerations in others, and occasional non-monotonic paths generates meaningful variation both within and between countries. This combination of temporal and cross-sectional variation is important for the two-way fixed effects framework applied in the subsequent analysis, as it supports identification of how changes in environmental policy stringency relate to EGSS employment outcomes.

- Employment in the Non-Environmental Goods and Services Sector

The evolution of employment in the non-Environmental Goods and Services Sector (non-EGSS) is summarised in Figure 4 using a compact representation of central tendency and dispersion. The solid line reports the cross-country mean of indexed employment, while the shaded band depicts the minimum–maximum range for each year. By normalising each country to 2014 = 100 prior to aggregation, the figure focuses on growth dynamics rather than levels, enhancing cross-country comparability and removing distortions due to differences in economic size or reporting conventions.

Figure 4 shows that the cross-country mean of non-EGSS employment increased steadily from the 2014 baseline to around 108 in 2019, indicating moderate job growth in the wider economy during the expansion years. In 2020, the mean declined to roughly 101, consistent with a broad pandemic-related contraction. The min–max band widens gradually until 2019 (from about 96–104 in 2015 to roughly 104–115 in 2019), signalling increasing cross-country divergence during the growth phase. In 2020, the lower bound drops to around 93, showing that the contraction was uneven across countries.

While most countries followed a broadly upward path before 2020, a few recorded mild declines or early stabilisation, indicating that employment outside the Environmental Goods and Services Sector was not uniformly expanding across Europe.

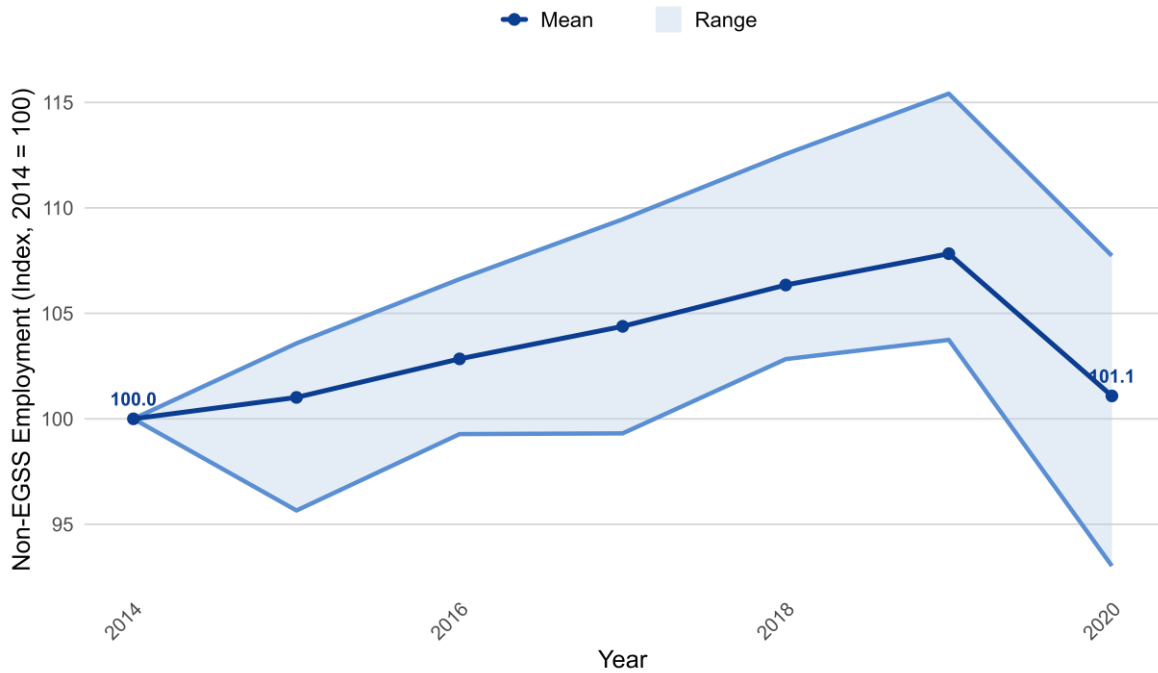


Figure 4 - Non-EGSS Employment: Mean and Min-Max Range (2014 = 100)

- EGSS vs. Non-EGSS Employment

To enable a direct country-by-country comparison between EGSS activities and the broader economy, Figure 5 presents a set of small-multiple panels showing EGSS and non-EGSS employment developments indexed to 2014 = 100. This representation is constructed by first normalising each employment series within each country to a common baseline year and then plotting the two indexed trajectories side-by-side. The use of a 4x4 grid preserves the individual national profiles while ensuring consistent scale and interpretation across countries. Plotting both series together in each panel allows for a clear visual assessment of how sector-specific employment dynamics evolve within the same economic environment.

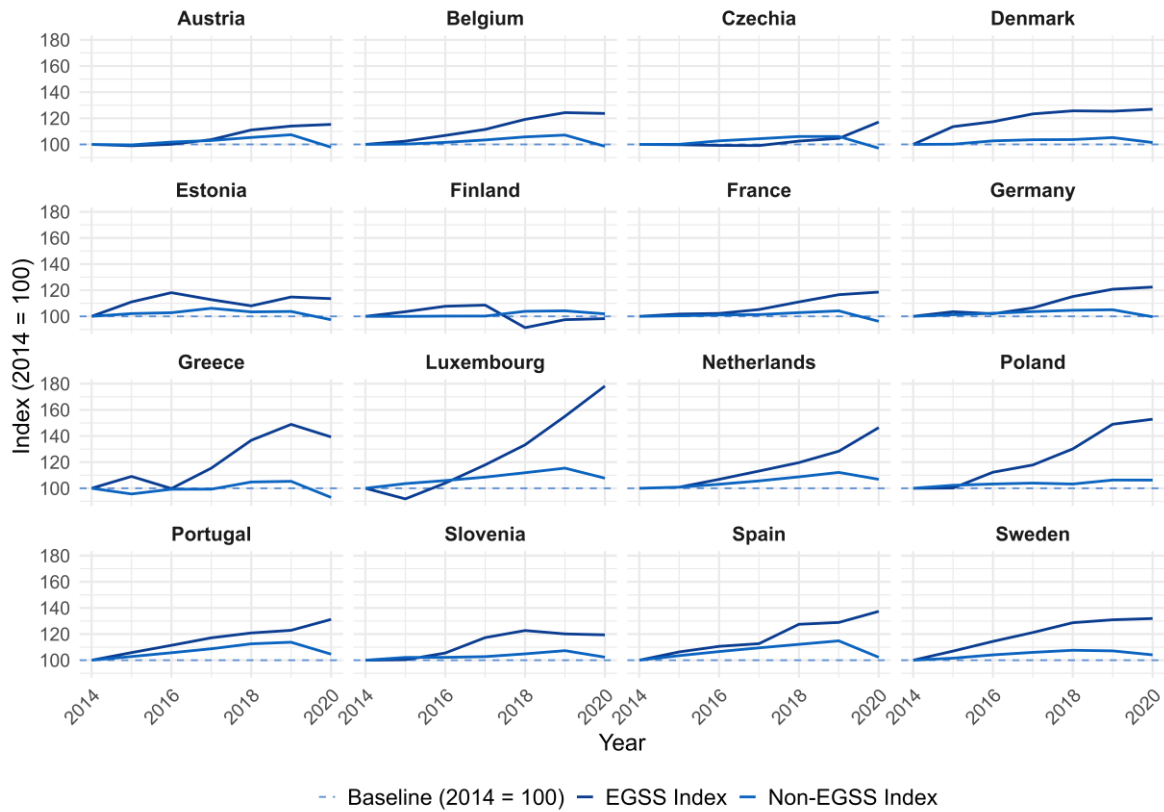


Figure 5 - EGSS vs. Non-EGSS Employment Index (2014 = 100), by Country

Based on Figure 5, a comparison of the two employment series reveals a consistent divergence between the Environmental Goods and Services Sector and the wider non-EGSS economy. Across most countries, EGSS employment follows a clearer and more sustained upward trajectory, whereas non-EGSS employment grows more slowly and with greater variation over time. The 2020 downturn amplifies this contrast: non-EGSS employment contracts more sharply and more unevenly, while EGSS employment displays comparatively milder adjustments. These differences highlight that the two sectors evolve along distinct paths, reinforcing the analytical rationale for examining them separately in the empirical framework that follows.

- Gross Domestic Product (GDP) per Capita (PPS)

The GDP per capita in purchasing power standards (PPS) displays only modest variation across the study period. The cross-country mean declines slightly from

approximately 114 in 2014 to around 111 in 2019 (a decrease of about 2.7%), followed by a minor rebound to roughly 112 in 2020 (+1.1% relative to 2019). The median value remains remarkably stable between 106 and 109, indicating that most countries cluster closely around the EU-27 = 100 benchmark. A few high-income economies, notably Luxembourg, drive the upper tail of the distribution, explaining why the dispersion narrows gradually from 2014 to 2019 (standard deviation falling from about 50 to 42) before widening slightly in 2020. Overall, the figures indicate a mild easing in relative income levels during the expansion years, followed by a small recovery in 2020, with the typical country remaining close to the European average throughout the period.

- Unemployment Rate

The unemployment rate shows a clear improvement across the sixteen countries during the expansion years, followed by a mild deterioration in 2020. Between 2014 and 2019, the cross-country mean declined steadily from about 10% to 6%, and the median from roughly 8.5% to 5%, reflecting broad-based labour-market recovery in the post-crisis period. The dispersion also narrowed, with the range of national unemployment rates tightening considerably, indicating some degree of convergence across European labour markets. In 2020, unemployment edged up again (mean around 7%), consistent with pandemic-related disruptions, although the upper end of the range remained well below earlier peaks. Overall, the pattern suggests a sustained decline in unemployment through 2019, followed by a moderate, temporary setback in 2020.

- Manufacturing Share of Value Added

The manufacturing share of value-added exhibits clear and persistent structural differences across the sixteen European countries. Czechia, Slovenia, and Germany consistently record the highest manufacturing intensities, maintaining shares around or above 20% throughout the period. A second tier—including

Austria, Poland, and Finland—remains in the high- to mid-teens, while Denmark, Estonia, Sweden, Belgium, and Portugal occupy the middle range. Spain, the Netherlands, and France lie somewhat lower, with manufacturing contributing roughly 10–12% of total value added by 2020. At the lower end, Greece and especially Luxembourg show the smallest manufacturing bases, below 10% in 2020.

Changes over time are generally modest. Several countries record slight declines, such as Czechia, Germany, and Estonia, whereas others, including Denmark, the Netherlands, Greece, and Slovenia, experience small increases. Overall, the data indicate stable but heterogeneous manufacturing structures, with limited convergence between 2014 and 2020. This persistence reflects longstanding differences in industrial composition and the varying importance of manufacturing within national economies.

- Population

The population patterns across the sixteen countries show gradual adjustments rather than major demographic shifts during the study period. Germany remains by far the largest country in the sample, followed by France, with both displaying broadly stable populations and modest increases over time. Spain and Poland form the next tier, with Spain recording a slight rise and Poland remaining largely flat or marginally declining. Among the mid-sized economies—including Belgium, the Netherlands, Sweden, Austria, Greece, Czechia, Portugal, Denmark, and Finland—most experienced gentle population growth, particularly the Netherlands, Sweden, Austria, and Denmark. In contrast, Greece and Portugal show small declines, while Czechia edges upward. At the smaller end of the distribution, Slovenia and Estonia remain almost unchanged, whereas Luxembourg continues to expand steadily from a low base. Overall, the data

confirm persistent structural size differences across the sixteen European countries, characterised by slow demographic change and a modest north–south divergence in population trends.

### 4.3 Empirical Strategy and Model Specification.

#### 4.3.1 Modelling Framework

The empirical analysis relies on a panel dataset covering 16 European countries observed annually from 2014 to 2020, with employment measured separately for the Environmental Goods and Services Sector (EGSS) and all remaining activities (non-EGSS). The dependent variable is the logarithm of employment at the country–sector–year level. Using the logarithmic form allows the estimated coefficients to be interpreted as approximate percentage changes, which is appropriate when comparing employment responses across sectors of different sizes.

A two-way fixed effects (TWFE) framework is used to exploit the longitudinal structure of the data. Country  $\times$  sector fixed effects account for all time-invariant characteristics that differ across sectors within countries, such as long-standing industrial structure, baseline employment composition, or persistent institutional features. Year fixed effects absorb shocks that affect all countries simultaneously, including EU-wide policy developments or macroeconomic fluctuations. With these fixed effects in place, identification is obtained from within-country–sector variation over time, meaning the estimates reflect how changes in Environmental Policy Stringency (EPS) coincide with changes in employment in the same unit. All data preparation, transformations, and regression estimations were conducted in R to ensure methodological consistency and reproducibility.

The key explanatory variable is the EPS index (OECD, 2024). To examine whether employment in environmental activities responds differently from employment

in the rest of the economy, the specification includes a simple sector indicator for EGSS and an interaction between this indicator and EPS. This specification allows the model to identify:

1. the association between EPS and employment in non-EGSS sectors, and
2. how this association differs for EGSS.

The total effect for EGSS employment is obtained by combining the main EPS coefficient and its interaction term. This approach avoids estimating separate models for each sector and ensures that the comparison between EGSS and non-EGSS is made within a unified empirical framework.

A set of macroeconomic controls is included to account for broad economic conditions that influence employment. These are: log GDP per capita (PPS), log population, the unemployment rate, and the manufacturing share of value added. Including these variables reduces concerns that observed changes in employment might stem from business-cycle movements, demographic trends, or structural features of the economy rather than from policy stringency.

All models are estimated using R, employing fixed-effects estimators with standard errors clustered at the country level. Clustering at this level accommodates serial correlation and heteroskedasticity within countries over time, which is a common feature of macro-panel data. The following subsections present the baseline model, a lag specification that captures delayed adjustments, and a nonlinear specification based on EPS quartiles.

#### 4.3.2 Baseline Regression Model

The baseline specification examines the contemporaneous relationship between environmental policy stringency and employment outcomes in the two sectors of interest. The model is formulated as a two-way fixed effects regression, where employment is expressed in logarithmic form:

$$Y_{i,s,t} = \beta_0 + \beta_1 EPS_{i,t} + \beta_2 (EPS_{i,t} \times EGSS_s) + \gamma' X_{i,t} + \mu_{i,s} + \lambda_t + \varepsilon_{i,s,t} \quad (4)$$

where  $Y_{i,s,t}$  denotes the log of employment in country  $i$ , sector  $s$  (EGSS or non-EGSS), and year  $t$ . The key explanatory variable is the Environmental Policy Stringency (EPS) index. The interaction term  $EPS_{i,t} \times EGSS_s$  allows the relationship between policy stringency and employment to differ between the EGSS and non-EGSS sectors. In this structure,  $\beta_1$  captures the relationship for non-EGSS sectors, while  $\beta_2$  measures how this relationship differs for EGSS activities. The total relationship for EGSS employment is given by the sum  $\beta_1 + \beta_2$ .

The vector  $X_{i,t}$  includes the control variables described in the previous subsection: log GDP per capita (PPS), log population, unemployment rate, and the manufacturing share of value added. These controls help account for general macroeconomic and demographic conditions that may influence employment independently of environmental policy stringency.

Country  $\times$  sector fixed effects  $\mu_{i,s}$  absorb time-invariant characteristics specific to each country–sector pair, while year fixed effects  $\lambda_t$  account for shocks common to all observations in a given year. The error term  $\varepsilon_{i,s,t}$  is clustered at the country level to allow for arbitrary serial correlation within countries over time.

This baseline specification provides the foundation for the empirical analysis. It establishes the contemporaneous relationship between EPS and employment and serves as the reference point for the subsequent extensions that incorporate lagged and nonlinear policy effects.

#### 4.3.3 Lagged Regression Model

To examine whether environmental policy stringency affects employment with a delay, the analysis extends the baseline specification by introducing a one-year lag of the EPS index. This approach reflects the idea that adjustments in labour demand—such as changes in hiring, restructuring, or the adoption of

cleaner technologies—may not occur immediately within the same year in which policy stringency changes. The lag structure therefore allows the model to capture potential temporal dynamics in the relationship between EPS and employment.

The lagged specification is given by:

$$Y_{i,s,t} = \theta_0 + \theta_1 EPS_{i,t-1} + \theta_2 (EPS_{i,t-1} \times EGSS_s) + \eta' X_{i,t} + \mu_{i,s} + \lambda_t + \varepsilon_{i,s,t} \quad (5)$$

where all variables retain the same definitions as in the baseline model, except that EPS enters with a one-year lag. The control variables remain contemporaneous, as they are intended to capture the economic and demographic environment in the year in which employment is observed. The coefficient  $\theta_1$  represents the lagged relationship between EPS and employment in non-EGSS sectors, while  $\theta_2$  captures how this relationship differs for EGSS. As before, the total lagged relationship for EGSS employment is obtained by summing  $\theta_1 + \theta_2$ .

The fixed effects structure is identical to the baseline model: country  $\times$  sector fixed effects absorb all time-invariant characteristics, and year fixed effects account for common shocks affecting all countries simultaneously. Standard errors are clustered at the country level to allow for serial correlation over time. Estimation is carried out in R using fixed-effects methods suitable for panel data.

This lagged model complements the baseline specification by allowing the empirical analysis to assess whether employment responses to changes in environmental policy stringency unfold gradually rather than contemporaneously.

#### 4.3.4 Nonlinear (Quartile) Regression Model

The third specification extends the empirical analysis by allowing the employment effects of environmental policy stringency to vary across different intensity levels. Instead of treating the EPS index as a continuous variable, the model

groups the full EPS distribution into four quartiles (Q1–Q4), where Q1 represents the lowest policy stringency and serves as the omitted reference category. Quartiles were constructed using the pooled EPS distribution across all countries and years (2014–2020), based on the empirical minimum and maximum values observed in the sample rather than the theoretical 0–6 scale of the OECD index. This approach ensures that the quartile thresholds reflect the actual variation in regulatory stringency present in the dataset and remain comparable across countries and years.

The quartile specification allows for potential non-monotonic or nonlinear policy effects by estimating separate coefficients for each EPS group. To capture differential impacts on the Environmental Goods and Services Sector (EGSS), the model includes interaction terms between each quartile dummy and the EGSS indicator. These interaction terms measure the extent to which employment responses to increasingly stringent policies differ between EGSS and non-EGSS activities. The total effect for EGSS in each quartile is therefore obtained as the sum of the main quartile coefficient and the respective interaction term.

The regression is estimated using a two-way fixed effects (TWFE) framework of the following form:

$$Y_{i,s,t} = \sum_{k=2}^4 \alpha_k Q_{k,i,t} + \sum_{k=2}^4 \delta_k (Q_{k,i,t} \times EGSS_s) + \gamma' X_{i,t} + \mu_{i,s} + \lambda_t + \varepsilon_{i,s,t} \quad (6)$$

where  $Y_{i,s,t}$  denotes the logarithm of employment in country  $i$ , sector  $s$ , and year  $t$ .  $Q_{k,i,t}$  are dummy variables for EPS quartiles (with Q1 omitted), and  $EGSS_s$  equals 1 for EGSS activities and 0 otherwise.

The vector  $X_{i,t}$  includes the same set of controls as in previous models: log GDP per capita (PPS), log population, unemployment rate (%), and the manufacturing share of value added (%).

Country–sector fixed effects ( $\mu_{i,s}$ ) absorb all time-invariant characteristics specific to each country–sector pair, while year fixed effects ( $\lambda_t$ ) capture common shocks affecting all countries simultaneously.

Standard errors are clustered at the country level to account for arbitrary within-country correlation over time.

This specification provides a flexible framework to examine whether the relationship between policy stringency and employment differs across the distribution of EPS values and whether these effects are systematically stronger for environmental sectors.

To assess whether the quartile–EGSS interaction terms are jointly significant, a joint Wald test is conducted and presented in the results section.

## 5 Empirical Results and Discussion

### 5.1 Baseline Model Results

Table 1 - Baseline Two-Way Fixed Effects Estimates for Employment

Variable	Coefficient	Std. Error	t-Statistic	p-Value
Environmental Policy Stringency (EPS)	-0.095	0.037	-2.56	0.021**
EPS × EGSS Dummy	0.258	0.077	3.34	0.004***
EPS in EGSS ( $\beta_1 + \beta_2$ )	0.1629	0.052	3.137	0.0017***
Log GDP per Capita (PPS)	0.072	0.204	0.353	0.729
Log Population	2.711	0.4836	5.606	0.000***
Unemployment Rate (%)	-0.023	0.005	-4.030	0.001***
Manufacturing Share of Value Added (%)	0.0044	0.0066	0.666	0.515
Number of Observations	224			
R <sup>2</sup> (Overall)	0.999			
R <sup>2</sup> Within	0.315			
RMSE	0.050			

Significance levels — \* p < 0.10; \*\* p < 0.05; \*\*\* p < 0.01.

Country × sector and year fixed effects included. Standard errors clustered at country level

The baseline results show that environmental policy stringency is associated with markedly different employment responses across sector groups. For non-EGSS sectors, the coefficient on the EPS index is  $-0.095$  ( $p = 0.021$ ). Because the dependent variable is specified in logarithmic terms, the implied percentage change is obtained using the log-to-percentage transformation shown in Equation 7 (Wooldridge, 2016, p. 171):

$$\% \Delta Y = (e^{\theta} - 1) \times 100. \quad (7)$$

Applying this to the estimated EPS coefficient gives:

$$\% \Delta Employment_{non-EGSS} = (e^{-0.095} - 1) \times 100.$$

which yields approximately  $-9.1\%$ , indicating that a one-point increase in the EPS index is associated with a sizable employment reduction in non-EGSS activities. The estimate is statistically significant and precisely estimated. The interaction term  $\beta_2 = 0.258$  (EPS  $\times$  EGSS dummy) captures how the association between EPS and employment differs in EGSS sectors relative to non-EGSS sectors. It does not represent a stand-alone effect; rather, it modifies the baseline EPS coefficient. The total EPS effect in EGSS sectors is therefore:

$$\beta_{EGSS} = \beta_1 + \beta_2 = -0.095 + 0.258 = 0.1629. \quad (8)$$

Based on the total EPS effect in Equation 8, and using the same transformation formula (Equation 7), the implied percentage change for EGSS activities is:

$$\% \Delta Employment_{EGSS} = (e^{0.1629} - 1) \times 100 \approx 17.7\%.$$

The corresponding p-value (0.0017) confirms a highly significant positive relationship.

Regarding additional covariates, population size is positively associated with employment (coefficient 2.711,  $p < 0.001$ ), while the unemployment rate shows a significant negative association ( $-0.023$ ,  $p = 0.001$ ). GDP per capita and manufacturing share of value added display no statistically significant within-variation once fixed effects are included.

The very high overall  $R^2$  arises because the inclusion of fixed effects explains most of the underlying variation in the data. As Wooldridge (2016, p. 438) notes, models that contain a dummy for each cross-sectional unit typically display a high  $R^2$  because these dummies capture a substantial share of the differences across units. In the present setting, the country  $\times$  sector fixed effects absorb nearly all cross-sectional variation in employment levels, while the year fixed effects eliminate shocks that apply uniformly to all countries. Together, these components produce the exceptionally large overall  $R^2 = 0.999$  observed in the

two-way fixed effects specification. Thus, the large majority of structural and time-specific variation is captured before estimating the remaining coefficients. The more informative statistic is the within  $R^2 = 0.315$ , which indicates that the explanatory variables account for around 31.5% of the year-to-year variation within each country–sector unit. The low RMSE (0.050) further suggests a reasonably close fit in the within dimension.

Overall, the baseline model points to a clear and robust pattern: employment in non-EGSS activities declines as environmental policy becomes more stringent, whereas employment in EGSS activities increases. The magnitude and precision of the estimated effects highlight a substantial divergence between the two sectors in how employment aligns with policy stringency over time.

## 5.2 Lagged Model Results

Table 2 - Lagged Two-Way Fixed Effects Estimates for Employment

Variable	Coefficient	Std. Error	t-Statistic	p-Value
EPS (t-1)	-0.105	0.045	-2.356	0.033 **
EPS (t-1) × EGSS	0.256	0.086	2.972	0.009 ***
EPS in EGSS (t-1) (Total effect)	0.150	0.053	2.855	0.012**
Log GDP per Capita (PPS)	0.116	0.231	0.505	0.621
Log Population	3.423	0.662	5.170	0.000 ***
Unemployment Rate (%)	-0.026	0.008	-3.422	0.004 ***
Manufacturing Share of Value Added (%)	-0.001	0.010	-0.104	0.918
Number of Observations	192			
R <sup>2</sup> (Overall)	0.999			
R <sup>2</sup> Within	0.296			
RMSE	0.049887			

Significance levels — \* p < 0.10; \*\* p < 0.05; \*\*\* p < 0.01.

Country × sector and year fixed effects included. Standard errors clustered at country level

The lagged specification replaces contemporaneous EPS with its one-year lag,  $EPS_{t-1}$ , to examine whether employment adjusts with delay. For non-EGSS activities, the coefficient on  $EPS_{t-1}$  is  $-0.105$  ( $p = 0.033$ ). Using the log–percentage transformation (see Equation 7), the implied effect is:

$$\% \Delta Employment_{non-EGSS} = (e^{-0.105} - 1) \times 100 \approx -10.0\%$$

Thus, a one-point increase in the EPS index in the previous year is associated with about a 10% lower level of employment in non-EGSS sectors, conditional on controls and fixed effects. The estimate is statistically significant and very similar in magnitude to the contemporaneous coefficient in the baseline model.

The interaction term  $EPS_{t-1} \times EGSS$  equals  $0.256$  ( $p = 0.009$ ). As before, this coefficient modifies the baseline EPS effect for EGSS sectors. The total lagged EPS effect in EGSS is

$$\theta_{EGSS} = \theta_1 + \theta_2 = -0.105 + 0.256 = 0.150, \quad (9)$$

Using the total lagged EPS effect in Equation 9 and the log-to-percentage conversion in Equation 7, the implied change in EGSS employment is:

$$\% \Delta Employment_{EGSS} = (e^{0.150} - 1) \times 100 \approx 16.2\%$$

Hence, stricter environmental policies in the previous year are associated with substantially higher EGSS employment, while non-EGSS employment declines. Compared with the baseline model, the lagged effects remain of similar order of magnitude: the negative association for non-EGSS becomes slightly stronger, while the positive association for EGSS becomes slightly smaller, indicating that the main pattern is stable when moving from contemporaneous to lagged EPS.

The coefficients on the control variables are close to those in the baseline specification. Log population remains strongly positive and highly significant ( $3.423$ ,  $p < 0.001$ ), while the unemployment rate continues to be significantly negative

(-0.026,  $p = 0.004$ ), reflecting weaker overall labour-market conditions. GDP per capita and the manufacturing share of value added again show no statistically significant within-country $\times$ sector association with employment once fixed effects are included.

The overall  $R^2$  is 0.999, as most of the cross-country, cross-sector, and common time variation in employment is absorbed by the fixed effects. The within  $R^2$  of 0.296 indicates that lagged EPS and the covariates together explain around 30% of the remaining variation over time within country-sector cells, only slightly below the baseline within  $R^2$ . The RMSE ( $\approx 0.050$ ) is also very similar to that of the contemporaneous model. Taken together, the lagged specification confirms the core result: environmental policy stringency is consistently associated with declining employment in non-EGSS sectors and expanding employment in EGSS activities, and these patterns persist when policy changes are measured with a one-year delay.

### 5.3 Nonlinear (Quartile) Model Results

The nonlinear specification replaces the continuous EPS index with dummy variables for quartiles (Q2-Q4), using Q1 as the reference category. For non-EGSS sectors, the estimated coefficients are  $\alpha_{Q2} = -0.030$ ,  $\alpha_{Q3} = -0.067$ , and  $\alpha_{Q4} = -0.051$ . Using Equation 7, their implied percentage differences relative to Q1 are:

$$Q2 = (e^{-0.030} - 1) \times 100 \approx -2.96\%$$

$$Q3 = (e^{-0.067} - 1) \times 100 \approx -6.44\%$$

$$Q4 = (e^{-0.051} - 1) \times 100 \approx -4.95\%$$

All three estimates are negative, with the largest magnitude and highest precision observed in Q3. These results indicate that employment in non-EGSS activities is systematically lower in country-years falling into higher quartiles of the

EPS distribution, even after conditioning on country-sector and year fixed effects.

The interaction terms  $Q_k \times EGSS$  show how the quartile effects differ for EGSS activities relative to non-EGSS sectors. The total effect for EGSS in each quartile is obtained by adding the corresponding main effect and interaction term,

$$\beta_{Q_k}^{EGSS} = \alpha_k + \delta_k \quad (10)$$

Based on Equation 10, the estimated total effects are:

$$Q2: -0.030 + 0.051 = 0.0209$$

$$Q3: -0.067 + 0.171 = 0.1049$$

$$Q4: -0.051 + 0.161 = 0.1097$$

To convert these into percentage changes, we again apply Equation 7. In this context, the general parameter  $\theta$  corresponds to the quartile-specific EGSS effect, that is,

$$\theta = \beta_{Q_k}^{EGSS} \quad (11)$$

Substituting Equation 11 into Equation 7 yields:

$$\left( e^{\beta_{Q_k}^{EGSS}} - 1 \right) \times 100$$

which provides the exact percentage difference in EGSS employment relative to Q1. The resulting values are:

$$Q2: (e^{0.0209} - 1) \times 100 \approx +2.12\%,$$

$$Q3: (e^{0.1049} - 1) \times 100 \approx +11.06\%,$$

$$Q4: (e^{0.1097} - 1) \times 100 \approx +11.59\%.$$

The Q2 effect is small and statistically insignificant, whereas Q3 and Q4 exhibit sizable and precisely estimated positive differences. These results suggest that meaningful EGSS employment gains arise primarily in the upper half of the EPS

distribution, particularly in policy environments corresponding to Q3 and Q4. Table 3 reports the full set of estimated coefficients for this nonlinear specification.

Table 3 - Nonlinear EPS Quartile Effects on Employment

Variable	Coefficient	Std. Error	t-Statistic	p-Value
EPS Quartile Q2 (non-EGSS)	-0.030	0.010	-2.875	0.0116**
EPS Quartile Q3 (non-EGSS)	-0.067	0.015	-4.527	0.0004***
EPS Quartile Q4 (non-EGSS)	-0.051	0.028	-1.842	0.0853*
Q2 × EGSS	0.051	0.029	1.775	0.0961*
Q3 × EGSS	0.171	0.028	6.098	0.000020***
Q4 × EGSS	0.161	0.051	3.170	0.00634***
EGSS Total Effect (Q2) = Q2 + Q2×EGSS	0.0209	0.0197	1.064	0.3041
EGSS Total Effect (Q3) = Q3 + Q3×EGSS	0.1049	0.0238	4.402	0.000515***
EGSS Total Effect (Q4) = Q4 + Q4×EGSS	0.1097	0.0304	3.611	0.00257***
Log GDP per Capita (PPS)	0.084	0.195	0.429	0.6739
Log Population	2.829	0.515	5.488	0.000062***
Unemployment Rate (%)	-0.0248	0.0061	-4.073	0.00101***
Manufacturing Share of Value Added (%)	0.0031	0.0061	0.504	0.6213
Number of Observations	224			
R <sup>2</sup> (Overall)	0.999			
R <sup>2</sup> Adj.	0.999			
R <sup>2</sup> Within	0.269			
RMSE	0.050			
Wald Test ( $\delta_2 = \delta_3 = \delta_4 = 0$ )	F(3, 15) = 12.686, p-value = 0.00022			

Significance levels — \* p < 0.10; \*\* p < 0.05; \*\*\* p < 0.01.

Country × sector and year fixed effects included. Standard errors clustered at country level

The Wald test reported at the bottom of Table 3 provides a joint assessment of whether the quartile interaction terms contribute meaningfully to the model. The null hypothesis tested (Equation 12) is:

$$H_0: \delta_{Q2} = \delta_{Q3} = \delta_{Q4} = 0 \quad (12)$$

states that EPS quartiles would influence EGSS employment in exactly the same way as non-EGSS employment, implying no differential response across the two sector groups. Under this hypothesis, the interaction terms would be jointly irrelevant, and the nonlinear specification would reduce to the non-EGSS pattern alone. As in standard econometric practice, this joint test can be viewed as a Wald test of multiple linear restrictions in a linear regression framework (Wooldridge, 2002, p. 463).

The test statistic  $F(3,15) = 12.686$  with p-value 0.00022 rejects this null, as shown in Equation 13:

$$(\delta_{Q2}, \delta_{Q3}, \delta_{Q4}) \neq 0 \quad (13)$$

This rejection indicates that the interaction coefficients are not only individually important but also jointly significant. In the context of fixed-effects estimation, such Wald-type joint tests are routinely used to determine whether a group of coefficients contributes systematically to the explained within-variation, making them particularly informative when analysing heterogeneous policy effects across sectors. In other words, the responsiveness of EGSS employment to changes in EPS differs systematically from that of non-EGSS sectors across the entire quartile distribution. The Wald test therefore confirms that the nonlinear specification captures meaningful heterogeneity and that EGSS employment exhibits a distinct pattern in higher policy-stringency environments. This strengthens the interpretation that employment outcomes in EGSS sectors respond more strongly once countries move into higher ranges of policy stringency, a pattern that would not be detectable without evaluating the joint significance of the quartile interactions.

The coefficients on the control variables remain similar to previous models. Log population is strongly positive and significant, the unemployment rate remains significantly negative, and neither GDP per capita nor the manufacturing share

shows significant within-variation once fixed effects are included. The overall  $R^2$  again reaches 0.999 because most cross-sectional and common time variation is absorbed by the fixed effects, while the within  $R^2$  of 0.269 indicates that the quartile specification explains a meaningful portion of the remaining variation. The RMSE of 0.050 is virtually identical to the previous models.

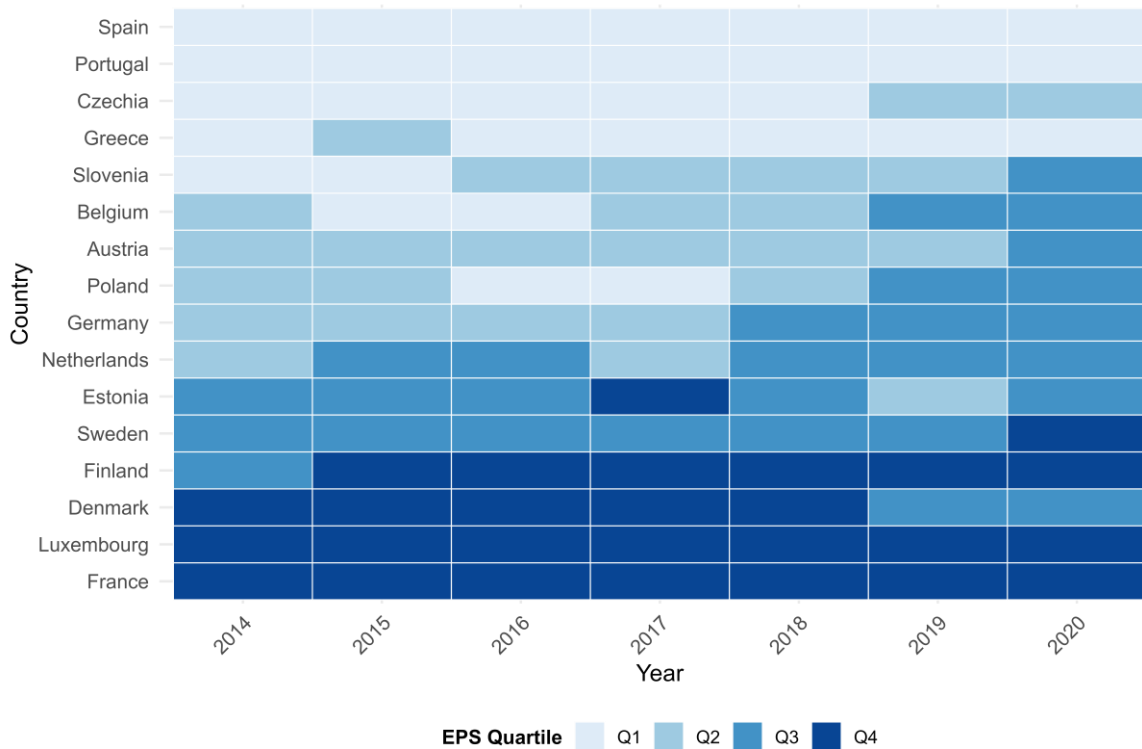


Figure 6 - EPS Quartile Distribution by Country and Year (2014–2020)

The heatmap of EPS quartiles provides a descriptive overview of how environmental policy stringency evolves across countries and over time. The distribution of quartile placements is clearly uneven. Northern and Western European countries—such as Denmark, Finland, Sweden, Luxembourg, and France—are consistently found in Q3 and Q4, indicating persistently stringent policy environments throughout most of the sample. Their quartile positions remain relatively stable across years, suggesting a steady regulatory framework rather than fluctuations between higher and lower levels of policy intensity. Germany, the

Netherlands, Austria, and Belgium also appear frequently in Q2 and Q3, although with some observable movement across quartiles, particularly in the earlier part of the period.

In contrast, countries such as Spain, Portugal, Greece, and several Central and Eastern European economies appear predominantly in Q1 or Q2, reflecting comparatively lower or moderate levels of policy stringency. While a few of these countries shift into higher quartiles toward the end of the sample, others remain concentrated in the lower half of the EPS distribution throughout. Taken together, the heatmap highlights a clear regional pattern: higher policy stringency is more common in Northern and Western Europe, whereas Southern and Eastern European countries typically exhibit lower quartile assignments. This descriptive pattern complements the regression findings by showing that the strong EGSS effects in Q3 and Q4 correspond primarily to observations from countries with consistently stringent policy regimes.

## 6 Conclusion

This thesis examined how environmental policy stringency (EPS) is associated with employment outcomes across European sectors during the period 2014 to 2020. By combining the OECD EPS index with Eurostat's sector-specific employment data, the analysis distinguished between activities classified in the Environmental Goods and Services Sector (EGSS) and those outside it. Using a country, sector, and year panel within a two-way fixed effects framework, the study evaluated contemporaneous and one-year lagged effects of policy stringency and assessed nonlinear responses across different levels of regulatory intensity.

The empirical results reveal a clear and robust pattern. In non-EGSS sectors, stricter environmental policies are associated with notable employment declines. A one-point increase in the EPS index corresponds to an estimated reduction of approximately 9 to 10 percent in the baseline and lagged models. The quartile specification also shows that employment tends to be lower in higher EPS environments, even after controlling for fixed effects. In contrast, the interaction terms indicate that EGSS activities respond in the opposite direction. When combining the baseline coefficient with the EGSS modifier, the estimated effect becomes strongly positive. Employment in EGSS activities increases by roughly 16 to 18 percent following a one-point rise in the EPS index, and the nonlinear model confirms that the largest positive associations occur in the third and fourth quartiles of policy stringency. These findings are highly consistent across all specifications.

Overall, the evidence suggests that environmental policy stringency does not exert uniform effects across the labour market. Instead, it reallocates employment away from non-EGSS activities and towards the Environmental Goods and Services Sector. This pattern is consistent with a reallocation or adjustment-cost

interpretation in which stricter regulation reshapes the relative economic conditions of different activities. The analysis does not provide support for, nor does it attempt to test, innovation-based mechanisms, since such dynamics require longer time horizons than the available panel allows.

The thesis contributes to the literature in several ways. It provides one of the few empirical studies that examines employment effects of environmental policy at the country, sector, and year level across Europe. It also incorporates a nonlinear perspective by using EPS quartiles, which shows that employment responses vary across the policy distribution. In addition, the comparison between contemporaneous and lagged EPS highlights that the main results remain stable when accounting for short delays in policy adjustment.

The study has several limitations. The available data cover only the years from 2014 to 2020, which restricts the ability to examine longer-term policy effects or to estimate additional lags. The short time horizon also prevents the evaluation of innovation-related mechanisms, such as those captured by green patent activity, which typically require many years before meaningful effects appear. Furthermore, the analysis relies on sector-level employment data, which does not allow the examination of firm-level heterogeneity or skill-specific adjustments. As with any composite measure, the EPS index cannot fully capture differences in enforcement intensity or institutional quality across countries.

Despite these limitations, the results offer several general implications. The consistent divergence between EGSS and non-EGSS activities indicates that environmental policy stringency is associated with a shift in the structure of employment. Policymakers may therefore need to anticipate transitional labour-market adjustments, since some activities contract while others expand in response to regulatory tightening. Complementary labour-market measures, such as re-training or mobility support, may help ease these transitions.

Future research would benefit from longer time series that allow for a fuller assessment of medium-term and long-term effects. Access to micro-level or occupational data would also make it possible to analyse within-sector heterogeneity, including skill differences and firm-level adjustments. Additional work could also examine institutional features or specific policy instruments that influence the magnitude of employment responses.

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## Statement of Authorship

"I hereby confirm that I have completed the submitted work on my own without inadmissible tools or without help that is not expressly mentioned in this work. All material that is directly or indirectly taken from other sources is properly referenced."

date of submission 23.02.2026

Signature

A handwritten signature in black ink, consisting of several loops and a horizontal line at the end.