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The Cleantech Startup Sector: a study on the impact of factors influencing the birth and growth of cleantech companies

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Abstract

Climate change is one of the most urgent global challenges, with significant environmental, social, and economic impacts. The cleantech sector plays a pivotal role in mitigating these effects by offering innovative solutions in renewable energy, energy efficiency, waste management, and sustainable mobility.

National and international institution are committing to the transition towards a greener economy, achieving this difficult goal by setting up new rules and policies that are trying to regulate and stimulate the green transition, especially in the European Union, with comprehensive policies such as the European Green Deal, and the cleantech economy is in the centre of this revolution.

This research examines the role of national policies, financial support mechanisms, and regulatory frameworks, in enabling the growth and sustain of those cleantech startups which are driving clean innovation. Using various data from different datasets, issued by many world organizations, the study analyses the dynamics of cleantech firms, and the impact of various factors, such as the number of green policies issued and the expenditures in research and development, on the financial indicators of the cleantech sector.

The goal is to identify which key factor can drive the success of cleantech firms, providing valuable insights for policy development and strategies that can accelerate the transition to a sustainable, climate-neutral economy. Through a country-level analysis, this thesis contributes to the understanding of how national policies and public expenditures can support the scaling of cleantech startups.

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1. Introduction

Climate change has become increasingly recognized as one of the most pressing global challenges, impacting various aspects of human life, from environmental to social dimensions. The effects of climate change, such as rising sea levels, frequent and severe natural disasters, pollution of water bodies, and shifts in biodiversity, are becoming more pronounced. Addressing these issues requires international cooperation and coordinated action at all levels.

The cleantech sector plays a pivotal role in combating these environmental challenges and supporting the transition to a sustainable economy. Cleantech technologies are vital not only for mitigating the environmental impact of human activities but also for fostering economic growth, creating jobs, and attracting investments. These technologies encompass innovative solutions in key areas such as renewable energy, energy efficiency, waste management, and sustainable mobility.

The European Union has recognized the importance of cleantech technologies and has adopted the European Green Deal, an ambitious set of policies aimed at transforming Europe into the first climate-neutral continent by 2050. This initiative marks a historic commitment to sustainability, providing a clear roadmap towards environmental goals while stimulating innovation within the cleantech sector.

However, the success of cleantech companies is heavily influenced by the ecosystem of policies and regulations that support their development. A stable regulatory framework, economic incentives, and access to sufficient financing are crucial for fostering the growth of cleantech enterprises. In this context, it becomes essential to analyze the key enabling factors that can accelerate the expansion of cleantech companies in Europe.

The focus of this research is to explore these enabling factors through a country-level analysis of the cleantech sector. This approach aims to identify new research gaps and adapt findings from broader European studies to the specific dynamics at the national level. Over recent years, the European Union and its member states have introduced a series of green policies designed to transition the EU economy toward greater sustainability while ensuring that the transition remains equitable for all stakeholders. A central aspect of this work draws from the CLEU project ("Cleantech in the European Green Deal: Policy Challenges and the Finance Landscape for SMEs"), supported by the EIBURS funding program of the European Investment Bank (EIB). This project provides valuable frameworks for classifying cleantech companies into innovators and ecosystem participants.

The objective of this research is to analyze how various indicators of cleantech firms, such as sales and employee numbers, fluctuate across countries and years in response to specific indices that drive these changes. Particular attention will be given to understanding whether national policies, financial support mechanisms, and other enabling factors contribute to the growth or decline in the value of cleantech firms. This will provide an empirical basis to inform the development of more effective strategies to support these innovative technologies. The study will focus on key countries and sectors selected for their relevance and contribution to the European cleantech landscape. The goal is to examine in-depth the factors at the country level that influence the creation and development of cleantech companies and startups through a comparative analysis. By identifying and analyzing these factors, the research aims to offer valuable insights into the conditions that foster innovation and growth within the cleantech sector. This will contribute to the broader goal of achieving a sustainable, climate-neutral future while identifying best practices and specific challenges within each national context and support the creation of more targeted and effective policies to promote sustainable technologies in Europe.

Keywords: Cleantech, Environmental Innovation, National Policies, Venture Capital Investments, Country-Level Analysis.

2. The Cleantech Sector

The Cleantech sector has emerged as one of the most dynamic and transformative industries in the global economy. With growing concerns over climate change and the increasing demand for sustainable solutions, cleantech companies are at the forefront of driving innovation across various sectors. These companies develop technologies and processes that address environmental challenges while providing economic opportunities. From renewable energy to waste management, cleantech solutions are essential for transitioning towards a more sustainable and low-carbon economy. This chapter explores the growth and evolution of the cleantech sector, delving into the factors that have contributed to its rapid expansion and the critical role cleantech startups play in shaping a sustainable future.

2.1 Diving into the Cleantech startup sector

The increasing global emphasis on sustainability and environmental responsibility has led to the birth and rapid growth of the Cleantech sector, made up of cleantech companies. The most commonly used definition of cleantech comes from Pernick and Wilder [1], who state in their article that "cleantech refers to any product, service, or process that delivers value using limited or zero non-renewable resources." This definition captures the essence of the sector, emphasizing the innovative use of resources that minimize or eliminate environmental impact while promoting sustainability. The cleantech sector is a diverse and dynamic area that spans multiple industries, including renewable energy, energy storage, water purification, waste management, and sustainable transportation. These companies focus on creating solutions that are economically viable while also addressing global environmental challenges. The innovations within the sector often leverage cutting-edge technologies, digital platforms, and novel engineering solutions to improve resource efficiency, reduce emissions, and create sustainable alternatives to traditional processes.

As the global economy transitions toward a low-carbon future, cleantech startups have become increasingly central to driving the transformation. These startups are innovating in ways that align with international climate goals, pushing the boundaries of what is possible in green technologies and practices. The rapid growth of cleantech companies reflects the increasing recognition of their potential to address not only environmental issues but also economic and social challenges. Several key elements are fuelling the expansion of cleantech startups:

- **Increasing Investment**: the inflow of venture capital and private equity funding into the cleantech sector has been substantial, with venture capital serving as the primary funding source for early-stage startups. Investors are increasingly aware of the significant market potential of cleantech solutions, recognizing their capacity to generate returns while contributing to sustainability efforts. As a report of PwC states, VC and corporate investment in startups developing technology enabled solutions to climate change, and the transformation to net zero emissions, grew at a faster rate than VC investment between 2013 and 2019. In that time, US$60 billion of early-stage capital was invested globally into startups contributing to tackling the net zero challenge 8 [2]. Furthermore, new forms of financing, such as crowdfunding, have also emerged to support cleantech ventures, democratizing access to capital for smaller companies.
- **Supportive Policies**: government policies and international agreements, such as the Paris Agreement and the European Green Deal, have played a significant role in creating a favourable regulatory environment for cleantech innovations. These policies provide financial incentives, subsidies, and regulatory frameworks that encourage the adoption of clean technologies and support the transition to renewable energy sources. They also set ambitious targets for reducing greenhouse gas emissions and achieving carbon neutrality by 2050 [3]. Such policies not only drive demand for sustainable solutions but also help cleantech startups secure funding and market access by reducing the barriers to entry.
- **Technological Advancements**: the rapid evolution of technologies such as artificial intelligence, blockchain, and advanced materials has accelerated the development of cleantech solutions. These technologies enable more efficient, scalable, and cost-effective solutions for managing resources and reducing environmental impacts. The integration of digital tools and artificial intelligence, for instance, has allowed cleantech companies to optimize processes, increase energy efficiency, and

automate complex tasks, significantly enhancing the scalability and affordability of green technologies [4].

- **Consumer Demand**: growing consumer awareness of environmental issues and the desire for sustainable products and services have contributed to a surge in demand for cleantech solutions. As sustainability becomes an integral part of consumer behaviour, businesses are under increasing pressure to adopt environmentally friendly technologies. This shift in consumer preferences is driving companies across various industries to incorporate cleantech solutions into their operations, helping them meet market expectations and achieve their sustainability goals. The adoption of sustainable practices, driven by consumer demand, is transforming traditional industries, making cleantech solutions integral to corporate strategies [5].

The growth of technology-based startups, such as cleantech ventures, can be influenced by various factors. These factors can be classified into three broad categories: individual, firm-specific, and external. Individual factors refer to the personal characteristics of entrepreneurs, such as their skills, knowledge, and experiences, which influence their ability to innovate and manage new ventures. Firm-specific factors include the resources and networks that firms can leverage, such as partnerships, access to capital, and organizational capabilities. External factors, on the other hand, encompass the broader regulatory environment, market conditions, and government policies that can either facilitate or hinder the growth of startups. The interplay between these factors is critical to understanding the success and challenges faced by cleantech startups, which are constantly navigating the complexities of a rapidly evolving market. In this context, government regulations, which play a vital role in shaping the landscape for cleantech innovations, will be a focus of investigation in this thesis.

2.2 Cleantech Segmentation

The cleantech sector is multifaceted, encompassing a wide range of technologies and industries aimed at achieving environmental sustainability. This diversity allows cleantech companies to address numerous environmental challenges, such as reducing carbon emissions, conserving resources, improving energy efficiency, and minimizing pollution. The sector spans industries like renewable energy, water purification, energy storage, waste management, and sustainable transportation. It is often driven by a sense of urgency to combat climate change and to transition towards a more sustainable, low-carbon global economy. The increasing demand for sustainable solutions, coupled with advances in technology, has led to the rapid expansion of this sector globally.

In their research, Ambrois et al. [6] address a significant gap in the understanding of the cleantech sector by providing a segmentation of European cleantech companies. Prior to this study, no comprehensive and systematic list of cleantech firms existed, making it difficult to assess their contributions or track their progress. The segmentation process is essential as it allows for a more in-depth analysis of the different types of companies within the sector and provides a clearer understanding of their roles in driving innovation and adoption of clean technologies. By categorizing cleantech companies, researchers and policymakers can more accurately target interventions, investments, and regulatory efforts to support the sector's growth.

The segmentation method employed by Ambrois et al. [6] is both innovative and thorough, combining advanced data science techniques with traditional classification methods. The first step in this process involved using a supervised machine learning (ML) algorithm, which was trained to recognize cleantech companies based on their extended business descriptions extracted from the Orbis database. These descriptions contain valuable keywords and information related to cleantech activities, such as sustainability practices, renewable energy, energy efficiency, waste management, and pollution reduction. By manually labelling a sample dataset of companies as either cleantech or non-cleantech, the algorithm was able to learn patterns in the data and build a model capable of classifying a larger dataset. This initial classification helped to identify a broad set of companies with potential cleantech characteristics.

Following this automated classification, computer-aided filters were applied to further refine the results. These filters cross-referenced additional criteria and datasets to eliminate any false positives and improve the accuracy of the classification. This two-step approach of ML and automated filtering ensured that the dataset was both comprehensive and reliable, minimizing the risk of misclassification. The final step in the segmentation process involved manual verification and categorization of the companies. This was necessary to ensure the accuracy of the classification and to assign each company to one of two main categories: **Cleantech Innovators** and the **Cleantech Ecosystem**.

Cleantech Innovators are companies that focus on developing new clean technologies and solutions that have the potential to significantly reduce environmental impact. These include firms working on next-generation renewable energy technologies, energy storage solutions, green chemistry, and sustainable materials. For instance, companies engaged in the development of advanced solar panels, hydrogen fuel cells, or next-generation recycling technologies fall into this category.

On the other hand, the **Cleantech Ecosystem** encompasses companies that are involved in the adoption, commercialization, or supporting activities related to cleantech solutions. These companies play crucial roles in enabling the scaling and distribution of clean technologies. They are further subdivided into the following categories:

- **Experimenters**: these are companies involved in experimental activities that contribute to the development and refinement of cleantech solutions. They often engage in early-stage research and development, pushing the boundaries of cleantech science.
- **Manufacturers**: these firms are responsible for producing the components, materials, and equipment required for clean technologies. Their work is fundamental to ensuring the availability of the necessary inputs for large-scale production and adoption.
- **Distributors**: companies in this category are involved in the distribution and commercial provision of cleantech products or services, ensuring that these technologies reach the market and are accessible to end users.
- **Integrators**: integrators focus on engineering, installation, and the design of systems that make cleantech solutions operational. Their work ensures that clean technologies are ready for use by consumers and businesses.
- **Operators**: these firms are involved in the construction, operation, and maintenance of facilities that utilize cleantech. They may also include adopters, such as energy

production companies, that incorporate clean technologies into their operations to reduce their environmental footprint.

This meticulous process of segmentation reduced the initial dataset of over 537.000 companies to a refined list of 23.858 cleantech companies, of which 2.990 were classified as innovators, while 20.868 were categorized as part of the broader cleantech ecosystem. By narrowing down the dataset in this way, researchers can now focus on analyzing the specific needs, contributions, and challenges faced by different groups within the sector.

This segmentation serves multiple purposes in the research, particularly in understanding how different categories of cleantech companies respond to regulatory changes, investment patterns, and market dynamics. It also allows for a more targeted analysis of the financial performance and growth trajectories of cleantech firms, which is critical for evaluating the effectiveness of policies and incentives aimed at fostering sustainability. Moreover, the segmentation enables detailed geographical analysis, which can highlight regional strengths and weaknesses within the cleantech sector, thus helping policymakers tailor interventions that support the development of cleantech hubs across Europe.

2.2.1 Database Utility

The segmented database plays a crucial role in providing valuable insights for this research, offering a multifaceted approach to understanding the dynamics of the cleantech sector in Europe. The comprehensive database serves several critical functions that are instrumental in analyzing the sector's growth and identifying the factors influencing cleantech companies.

1. **Policy Impact Analysis**: the segmentation of cleantech companies into innovators and ecosystem participants enables a more granular analysis of how different types of companies respond to varying policies and regulations. This distinction allows researchers to explore how innovations are fostered in response to supportive policies, such as financial incentives, subsidies, or market access programs. By tracking the regulatory environments in which these companies operate, it becomes possible to assess whether policy changes stimulate innovation, accelerate the adoption of clean technologies, or lead to industry consolidation. For example, analyzing the impact of the European Green Deal could reveal whether it accelerates

technological advancements or changes the competitive landscape among cleantech firms.

2. **Financial Performance and Investment Trends**: segmentation of the cleantech sector also facilitates the tracking of key financial performance indicators (KPIs) and venture capital (VC) investment patterns, providing deeper insights into how investment flows correlate with sector performance. The database enables the identification of investment trends, such as whether cleantech innovators experience a greater influx of venture capital following the introduction of supportive policies. This information is critical in understanding the financial health of the sector, determining which sub-sectors attract the most attention from investors, and evaluating the effectiveness of government initiatives in promoting the financial sustainability of cleantech firms. Tracking these patterns over time allows for more informed decisions regarding resource allocation, as well as the identification of high-potential investment opportunities.

3. **Geographical and Sectoral Insights**: the database offers detailed geographical analysis, which is essential for identifying regions with high concentrations of cleantech activities. By examining these regional clusters, it becomes clear which areas in Europe are most active in cleantech innovation and adoption. For instance, the concentration of cleantech innovators in Northern Europe, driven by favourable policies and investment climates, could be identified. This geographical insight also aids in understanding sectoral trends, such as which specific industries within the cleantech sector - like renewable energy, sustainable transportation, or waste-to-energy technologies - are thriving and which are lagging. With this knowledge, policymakers can design more targeted interventions, such as increased funding or tax incentives for underdeveloped sectors, thereby ensuring more balanced growth and fostering innovation across the entire sector.

4. **Mapping Cleantech in Europe**: one of the most valuable aspects of the database is its ability to map the distribution of cleantech companies across Europe. The geographical mapping of cleantech activities allows for the visualization of clusters of innovation and adoption, identifying areas of growth and potential for further development. For example, specific countries or regions may emerge as hubs of

cleantech development due to favourable investment conditions, policies, or technological expertise. By pinpointing these regional hubs, it is possible to focus policy efforts on areas with high potential for growth or to address disparities in cleantech development. The visual representation of this data helps inform strategic decisions for industry stakeholders, guiding efforts to support lagging regions, stimulate local economies, and promote the widespread adoption of cleantech solutions.

5. **Innovation and Patent Activity**: the focus on cleantech innovators in the database allows for an in-depth examination of technological advancements and patent activity within the sector. By analyzing the rate of patent filings and the emergence of new technologies, this research can identify which technologies are gaining traction and have the potential to transform the cleantech landscape. For example, an uptick in patents related to battery storage technology could indicate that this area is poised for significant growth, highlighting a promising opportunity for further investment and policy support. This focus on innovation and patent activity provides a critical indicator of the sector's technological trajectory and can guide decisions regarding research funding and public-private partnerships.

6. **Support Scheme Design**: a well-segmented database offers policymakers the necessary insights to design more effective support schemes for cleantech companies. Understanding the financial needs and operational challenges faced by both cleantech innovators and ecosystem participants enables the creation of more tailored funding programs and incentives. For example, early-stage innovators may require grants and subsidies to support research and development, while companies in the cleantech ecosystem may benefit from tax incentives or access to low-cost capital for scaling technologies. The database helps pinpoint the specific requirements of different types of companies, allowing for the development of more effective policies that cater to the diverse needs of the sector.

The segmentation and creation of a detailed database are foundational to this research. This approach offers a nuanced understanding of the cleantech sector, allowing for the analysis of how policies, investment trends, and technological advancements influence the growth and development of cleantech companies across Europe. By leveraging statistical tools like

Stata, it is possible to analyze the relationship between regulatory changes and the financial performance of cleantech firms, providing valuable insights for policymakers, investors, and industry stakeholders. Furthermore, the geographical mapping of cleantech companies highlights regional strengths and weaknesses in sectoral development, contributing to a more targeted and informed policy approach that supports sustainable innovation across Europe.

3. Literature Review

Before proceeding with data collection and analysis, a comprehensive literature review was conducted to understand the existing body of knowledge surrounding the cleantech sector. This phase was crucial for framing the research questions and identifying the key factors influencing the growth and development of cleantech companies. The review focused on understanding the state of the cleantech sector, examining current trends, and exploring the factors that have been identified as significant drivers for the emergence and expansion of cleantech enterprises.

The Cleantech sector has become an increasingly important part of global economic and environmental strategies. As countries strive to meet international climate goals and reduce their carbon footprints, Cleantech technologies have emerged as essential for mitigating the environmental impact of human activity. These technologies span across a range of industries including renewable energy, waste management, energy efficiency, sustainable mobility, and more. Cleantech companies are often seen as critical players in addressing the global challenges posed by climate change, offering solutions that not only reduce environmental harm but also promote economic growth and job creation.

The rise of Cleantech is not a mere trend, but part of a larger, more profound shift toward sustainable development. As defined by the European Union and other international bodies, Cleantech represents innovations designed to address the world's most pressing environmental challenges through new products, services, or processes that reduce the use of natural resources or minimize negative environmental impacts. Companies operating in this sector typically engage in the development of renewable energy solutions, pollution reduction methods, and the enhancement of energy efficiency across various sectors of the economy.

In the past few decades, Cleantech has seen significant growth, fuelled by governmental policies, public-private partnerships, and increasing consumer demand for sustainable products. This growth is not only relevant for environmental protection but is also seen as a potential driver of economic prosperity and competitive advantage.

3.1 Purpose of the Literature Review

The primary objective of the literature review was to:

1. Identify the most relevant **indicators and variables** that affect the cleantech sector, with particular emphasis on **environmental factors** (e.g., CO2 emissions, R&D expenditure, patent activity, venture capital availability).

2. Examine **policies and regulations** implemented by governments and their direct or indirect impact on cleantech company formation and growth.

3. Understand **current trends** within the cleantech industry, including market shifts, technological innovations, and the global transition towards sustainability.

4. Provide a **theoretical framework** that links **national environmental indicators** with cleantech growth metrics, helping to form the foundation for the quantitative analysis that follows.

3.2 Sources and Scope of the Literature Review

The literature review encompassed a variety of sources, ranging from academic papers to industry reports.

In order to select the relevant literature to be reviewed we proceeded with the following steps: first, we conducted an extensive search in the titles and abstracts of published, peer-reviewed articles, using a series of keywords that cover the topics under scrutiny. The selected keywords have been the following ones: Cleantech, Cleantech sector, Cleantech startups. We then selected all the relevant research published from various sources, such as academic journals, industry reports, and government publications, including those from the European Commission, OECD, and World Bank, along a proper time frame (from 2000 to 2023). We then read all those articles by choosing the ones that fit the most with the main topic and finally reviewed extensively and included them in our literature review.

- **Policy and Regulatory Analysis**: papers and reports discussing the role of government policies in fostering clean technology innovation and the broader regulatory environment shaping the cleantech sector.

- **Technological Trends**: papers that examine technological advancements, including renewable energy solutions, energy efficiency technologies, sustainable mobility, and waste management systems.
- **Economic and Financial Aspects**: articles exploring the role of financial mechanisms such as venture capital (VC), public funding, and private investment in supporting cleantech innovation.
- **Geographic and Market Insights**: research that analyses how different regions, especially Europe, have approached the cleantech sector and the varying levels of success and challenges encountered.

This diverse collection of sources helped to create a comprehensive understanding of the sector, including insights into policies, technological innovations, market conditions, and financial dynamics that have shaped cleantech development.

3.2.1 The Role of Policies and Regulations in Cleantech Growth

Environmental policies play a key role in determining the growth trajectory of Cleantech companies. At both the national and international levels, regulatory frameworks shape the incentives and barriers faced by firms in the Cleantech sector. The European Green Deal, for instance, outlines the European Union's commitment to achieving climate neutrality by 2050, with specific policies to promote renewable energy and energy efficiency, curb carbon emissions, and foster green innovation. Policies such as carbon pricing, tax incentives for sustainable practices, and funding for research and development in clean technologies are some of the tools being used to drive Cleantech adoption across Europe.

The economics literature argues that since environmental problems arise from market failures, government interventions such as taxes and/or regulations are the best way to deal with these problems[7], creating a need for policies.

These policies impact Cleantech firms in several ways. First, they create a market environment where clean technologies are incentivized through financial and regulatory benefits. Second, such policies help to increase the long-term predictability of environmental markets, providing firms with the certainty needed to make substantial investments in clean technologies.

While there aren't many studies in the literature regarding this topic, some studied provided by the European Commission, the IEA (International Energy Agency) and the IMF (International Monetary Fund) analyze the impact of policies in supporting Cleantech startups in different fields.

A study of the European Commission done in 2021 provides a selective review of policies that can help to foster a transition towards green technologies, focusing on policies that support the supply of clean technologies, such as R&D funding, as well as those supporting demand, such as carbon pricing and clean technology standards [8].

The study highlighted how technology is important to the transition into green economy, however some critical points should be highlighted: solutions to problems typically do not fall from the sky, or from market economies when markets are blinded to the problems, or by waiting for cleaner technologies to come about, but instead in designing government interventions that will tackle the various market failures at different points of the technological change pipeline. Solar power is an example of this, where multiple policies in different markets led to a strong support of demand of solar panels, which eventually led to impressive cost reductions [8].

This study also highlights the importance of the direction of technological change, and that should be evaluated not in absolute terms, but relative to dirtier solutions.

Economists have identified several market failures that contribute to clean technologies being under-provided [9][10]. The two most important ones are the environmental market failure, where pollutants are emitted as a side effect of economic activities and impose a cost on society overall, and the public-good characteristics of knowledge. When knowledge is created, it can often be acquired and used by others for free.

The variety of market failures in green technological change establishes the need for a mix of policies that go from carbon pricing and R&D subsidies to technology standards and adoption subsidies.

On the supply side, the industry's typical high capital intensity and long payback periods require patient investment with very deep pockets, which private-sector firms may not be able to provide easily. As a result, the public sector has a complementary role to play by having high er tolerance to risk and payback time, which is also critical when supporting the development of early-stage and more radical innovations [8].

Another study from the IEA [11] highlighted how important policies and programs are in order to help gaps in early stages. This study has yet to produce a consolidated catalogue of agreed best practices, however it has shown numerous ways taxpayer resources can be used to significantly boost innovation, beyond what conventional public and private sector support can do. In fact, the value of some services governments provide directly to start-ups far outweighs the financial cost to the taxpayer. This is especially true for granting access to laboratory infrastructure and using the government's brand to unite stakeholders. All those factors, driven by governments, can help cleantech startups in their growth and success.

Policies in different countries can also lead to different levels of investments, both from the private and public sectors, which are vital for cleantech startups in order to survive. As R. Bianchini and A. Croce states in their study, environmental policies can help promoting venture capital investments in companies involved in the development of clean technologies. Given this peculiar risk profile of cleantech companies, governments can play a crucial role in designing environmental policies for both demand or supply aimed at reducing the risk profile of these technologies and fostering financial investments by VC investors.

The study highlights that GVCs' (Governments Venture Capital) and IVCs' (Independent Venture Capital) investment in the cleantech sector are driven by different environmental policies. IVC investments react positively to mechanisms able to increase revenues and, with non-monotone behavior, to instruments that impose a pollution cost on companies. On the contrary, GVCs and indirect support mechanisms, such as subsidies and tariffs, result in substitutes and GVCs seem to support cleantech initiatives in countries where the implementation of environmental policies is more stringent [12]. The financial part of cleantech startups will be discussed in more detail later in the literature review.

3.2.2 Innovation as a Driver of Cleantech Growth

Innovation is often seen as the backbone of the Cleantech sector. The rapid pace of technological advancement in renewable energy, waste management, energy storage, and other Cleantech solutions is essential for addressing environmental challenges. However, the creation of new, sustainable technologies requires significant investment in research and development (R&D), a process that can be hindered without adequate financial support. The role of national governments and the private sector in fostering innovation through funding, policy, and infrastructure is therefore crucial.

Innovative technologies in Cleantech encompass a wide range of solution, ranging from next-generation solar panels, advanced wind turbines, and energy-efficient systems for both residential and industrial use. One area where innovation has been particularly promising is in the development of energy storage technologies, which are crucial for integrating renewable energy sources into the grid. This is because energy generation from renewable sources like wind and solar is intermittent, and efficient storage technologies are needed to smooth out supply-demand imbalances.

The innovation against policy indicators is studied by some papers, which highlight the importance of stronger policies. A study of Eugster analyses the impact of environmental policy on innovation in clean technologies, underlining the positive impact over the cleantech sector. The paper's main conclusions are three-fold. First, tightening environmental policies made a statistically and economically significant contribution to increased innovation in clean technologies, with effects of such a tightening materializing rather quickly, becoming statistically significant almost immediately and strengthen over the first 2 to 3 years after the policy change. Second, distinguishing between different technologies, the paper finds that both market policies (including trading schemes and feed-in tariffs) as well as non-market policies (including emission limits (e.g. on power plants) and R&D subsidies) made positive, statistically significant and roughly comparable contributions to clean innovation, making the result encouraging in two ways. It first confirms that market mechanisms are effective at stimulating innovation, consistent with models of endogenous technological change, where the expected future demand for a product can incentivize research into producing it more efficiently. Finally, the paper looks at whether environmental policies induce additional innovations or merely change its composition towards cleaner alternatives. Focusing on electricity related technologies only, the paper finds that policies contributed to a shift in the composition of innovation away from dirty towards clean as well as "grey" technologies. This suggests that the technological improvements necessary to curb climate change will not only come from entirely new green technologies, but also from increased carbon efficiency of *a priori* dirty technologies [13].

These, as well as Johnstone et al [14], generally provide support for the idea that clean innovation can be "induced" by environmental policies.

In addition to technological innovation, policy-driven innovation is also vital for Cleantech development. Countries that provide financial incentives for R&D in sustainable technologies tend to see more innovation in the sector. For instance, nations with robust patenting systems and strong intellectual property protection offer a better environment for Cleantech firms to protect and commercialize their innovations [14][15]. Moreover, policies that promote cross-sectoral collaboration between private firms, universities, and government agencies have been instrumental in accelerating the pace of innovation within the Cleantech space.

3.2.3 Venture Capital and Financial Support in Cleantech

Literature has extensively analysed the impact of venture Capital in the cleantech sector, given the importance of financing research and development of new technologies, and how those funds can influence and drive this sector.

Access to capital is a critical factor for the development and growth of Cleantech companies. Given the capital-intensive nature of many Cleantech innovations, venture capital (VC) plays an essential role in financing the early-stage growth of startups. The Cleantech industry, however, faces particular challenges related to the riskiness and long-time horizon of these investments. Venture capital funds are essential for bridging the financing gap between early-stage concept development and commercialization.

Firstly, we should wonder why Corporate Venture Capitalists invest in the cleantech sector. A study from Hegeman and Sørheim tries to highlight why this is the case, despite the riskier nature of this type of investment: in general, CVCIs invest for more than purely financial gain, balancing a mix of financial and strategic reasons as well [17], which can be as important as the financial return itself. The goal of strategic investments is to benefit the companies' own businesses, which can take different forms. Investing in a startup can provide the CVCI with insights into new technologies and practices [18][19][20][21][22]. Companies can also invest because of the early window on new markets or on government development that these investments provide [23]. In all these cases, CVC is associated with explorative learning [24], which requires the investment target to have a certain distance from the investor's existing knowledge base [25]. In other cases, a CVCI contributes to a startup that is developing a complementary product, as it may increase the demand for the CVCI's own products [26][27]. By making CVC investments, a company will also be exposed to entrepreneurial knowledge, culture and thinking, which may again enhance its innovative capabilities [28][29]. Even if the investment fails, the learning provided to the investing firm can be such that the endeavor is still regarded as a success because of strategic returns [30][31].

There are also substantial differences between cleantech venture capital and typical venture capital investment: it tends to be very capital intensive and faces greater technological risks associated with the functioning of technology, scalability and exit requirements than the typical venture capital investment. Moreover, unlike the typical venture capital investment, the benefits arising from cleantech cannot be totally captured by the venture capitalist as many of its benefits accrue to society via reduced environmental degradation and better health and quality of life outcomes, for example cleantech investments that improve air/water quality, will benefit everyone, including competitors [30][31]. This study concludes that there are several factors that can influence VC investments in the cleantech sector: government effectiveness and rule of the law each have positive and statistically significant impacts on cleantech VC deals; media coverage is found to be an important explanatory variable of cleantech VC deals, helping to build image, reputation, and legitimacy and these factors help to increase the growth of new markets; oil price also have an influence on VC investment, increasing the rate of investments with a slowing rate of increase (this could be done to the fact that higher oil prices can lead to exploitation of more expensive and polluting oil deposits).

However, the type of venture capital available and the geographical distribution of this funding can significantly influence the success of Cleantech ventures. Countries with higher levels of VC funding, especially in Cleantech and sustainability-focused sectors, tend to have a more vibrant Cleantech ecosystem. Conversely, a lack of adequate VC resources in countries with high demand for Cleantech solutions can slow the growth of new companies in these regions [31][32].

Beyond venture capital, governments also play a role in funding Cleantech through grants, subsidies, and research collaborations. These mechanisms help offset the risks associated with the initial stages of Cleantech innovation, providing firms with the financial resources necessary to scale their technologies. Financial tools such as carbon credits, green bonds, and subsidies for energy efficiency improvements have become increasingly important for both private and public sector players in the Cleantech market.

However, VC investments cannot always be profitable, as the lesson from the boom-and-bust cycle from 2006 to 2011 teaches. The cleantech sector gained considerable investor attention in the years before the investment peak of 2008. A number of factors contributed to increased investor appetite for the sector, which rose sharply starting in 2006, such as the increase in oil and energy prices in the US.

Venture capital (VC) firms spent over $25 billion funding clean energy technology (cleantech) start-ups from 2006 to 2011. Less than half of that capital was returned; as a result, funding has dried up in the cleantech sector.

The cleantech boom-and-bust demonstrated that cleantech investment are poorly suited to the VC investment model for many reasons, some of them are explained earlier in the paragraph. The study proposes that broader support from policymakers, corporations, and investors is needed to underpin new innovation pathways for cleantech, with the support of R&D, incubators and encouraging policies that increases participation in cleantech innovation, both from corporations and institutional investors [33].

Another method of cleantech financing is crowdfunding, a method of raising capital from a large number of people, typically via online platforms. It allows individuals, startups, and businesses to gather small contributions from a broad audience instead of relying solely on traditional funding sources like banks or venture capital. Crowd funding has recently emerged as an effective alternative to traditional entrepreneurial finance, with the potential of transforming the financial landscape for young innovative ventures [34]. The study examines the relationship between risk and returns in crowdfunding. The authors find that, on average, project returns are negatively related to risk; however, projects offering better risk-adjusted returns tend to attract larger average contributions. Behavioral factors like bounded rationality or altruism may explain this apparent mispricing of risks. The study provides important lessons for policymakers, that should improve the technological risk-adjusted returns of emerging technologies in order to attract larger investors that provide higher average investments, that could make this form of investment viable and sustainable for this sector, even for projects with high risks, by unlocking the potential of investments by a large number of micro funders [34].

All of these studies highlight how different and complex the financing of the cleantech startup sector could be, given the uncertain and complex nature of it, while remarking the importance of the sector for the future of the environment and our planet, thus inviting policymakers to be more effective in their critical role.

3.2.4 Environmental and Technological Indicators Affecting Cleantech Growth

Several environmental and technological indicators are critical in assessing the potential growth of Cleantech companies. Among these, CO_2 emissions levels, national R&D spending, patent activity, and the concentration of venture capital are key factors that influence Cleantech entrepreneurship. Countries with lower levels of CO_2 emissions, higher spending on R&D, and strong patenting activity often see higher levels of Cleantech innovation and entrepreneurship.

The correlation between environmental performance (e.g., emission reductions) and innovation is an essential topic in environmental economics. Studies have shown that countries with stringent emissions reduction policies tend to foster greater technological innovation, particularly in sectors that are most affected by environmental regulations. For instance, carbon-intensive industries like energy and transportation often require major innovations to meet regulatory standards, creating opportunities for Cleantech firms to develop disruptive technologies [35][36].

Similarly, the availability of venture capital and other financial mechanisms is crucial for the scalability of Cleantech firms. Countries with a high concentration of venture capital dedicated to green technologies are better equipped to support the rapid growth of Cleantech startups. In contrast, nations with limited financial resources for innovation often experience slower development in the Cleantech sector. This highlights the need for integrated policies that not only support innovation but also ensure that financial resources are available to scale successful technologies.

3.3 Conclusion & Implications for the Current Research

The literature on Cleantech growth emphasizes the critical role of environmental policies, innovation, financial support, and regulatory frameworks in fostering the development of Cleantech companies. However, while significant work has been done on the effects of these factors at the global level, there remains a need for more detailed research on the interaction between country-level indicators and Cleantech entrepreneurship. The literature review provided essential insights that directly inform the design and focus of the current study. The following implications were drawn:

- **Policy Impact**: national and European-level policies significantly influence the cleantech sector. Thus, understanding how policies interact with environmental and economic variables will be a central focus of the analysis.
- **Financial Support Mechanisms**: the role of venture capital and government funding is crucial for cleantech startups. It will be important to explore how access to financial resources impacts firm growth, particularly in different national contexts.
- **Technological Innovation**: R&D expenditure and patent activity will serve as critical indicators for analyzing innovation within cleantech firms.
- **Geographic Variability**: the research will analyze how cleantech growth varies by region, identifying countries that are outliers or leaders in cleantech development.

By addressing these points, the literature review has helped establish the foundational knowledge required to evaluate the relationship between environmental indicators, national policies, and cleantech firm growth. The next step in the research will involve applying this knowledge through **statistical analysis** and **policy comparison** encompassing all those indicators in order to empirically test the hypotheses related to the growth of cleantech firms in different countries, and which factors can contribute the most to this sector.

4. Research Methodology

In this study, an accurate and well-structured methodology is essential to explore the enabling factors that influence the development of cleantech companies in Europe. The methodology adopted in this research is divided into several phases, each contributing to a comprehensive and detailed understanding of the phenomenon under examination.

4.1 Research Objectives

The cleantech sector is essential for addressing the world’s most pressing environmental challenges, including climate change, resource depletion, and pollution. The expansion of this sector has the potential to drive both environmental and economic transformation by fostering the development of new technologies and solutions aimed at reducing environmental impacts. However, the success and growth of cleantech companies are significantly influenced by the regulatory and policy environment in which they operate. Therefore, understanding the factors that drive the growth of these companies, particularly the influence of national and European policies, is crucial for ensuring the continued success of the sector. The objective of this research is to investigate these key factors, with a particular focus on policies and regulations at both the European and national levels, as well as the trend of investments in the sector and how these influence the creation and development of cleantech companies in different European countries.

4.1.1 Specific Objectives

Analyze the European Regulatory Framework

A key objective of this research is to analyze in detail the policies and regulations introduced by the European Union, particularly the European Green Deal. This analysis will involve reviewing key directives, regulations, and initiatives that regulate the environmental impact of human activities and support the cleantech industry. Understanding the impact of these EU policies is essential to assess how effectively they are fostering a favourable environment for cleantech technologies. For instance, the European Green Deal outlines ambitious objectives, including carbon neutrality by 2050, which has the potential to significantly influence the cleantech sector by creating long-term demand for sustainable solutions. It will also be important to evaluate whether EU funding programs, such as Horizon Europe, are adequately supporting cleantech innovation across the region. By analyzing these frameworks, the research aims to assess whether they sufficiently address the needs of cleantech firms and the challenges they face in terms of market access, regulation, and financing [37][38].

Evaluate National Policies

In addition to the EU-wide regulatory framework, individual member states have implemented specific policies designed to support cleantech industries. The research will explore how these national policies differ across countries and examine the outcomes of their implementation. This analysis will provide valuable insights into the varying effectiveness of these policies in different contexts, as some countries may offer more robust support for cleantech companies, while others may face barriers to their growth. For example, certain countries may prioritize market-based policies, while others may implement more direct interventions like subsidies, grants, or tax incentives. By comparing these national policies, the research aims to identify best practices and highlight the most effective policy mechanisms that could be replicated across other national contexts to further accelerate cleantech innovation and adoption [39][40]. Furthermore, the research will also consider the interaction between these national policies and other country-level factors, such as economic development, infrastructure, and innovation capacity, which can influence the success of cleantech firms. By examining how policies work in synergy with these factors, the study aims to provide a deeper understanding of the conditions that foster a thriving cleantech ecosystem in various countries.

Identify Financial Support Mechanisms

An essential aspect of this research is to explore the financial support mechanisms available for cleantech companies at both the European and national levels. The availability of funding, particularly for early stage firms, plays a critical role in the development and scaling of cleantech innovations. The research will examine how government funding programs, tax incentives, and grants are structured to support cleantech startups, as well as the role of venture capital in funding these companies. VC investment has become increasingly important in supporting cleantech firms, especially in the early stages of their development, as it provides the necessary capital to drive innovation and scale operations.

The study will also explore how the presence of venture capital in specific countries influences the growth of cleantech companies. By comparing the amount of VC funding available in countries with strong cleantech sectors versus those with less developed industries, the research aims to identify the relationship between financial support and the success of cleantech enterprises. Additionally, it will examine how financial tools, including green bonds, green loans, and other alternative financing mechanisms, can be leveraged to further promote the cleantech sector [41][42][43][44].

Analyze the Relationship Between Policies and Company Value Using Statistical Analysis

A key objective of this research is to evaluate the relationship between the introduction of new environmental policies and the financial performance of cleantech companies. This will be done through statistical analysis using software such as Stata, allowing for the empirical testing of whether new laws and regulations lead to tangible economic outcomes for cleantech firms. The analysis will focus on the average value of cleantech companies across countries, correlating the implementation of policy changes with metrics such as company growth, sales, employee numbers, and overall market value. In particular, the research will investigate whether countries that have introduced more stringent environmental regulations, higher levels of funding, or more robust financial support mechanisms see better economic outcomes for their cleantech firms. This quantitative analysis will provide critical insights into how policies and regulatory changes impact the growth trajectory of cleantech companies and whether these effects differ across national contexts.

4.2 Research Design and Approach

This research is based on a mixed-methods approach, integrating both quantitative and qualitative techniques to ensure a comprehensive understanding of the factors affecting cleantech companies. The aim is to determine how environmental indicators, such as CO2 emissions, research and development (R&D) expenditures, and venture capital funding, interact with policies and regulations to shape the emergence and growth of cleantech startups across Europe. Specifically, the study uses secondary data analysis, regression modelling, and qualitative insights from industry stakeholders to explore these relationships.

The research design is divided into two main stages:

1. **Data Collection and Pre-Processing**: this includes gathering data from various sources such as OECD, Eurostat, national regulatory databases, and Orbis to provide a holistic picture of environmental indicators and cleantech firm performance.

2. **Data Analysis and Interpretation**: this phase involves applying statistical techniques (such as regression analysis and correlation analysis) to identify relationships between country-level environmental factors and the growth metrics of cleantech firms.

4.3 Data Collection

4.3.1 Data Sources

The primary source of data for this research will come from secondary data obtained from various databases and industry reports. These sources are invaluable for understanding both the environmental context and firm-level performance.

- **OECD Database**: The OECD provides a comprehensive set of environmental and economic indicators, including carbon emissions, energy consumption, research and development (R&D) spending, and innovation activity across different countries. These variables will be critical for understanding how national policies and environmental factors influence the growth of cleantech companies.

- **Eurostat**: Data from Eurostat will complement the OECD data, offering more granular insights into country-specific economic and environmental trends. This data includes information on renewable energy adoption, waste management practices, and investment in clean technologies.

- **Orbis Database**: This database contains information about the financial performance and structure of millions of companies worldwide. The data from Orbis will be used to assess the performance of cleantech firms, such as annual sales, growth in the number of employees, patent activity, and more. By cross-referencing this with environmental data, it will be possible to evaluate the correlation between environmental indicators and company performance in the cleantech sector.
- **National Policy and Regulatory Databases**: National policy data, including climate change policies, subsidies, tax incentives, and environmental regulations, will be sourced from country-specific governmental and international organizations. This data is essential for understanding the regulatory environment in which cleantech companies operate.
- **Venture Capital and Innovation Data**: The role of venture capital (VC) in the cleantech sector is critical for assessing firm growth. Data on VC investments in cleantech companies will be obtained from databases such as Crunchbase or PitchBook. Additionally, patent data will be analyzed to assess the level of technological innovation within the sector.

4.4 Statistical Analysis

The statistical analysis is the backbone of this research, enabling the exploration of the relationship between environmental indicators and the growth of cleantech companies. Various statistical techniques will be employed to test the hypotheses and investigate how policy measures and other environmental factors influence the performance of cleantech firms. The analysis will primarily involve regression models, correlation analysis, and time-series analysis, each contributing to different aspects of the research questions.

4.4.1 Regression Analysis

A key component of the methodology is the use of regression analysis to examine how various environmental indicators impact the growth of cleantech companies, allowing the identification and quantification of relationships between dependent and independent variables, providing insight into which factors most significantly affect firm performance.

The dependent variables in this analysis will be the growth metrics of cleantech firms, including:

- **Sales growth**: The percentage change in the annual revenue of cleantech companies, which is a direct indicator of financial performance.
- **Number of employees**: The growth in the number of employees within cleantech firms, which serves as a proxy for the expansion of business activities and market presence.
- **Firm age**: The length of time since a firm was established, used to analyze how the age of a firm influences its ability to scale and adapt to market conditions.

The independent variables will include a range of environmental indicators, such as:

- **CO2 emissions reduction targets**: the goals set by countries to reduce greenhouse gas emissions, which could directly affect cleantech innovation and firm growth by increasing demand for clean technologies.
- **R&D expenditure by country**: national investments in research and development, which drive innovation and technological advancement within cleantech sectors.
- **Venture capital investment levels**: the amount of venture capital funding available for cleantech startups, which can significantly impact their ability to scale and commercialize new technologies.
- **Government policy incentives related to cleantech**: policies and financial incentives such as subsidies, tax breaks, or grants that aim to promote the growth of the cleantech sector.

Multiple linear regression models will be used to estimate the relationships between these variables, allowing for the testing of hypotheses about how environmental factors and policies influence firm growth in the cleantech sector. The regression model will help answer key questions about the role of policy support, innovation, and financial backing in fostering the development of cleantech companies.

4.4.2 Correlation Analysis

In addition to regression analysis, correlation analysis will be employed to explore the strength and direction of relationships between key variables. Correlation analysis provides a useful means of understanding how variables move in relation to one another, helping to identify patterns that might not be immediately apparent through regression alone.

For example, one of the key relationships to explore is the correlation between the level of **venture capital investment** and the number of **cleantech startups** in a given country. It is expected that higher levels of venture capital funding will correlate with a greater number of startups entering the cleantech market, as access to financial resources is a significant enabler of new business formation.

Another relationship to explore is the correlation between national **CO2 emissions** and **cleantech innovation** (measured through patent filings). This analysis will provide insight into whether countries with higher emissions are investing more in cleantech innovation, as part of their efforts to mitigate climate change and meet their emissions reduction targets.

4.4.3 Time-Series Analysis

Time-series analysis will be used to examine trends over time and assess how the introduction of new environmental policies correlates with changes in cleantech company growth metrics. This method is particularly useful for understanding the long-term effects of policy interventions, as it allows for the analysis of trends in data over multiple years.

For example, one key area of focus will be the **European Green Deal** and its impact on cleantech firms. Time-series analysis will allow us to track how the implementation of this policy has influenced the growth metrics of cleantech companies across Europe over time. By analyzing trends before and after the introduction of specific policies, we can gain insight into the effectiveness of these regulations in promoting innovation and firm expansion within the cleantech sector.

Overall, the combination of regression analysis, correlation analysis, and time-series analysis provides a comprehensive approach to investigating the impact of environmental policies and indicators on cleantech company growth. This methodology will help identify key drivers of success in the cleantech sector and inform future policy recommendations aimed at fostering the growth of this critical industry.

5. Dataset Description

The dataset utilized in this research serves as the central tool for analyzing the growth and performance of cleantech companies, focusing on various critical business and economic metrics. This comprehensive dataset provides a broad view of cleantech firms operating across multiple European countries (as well as the United States), with data organized by year. The primary focus is on understanding the growth trajectories of cleantech companies, measured through sales, employee numbers, and firm creation, along with the factors that influence these dynamics.

5.1 Data Segmentation

The data is segmented into several important attributes, allowing for detailed tracking of each firm's performance over time, both in terms of absolute values and growth rates. The dataset includes metrics on sales, employee growth, and the emergence of new firms in the cleantech sector, each broken down by country and categorized by different cleantech segments, such as innovators, distributors, and ecosystem players.

5.1.1 Sales Data

The sales data provides a detailed analysis of the revenue generation of cleantech firms over multiple years, with specific metrics focusing on both average sales and the growth rates of those sales in the years following the founding of each firm. These variables are essential for understanding the financial trajectory of cleantech companies, as they reflect how well these firms are scaling their operations and capturing market share. The specific metrics include:

Ysales3YafterFY	Average value of sales in the 3 years following their founding
Ysales5YafterFY	Average value of sales in the 5 years following their founding
Ysalesg3YafterFY	Average growth of sales in the 3 years following their founding
Ysalesg5YafterFY	Average growth of sales in the 5 years following their founding
Ysales3Yafter	Average value of sales in the 3 years following the year
Ysales5Yafter	Average value of sales in the 5 years following the year

Ysalesg3Yafter	Average growth of sales in the 3 years following the year of the table
Ysalesg5Yafter	Average growth of sales in the 5 years following the year of the table

Table 1-Dataset fields of sales

These sales metrics are categorized across the cleantech sector as a whole and further divided into specific subcategories, such as Innovators, Distributors, and Ecosystem companies. This segmentation allows for a more nuanced analysis of how different types of cleantech companies perform and scale over time, offering valuable insights into which segments are leading in sales growth and which ones require more support or investment.

5.1.2 Employee Data

Another key component of the dataset is the employee data, which provides a snapshot of how cleantech firms grow in terms of workforce size. Employee growth is an important indicator of a firm's expansion, as it reflects how companies are scaling their operations to meet growing demand. The employee-related variables are structured similarly to the sales data, with focus on both the average number of employees and the growth in employee numbers over time:

YEmp3YafterFY	Average number of the employees in the 3 years following their founding
YEmp5YafterFY	Average number of the employees in the 5 years following their founding
YEmpg3YafterFY	Average growth of employees in the 3 years following their founding
YEmpg5YafterFY	Average growth of employees in the 5 years following their founding
YEmp3Yafter	Average number of employees in the 3 years following the year
YEmp5Yafter	Average number of employees in the 5 years following the year
YEmpg3Yafter	Average growth of employees in the 3 years following the year of the table
YEmpg5Yafter	Average growth of employees in the 5 years following the year of the table

Table 2-Dataset fields of employees

These metrics allow for a detailed longitudinal analysis of how workforce expansion correlates with company performance, and they are also segmented by the cleantech sectors to identify specific trends within each industry. By analyzing employee growth alongside sales data, the research can offer deeper insights into the operational scaling of cleantech firms.

5.1.3 Firm Birth and Growth Data

The dataset also includes data on the birth and growth of cleantech firms across the selected countries. This is crucial for understanding how the cleantech sector is evolving over time, particularly regarding the number of new firms entering the market each year. The specific variables in this category are as follows:

Y n comp born	Number of new cleantech firms that were born in each country in a given year
perc n comp born	Percentage of new cleantech firms born in each country in a given year

Table 3-Dataset fields of new companies bornw

These variables are crucial for understanding the dynamics of firm entry into the cleantech sector, helping to analyze how favourable environmental policies, financial conditions, and market opportunities influence the birth rate of cleantech companies. In addition, the data is further segmented into specific categories such as cleantech ecosystem firms, which helps to track not only the total number of firms but also the breakdown of firms across various subcategories, such as Innovators, Manufacturers, Distributors, and Integrators.

5.1.4 Categorization of Firms

A critical element of this dataset is the categorization of cleantech companies into different types, as this allows for a deeper understanding of the sector's dynamics. Firms are categorized into **Cleantech Innovators** and the **Cleantech Ecosystem** (which are subdivided into *distributors, experimenters, integrators, manufacturers, operators* as explained in chapter 2).

The categorization allows the research to focus on how different types of firms contribute to the overall growth of the cleantech sector. By breaking down data across these categories, it is possible to assess how different factors, such as policy interventions, R&D investment, or venture capital funding, have varying effects on the growth of each segment within the cleantech ecosystem.

5.2 Data Analysis

Below is a detailed comparative analysis of the data provided in the pivot tables for ***Italy, France, Germany, the Netherlands,*** and ***Denmark***. The countries focused on in this research have been selected due to their significant roles in the European cleantech sector. Each of these countries exhibits unique characteristics in terms of regulatory frameworks, government policies, and cleantech investments. The focus on these nations allows for a comparative analysis of how different national contexts shape the emergence and performance of cleantech companies. Therefore, this analysis focuses on the birth of new enterprises, sales generated five years after their establishment, and employment levels five years after establishment. The goal is to provide an extensive descriptive assessment of the economic dynamics in the selected countries.

5.2.1 Analysis of New Enterprise Births

The number of new enterprises created annually in the five countries is given by the variable "Y_n_comp_born". This metric provides insights into the entrepreneurial activity and market dynamism within each country.

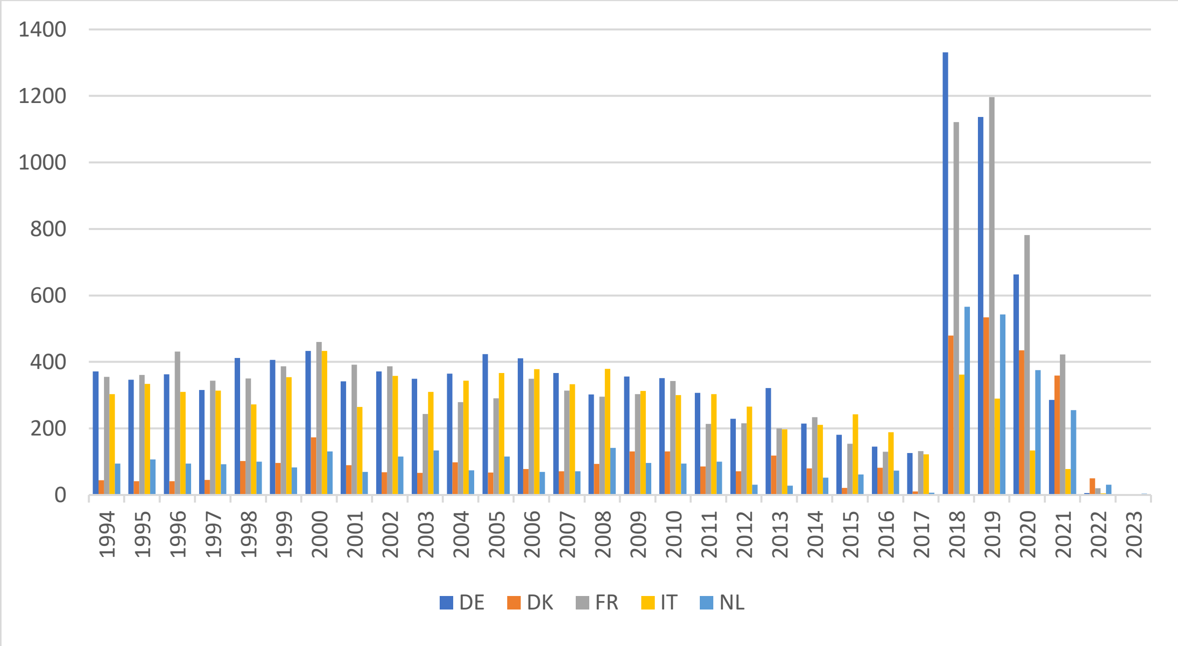

Figure 1-Chart of number of cleantech firms born over the years

The provided chart and table illustrate the number of new enterprises born annually from 1994 to 2023 for five countries: Germany (DE), Denmark (DK), France (FR), Italy (IT), and the Netherlands (NL). Below is an in-depth analysis of the data trends and patterns:

The total number of new enterprises shows a steady trend from 1994 until approximately 2017, with notable peaks around specific years (e.g., 2018-2019). After 2019, there is a significant decline in the number of new enterprises across all countries, likely due to external factors such as the global pandemic and its economic repercussions.

Germany consistently exhibits the highest number of new enterprises annually, reflecting its strong and stable entrepreneurial ecosystem. For example, in 1994, Germany reported 372 new enterprises, while Denmark had only 44, emphasizing the disparity in scale. On the other hand, **France and Italy** generally follow Germany, showing competitive but smaller numbers of new enterprises. Italy shows slightly higher figures than France in earlier years, but both countries remain significantly below Germany. Finally, **Netherlands and Denmark** have the lowest counts among the five. Denmark shows particularly low figures, consistent with its smaller population and focus on high-quality rather than high-quantity entrepreneurship.

Country Breakdown:

- **Denmark:** Denmark's entrepreneurial activity shows moderate but steady growth. For example, in 1994, 120 new enterprises were established. The number remained consistent, with 128 in 1995 and 130 in 1996. These figures highlight Denmark's focus on quality-driven startups rather than sheer volume. Denmark's policies, which emphasize sustainable growth and innovation, likely play a role in fostering a steady pipeline of new businesses.
- **Germany:** Germany remains a leader in new enterprise births. In 1994, 372 enterprises were established. The figures slightly declined in subsequent years, with 347 in 1995 and 363 in 1996. The high numbers reflect Germany's robust market infrastructure and strong support systems for entrepreneurship. However, the slight dip suggests potential challenges such as market saturation or increasing competition.
- **France:** France also demonstrates strong entrepreneurial activity. In 1994, 355 new businesses were established. This number grew to 361 in 1995 and peaked at 431 in 1996. France's upward trend highlights its dynamic business environment, likely supported by government incentives and access to international markets.
- **Italy:** Italy's performance is stable but lags behind Germany and France. In 1994, 303 new enterprises were established. This increased to 334 in 1995 before slightly decreasing to 310 in 1996. Structural challenges, such as bureaucratic hurdles and limited access to credit, might be hindering higher growth rates in entrepreneurial activity.
- **Netherlands:** The Netherlands reports consistently lower figures compared to the larger economies. In 1994, 94 new enterprises were established. This number remained stable in 1995 and 1996. Despite the lower volume, the Netherlands excels in fostering high-quality, niche-focused startups, reflecting its emphasis on innovation and specialization.

During the analysed period, the cleantech sector - both in terms of ecosystem participation (**perc_n_comp_born_cleaneco**) and innovation-focused enterprises (**perc_n_comp_born_clean**) - shows distinct trends across the five countries. Denmark stands out as a leader, maintaining high percentages in the cleantech ecosystem metric throughout the late 1990s and early 2000s, with peaks such as **44.91% in 2001**, indicating a sustained focus on eco-friendly and sustainable industries. Similarly, its leadership in cleantech innovation becomes more evident after 2000, with percentages steadily increasing and reaching a significant **14.23% in 2017**, suggesting a strong national emphasis on cutting-edge clean technology. Germany also shows substantial engagement in the cleantech ecosystem in the earlier years, with percentages hovering around 30-40% during the 1990s. However, a gradual decline after 2008, coupled with a reduced presence in cleantech innovation (dropping to **0.79% in 2017**), suggests a potential shift in focus or market dynamics.

France and Italy exhibit comparatively lower percentages across both metrics, with France consistently contributing minimal figures in cleantech innovation (often below 2%) and showing limited alignment with cleantech ecosystem efforts. Italy, while relatively consistent, does not surpass the mid-20% range in cleantech ecosystem metrics and shows sporadic engagement in innovation, with occasional peaks such as **4.47% in 2008**. The Netherlands displays significant early contributions to the cleantech ecosystem, with percentages comparable to Denmark in years like **2001 (49.11%)**, but its engagement diminishes over time. However, it occasionally demonstrates stronger contributions to innovation (e.g., **7.38% in 2009**), reflecting a more niche, high-value focus. Across all countries, the years 2000-2001 and 2018-2019 appear to mark pivotal moments, characterized by surges in cleantech ecosystem activity, while the period after 2020 highlights a stark drop, likely due to external economic pressures or global challenges such as the COVID-19 pandemic.

5.2.2 Analysis of Sales Five Years After Establishment

The dataset provides data on the revenue generated by enterprises five years after their establishment. This metric offers insights into the economic impact and scalability of startups in each country. In particular, the data analysed highlights the performance of enterprises in terms of their average sales (**Ysales5YafterFY**) and their average sales growth (**Ysalesg5YafterFY**) during the five years following their establishment. Across the analyzed countries there are notable disparities in both metrics, reflecting differences in entrepreneurial ecosystems and economic environments. Germany and France dominate in terms of absolute sales, consistently leading in **Ysales5YafterFY** values across the period.

Denmark and the Netherlands, while trailing in overall sales, showcase unique patterns of growth, with Denmark exhibiting significant negative spikes, suggesting potential instability or challenges in scaling. Italy's performance remains consistently modest, struggling to match the sales levels or growth trajectories of its counterparts.

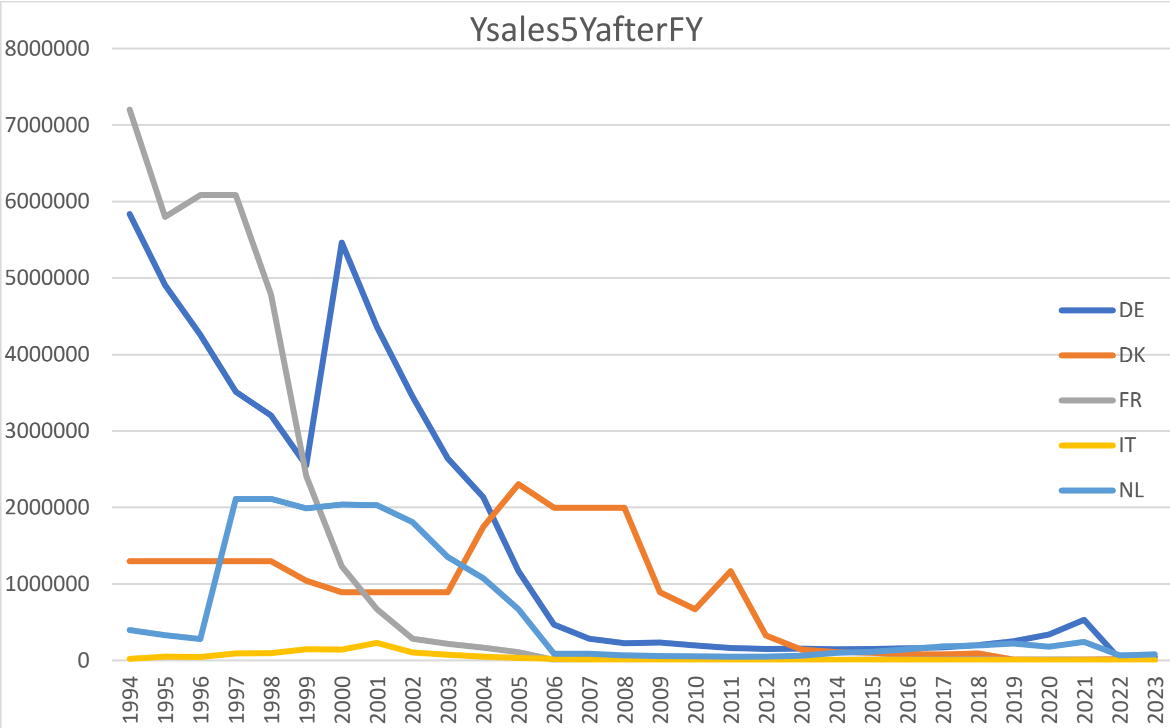

Figure 2- Sales after five years of birth for selected countries

Country Breakdown:

- **Germany:** demonstrates the highest absolute sales values (**Ysales5YafterFY**) across the years, totalling over **47 million monetary units** by the end of the period. This reflects Germany's robust market infrastructure and the scalability of its enterprises. Despite its strong sales figures, Germany's growth rates (**Ysalesg5YafterFY**) exhibit a gradual decline post-2000, suggesting a maturing entrepreneurial ecosystem with limited room for rapid expansion in established markets.
- **Denmark:** presents an intriguing case, with **Ysales5YafterFY** values significantly lower than Germany and France but still showing consistent performance in earlier years (e.g., **~12 million monetary units in 1994-1996**). However, the growth metric (**Ysalesg5YafterFY**) reveals stark volatility, with notable negative dips around 1999 and 2009. This pattern indicates potential challenges in maintaining growth or the susceptibility of Danish enterprises to external economic pressures.

- **France:** closely trails Germany in terms of **Ysales5YafterFY**, achieving a total of **35 million monetary units** over the analyzed years. The data reflects a steady sales performance, particularly during the mid-1990s. In contrast, France's growth rates show relative stability without significant volatility, suggesting a balanced but conservative entrepreneurial environment where enterprises grow at a steady pace without major fluctuations.
- **Italy:** performance is consistently modest, with **Ysales5YafterFY** values totalling just **12 million monetary units** by the end of the period. Growth metrics are similarly subdued, averaging **~0.2 growth rates** in most years. This underperformance highlights structural challenges such as limited scalability and constrained market opportunities for Italian enterprises, which lag behind their European counterparts.
- **Netherlands:** displays a mixed profile, with **Ysales5YafterFY** values reaching **18 million monetary units**, placing it ahead of Denmark and Italy but behind Germany and France. The growth metric (**Ysalesg5YafterFY**) shows more positive performance, particularly in years like 2009, where spikes suggest moments of rapid expansion for specific sectors or enterprises. This indicates that while Dutch enterprises may not achieve the highest sales, they are capable of significant growth under favourable conditions.

5.2.3 Analysis of Employment Five Years After Establishment

From the dataset the average number of employees (**YEmp5YafterFY**) and the average growth in employees (**YEmpg5YafterFY**) over five years following the establishment of enterprises have been analysed. The data and graphs reveal disparities in enterprise employment contributions across countries and years, with distinct trends and outliers.

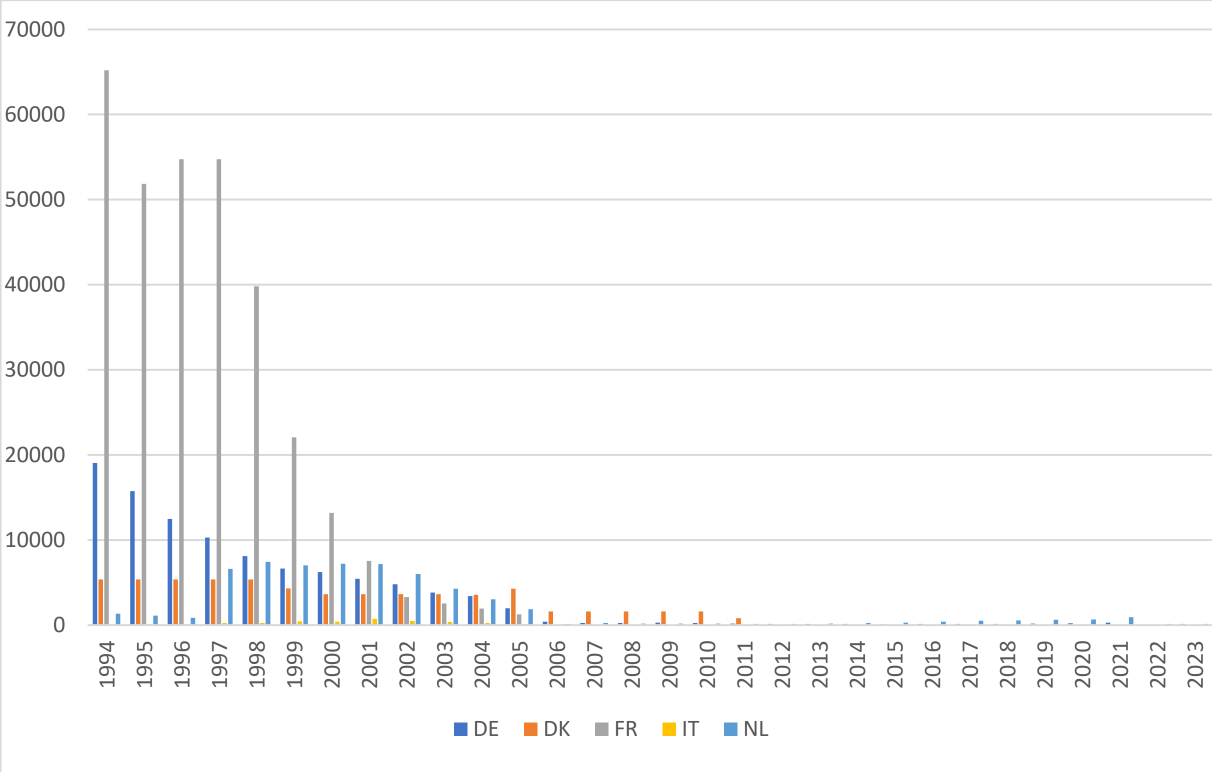

Figure 3-Employment five years for selected countries

General Trends and Country Comparisons

The **YEmp5YafterFY** data highlights significant differences in enterprise employment contributions. France consistently outpaces other countries in terms of absolute employee counts, with a peak in 1994 (**65,222 employees**) and significant totals throughout the analyzed period. Germany follows with consistently high employee figures, particularly in earlier years (e.g., **19,054 employees in 1994**) before declining steadily. Italy, the Netherlands, and Denmark lag behind, with Denmark showing particularly modest numbers, rarely exceeding **5,000 employees** annually. The data indicates that larger economies like France and Germany are able to scale businesses more effectively to contribute to higher employment.

In terms of growth (**YEmpg5YafterFY**), trends are more volatile across countries. Denmark shows sharp fluctuations, with notable growth peaks in the late 1990s (e.g., **~0.15 growth in 1998**) and then steady declines post-2010. France and Germany show relatively stable growth rates, typically in the range of **0.1–0.15**, but both countries exhibit diminishing returns over time. Italy and the Netherlands exhibit sporadic increases, with occasional spikes suggesting sector-specific or policy-driven growth moments, but they generally remain below France and Germany.

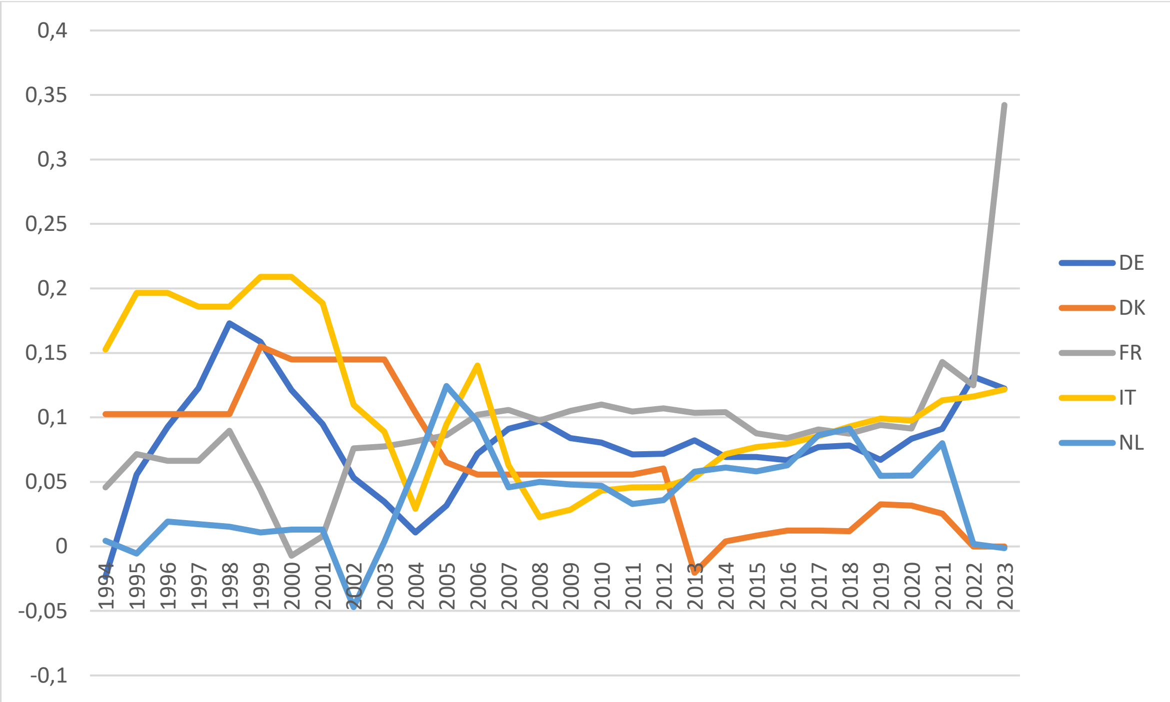

Figure 4- Employee growth in selected countries

Country Breakdown:

- **France**: France dominates in terms of absolute employment contribution, with the highest employee averages across nearly all years, particularly in the 1990s. This is indicative of large-scale enterprises with a significant capacity to employ. Growth, while steady, exhibits no major peaks, highlighting a stable but mature market with consistent employment trends.
- **Germany**: Germany ranks second in employment contributions, with strong performance in earlier years (e.g., **19,054 employees in 1994**) but a steady decline thereafter. Growth rates remain stable, suggesting Germany's enterprises maintain consistent scaling without significant spikes or volatility.
- **Italy**: Italy exhibits modest employment figures, rarely exceeding **40,000 employees** annually, even in its peak years. Growth rates remain relatively subdued but consistent, reflecting the country's smaller market size and challenges in scaling enterprises.

- **Netherlands**: The Netherlands performs similarly to Italy in absolute employee counts, with occasional growth rate spikes (e.g., **0.14 growth in 2001**) but no sustained periods of significant employment expansion. This suggests niche enterprises that may not scale widely but contribute positively in certain years.
- **Denmark**: Denmark consistently reports the lowest employment contributions, with employee figures rarely exceeding **5,000 annually** and volatile growth rates. Sharp declines in post-2010 growth highlight challenges in sustaining enterprise scaling within a smaller market.

In a nutshell, it comes to sight that France dominates in total employee contributions, reflecting its ability to support large-scale enterprises. Despite strong early performance, Germany's decline in employment contributions suggests a shift in market dynamics or challenges in scaling enterprises post-2000. Denmark and the Netherlands show greater volatility in growth rates, indicative of smaller markets that are more sensitive to policy or economic changes. Italy's consistent, albeit modest, performance underscores structural challenges in scaling enterprises for significant employment impact.

5.2.4 Comparisons and Key Insights

The analysis across Germany, Denmark, France, Italy, and the Netherlands reveals notable trends that shed light on the dynamics of economic contributions, innovation, and scalability. A general trend observed across the five nations is the steady decline in the number of new enterprises and their performance metrics, particularly after 2019. This is likely linked to global challenges such as the COVID-19 pandemic and its associated economic disruptions. Between 1994 and 2017, all countries experienced relatively stable or growing entrepreneurial activity, with marked peaks in enterprise births, sales, and employment contributions around the early 2000s and 2018-2019. These surges can be attributed to favourable market conditions, policy incentives, and increased focus on sustainability and cleantech innovation. However, the period post-2020 highlights significant declines across metrics, particularly in growth rates for smaller markets like Denmark and the Netherlands.

When comparing the five countries, Germany and France dominate both in scale and economic impact. Germany exhibits a robust market presence with consistently high absolute values in sales and employment metrics. However, its growth rates indicate a maturing entrepreneurial ecosystem with reduced room for rapid expansion in established markets. France, on the other hand, excels in employment contributions, reflecting its ability to support large-scale enterprises and stable, steady growth trends, particularly in the 1990s. Denmark and the Netherlands, despite their smaller markets, emphasize quality over quantity. Denmark maintains leadership in cleantech ecosystem engagement, focusing on sustainability-driven startups, while the Netherlands demonstrates high potential for growth in niche, high-value sectors. Italy's performance, while steady, underscores structural challenges, with consistently lower figures in enterprise scalability and growth. Its modest contributions in both sales and employment highlight the need for structural reforms to improve competitiveness. Overall, Germany and France lead the cleantech entrepreneurial landscape, while Denmark and the Netherlands stand out for innovation and specialization. Italy, despite lagging behind, shows promise if systemic issues are addressed. This analysis underscores how varied economic and policy contexts shape the cleantech landscape, offering insights for fostering a balanced, innovation-driven ecosystem across Europe.

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6. Policy and Regulatory Framework

The cleantech sector in Europe is shaped by a complex web of policies and regulations at both the European Union (EU) and national levels. These policies play a crucial role in fostering the development of clean technologies by providing a supportive framework that encourages innovation, investment, and adoption of sustainable practices. This section delves into the various policies and regulations influencing the cleantech sector, analysing their impact on the growth and sustainability of cleantech companies.

6.1 European Policies and Regulations

The EU has established a robust policy framework aimed at promoting environmental sustainability and accelerating the transition to a low-carbon economy. Key policies and regulatory instruments include:

- **European Green Deal:** launched in December 2019, the European Green Deal is a comprehensive roadmap aimed at making the EU climate-neutral by 2050. It encompasses a wide range of initiatives targeting climate change, biodiversity, clean energy, sustainable industry, and pollution reduction. The Green Deal sets ambitious targets, such as reducing greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. This overarching strategy provides a significant boost to cleantech companies by creating a favourable environment for green innovations and investments.
- **EU Taxonomy for Sustainable Activities:** the EU Taxonomy Regulation, effective from July 2020, establishes a classification system for sustainable economic activities. It aims to guide investors towards environmentally sustainable projects, thereby channelling financial flows into cleantech and other green sectors. The taxonomy defines criteria for activities to be considered environmentally sustainable, covering six environmental objectives, including climate change mitigation and adaptation. This regulation enhances transparency and fosters investor confidence in the cleantech sector.

- **Horizon Europe:** as the EU's research and innovation program for 2021-2027, Horizon Europe allocates €95.5 billion to support research and development in various fields, including cleantech. The program includes specific missions and partnerships aimed at addressing global challenges such as climate change and sustainable energy. Funding from Horizon Europe provides critical support for cleantech innovators, enabling them to advance their technologies and bring them to market.
- **Renewable Energy Directive (RED II):** the Renewable Energy Directive, revised in 2018 (RED II), sets binding targets for renewable energy use within the EU. It aims for at least 32% of the EU's energy consumption to come from renewable sources by 2030. RED II includes measures to simplify administrative procedures for renewable energy projects, improve grid integration, and enhance cross-border cooperation. These provisions directly benefit cleantech companies involved in renewable energy technologies by creating a more favorable regulatory environment.

6.2 National Policies and Regulations

In addition to EU-wide policies, individual member states implement their own regulations and initiatives to support the cleantech sector. These national policies often complement EU directives and can vary significantly between countries, reflecting local priorities and resources. Some examples of European nations are provided:

- *Germany:* Germany's Energiewende (Energy Transition) policy aims to transform the country's energy system towards renewable energy and increased energy efficiency. The Renewable Energy Sources Act (EEG) provides financial incentives for renewable energy projects through feed-in tariffs and auction schemes. Germany also supports cleantech innovation through funding programs like the Climate Initiative, which finances research and development in energy efficiency, sustainable mobility, and green technologies.
- *France:* France's Energy and Climate Law sets ambitious targets for carbon neutrality by 2050 and includes measures to phase out coal, promote renewable energy, and enhance energy efficiency. The law supports cleantech development through

subsidies, tax incentives, and regulatory measures aimed at reducing carbon emissions. France also has specific initiatives like the GreenTech Innovation program, which provides support for startups and SMEs in the cleantech sector. For example, the BPIfrance program offers financing solutions tailored to the needs of cleantech companies, facilitating their access to capital.

- *United Kingdom:* Although no longer an EU member, the UK continues to implement robust policies supporting the cleantech sector. The Clean Growth Strategy outlines measures to cut emissions, promote renewable energy, and support green innovation. The UK government offers grants and incentives through programs like the Industrial Strategy Challenge Fund and the Green Investment Group, which focus on advancing low-carbon technologies and sustainable practices. The Contracts for Difference (CfD) scheme has been particularly effective in supporting the deployment of renewable energy projects by providing price stability to investors.

6.3 OECD PINE Dataset: description and introduction

In recent years several datasets which collect information about environmental policies have been gathered by different organizations around the world, which contain different subsets of information with different levels of details. We chose to analyze the following dataset: the PINE.

The PINE database (Policy Instruments for the Environment) is a powerful tool provided by the OECD (Organization for Economic Cooperation and Development) which gathers data from all countries and territories (regardless of if they a are part of the OECD or not) about their environmental policy instruments, with their issuing dates starting from 1980 up to 2024. The dataset provides a deep insight into the policies, classifying them with different categories, ranging from a classification of the instrument type itself, the geographic scope, the domain to which it applies, the targeted payer of the policy itself.

Starting the analysis from the classification of the different tools the governments have and can use. The various policy alternatives all have different levels of efficiency and target different users. All of those can be categorized into two main types of policies: market-based and non-market based, as De Serres et al. [45] clearly explain.

The main purpose of market-based policies is to manipulate the market equilibrium by artificially modifying prices in markets that may have failures. The basis from which they are implemented is that many aspects of the natural environment are public goods. Public goods are goods that are **non-excludable** (everyone can access them, even without paying) and **non-rival** (one person's use doesn't reduce their availability for others). Examples of public goods include national defense, public transportation and public parks. These goods are typically provided by governments because private markets often struggle to supply them efficiently. This strongly applies to the environment, due to the difficulty of assigning property rights for environmental resources and the impossibility to exclude people from benefitting them. Without government intervention, decentralized market economies tend to generate an inefficient balance between the "supply" of environmental goods and services (that is, the levels of environmental quality) and the supply of other goods and services. Pigou's classic contribution showed that taxes could be employed to account for environmental externalities [46].

Non-market-based policies instead rely on direct regulations or measures without involving market mechanisms. They set strict rules, limits, or mandates that must be followed, but they do not put a cost on negative externalities, hence failing to modify market rules.

The subset of policies analysed in this dataset are:

- **Taxes and fees**: These economic instruments are used to penalize behaviours or practices that harm the environment. The taxes aimed at this purpose are called Pigouvian taxes: they serve to eliminate the cost wedge, raising private costs to a level that corresponds to social cost. The goal is to encourage behavioural changes toward more sustainable practices by increasing the cost of environmentally damaging activities. In this way, the Pigouvian tax internalizes the social cost from pollution, borne by society. Governments impose taxes or fees on activities or products that negatively impact the environment (e.g., CO2 emissions or fossil fuel usage).

  Taxing sources of environmental pollution and greenhouse gas emissions is an efficient and effective way to combat climate change, biodiversity loss and pollution. Environmental taxes can also contribute to revenue mobilization and redistribution

[47]. Some examples of taxes and fees are the Carbon Tax, a tax on CO2 emissions; the Plastic Bag Fee, which is present in many countries, especially in the European Union, which consists in a fee for single-use plastic bags to reduce plastic waste; the Congestion Charges, which are fees applied to vehicles entering urban areas, such as London's congestion charge, to reduce traffic and air pollution.

- **Deposit-Refund Systems**: These systems combine an upfront deposit, with similar effects of a tax, with a refund upon the return of an item, incentivizing proper disposal or recycling. They work as follows: consumers pay a deposit when purchasing a product (e.g., bottles or batteries) and receive a refund when they return the item to a designated collection point. Some examples of this policies are Bottle Deposit Schemes, which are widely used in countries like Germany and Norway, where consumers pay a deposit on beverage containers and receive a refund when they return the empty bottles and E-Waste Programs, where some regions have deposit-refund systems for electronic waste, encouraging the recycling of old devices like smartphones and batteries.
- **Environmentally Beneficial Subsidies and Payments:** Governments provide financial incentives to support environmentally friendly practices or technologies. These incentives aim to reduce the cost barrier to adopting green solutions. They are redacted in the forms of subsidies or payments that are given to individuals, companies, or organizations that invest in sustainable practices or technologies. Examples of this category are the Renewable Energy Subsidies, which are Grants or tax breaks for installing solar panels, wind turbines, or other renewable energy systems (e.g., the U.S. Investment Tax Credit for solar energy); Conservation Payments: which are payments to farmers to adopt sustainable agriculture practices, such as the EU's agri-environmental schemes; Electric Vehicle (EV) Incentives, which are present in many countries, where the government provides money directly for the purchase of EV, lowering their actual cost to consumers and pushing demand.
- **Tradable Permits and Offsets:** These tools are market-based instruments that create a system where environmental rights or responsibilities can be bought and sold in a free market. Governments usually set a limit (cap) on the total allowable environmental impact (e.g., CO2 emissions). Companies are allocated permits, which they can trade if they emit less or need more than their allowance. Examples of these

policies are the Cap-and-Trade Systems, like the EU Emissions Trading System (EU ETS) that caps CO2 emissions and allows companies to trade emission permits if they need more or are emitting less, creating a competitive advantage for those who can emit less and sell their permits, and Carbon Offsets, which allows companies to invest in projects like reforestation to offset their emissions. For example, airlines may offer customers the option to offset the carbon footprint of their flights**.**

- **Voluntary Approaches:** These involve initiatives where companies or individuals voluntarily commit to environmental goals, often driven by consumer demand, brand reputation, or corporate social responsibility. Organizations can adopt sustainable practices without legal obligation, often encouraged by public awareness campaigns or certification programs. Examples of those are the Corporate Sustainability Programs, where many companies, like Patagonia, adopt voluntary environmental goals, such as using 100% renewable energy or reducing waste; Certification Schemes, like LEED (Leadership in Energy and Environmental Design) for green buildings or Fair Trade for sustainable farming; Voluntary Carbon Neutrality Pledges: where companies, like Microsoft, have committed to becoming carbon negative through voluntary initiatives.

The **geographic scope** of a policy refers to the physical area or regions where the policy is applicable and enforced. It defines the boundaries within which the policy's rules, regulations, and effects are intended to operate. There are different levels of scope at which a policy can be enforced, ranging from a very specific geographic area to the whole country. The levels can be divided as follows:

- Local: Policies that apply within a city, town, or specific local jurisdiction (e.g., municipal recycling programs, city-specific congestion charges).
- Regional: Policies targeting a broader area, such as a province, state, or economic region (e.g., California's cap-and-trade program or EU regional environmental directives).
- National: Policies implemented at the country level, applying to all citizens and businesses within national borders (e.g., national carbon taxes or renewable energy incentives).

- International and supranational: Policies that apply across multiple countries, often established through treaties or agreements (e.g., the Paris Agreement on climate change).

The environmental policies contained in this dataset aim to regulate and manage various domains. Several domains are hence included, ranging from air pollution to noise reduction to renewable energy. For instance, air pollution addresses the emission of harmful substances like greenhouse gases and particulate matter into the atmosphere, while water pollution focuses on contaminants in water bodies that affect aquatic life and human health. Similarly, soil pollution concerns the degradation of land due to chemicals and waste, which impacts agriculture and biodiversity. Solid waste management seeks to reduce and responsibly dispose of waste materials, minimizing their environmental footprint. Sustainable use of natural resources is another key aspect, with domains like fisheries aiming to prevent overfishing, and forests focusing on preserving biodiversity and reducing deforestation. Freshwater management ensures the availability of clean water for consumption, agriculture, and ecosystems. In the energy sector, policies address both production and consumption. Renewable energy initiatives promote the use of sustainable energy sources like solar and wind, while regulations on fossil fuels aim to curb their environmental impact. Similarly, minerals extraction is monitored to minimize ecological damage, and energy efficiency policies encourage reducing energy consumption through better technologies. The circular economy concept supports reusing and recycling resources to limit waste, complementing efforts in chemical management to safely handle hazardous substances and mitigate their impact on the environment. Altogether, these domains highlight the interconnected nature of environmental issues and the need for comprehensive policies to address them effectively, with policies usually not targeting only one, but many.

The dataset lastly provides information about the targeted payer of the policy, so the entity that will be directly affected by this policy will pay the monetary cost. They can be the households, which are the end consumers, the firms or the government. From a general perspective however, even if the policy applies to firms, the final price will almost certainly be paid by the end consumers, since the firms will charge the amount of the tax to the final price of the goods, and households will absorb the cost of the policy.

The scope of our analysis will be limited to the European Countries, focusing on the ones with the most policies and the most affected by those policies in helping (or not helping) the cleantech sector in its formation, growth and sustainment.

6.3.1 Policy Instruments by Number & Continent

Over time, the number of environmental policies has shown a steady increase, reflecting growing global awareness and action to address environmental challenges. As the PINE dataset shows, the commitment from governments to the environment has become stronger and stronger, whit the constant introduction of policies, year over year. Among the various policy instruments, taxes and fees have consistently represented the largest share. These tools are favoured for their ability to generate revenue while incentivizing behavioural change, making them an efficient and widely adopted approach across both OECD and non-OECD countries.

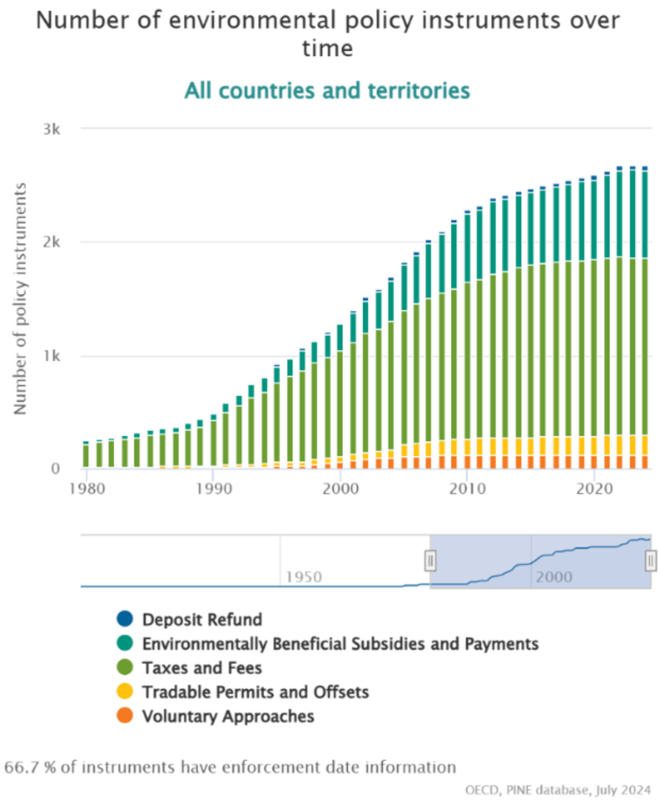

Figure 5-Number of environmental policy instruments over time

The distribution of those policies around the world is not uniform, with notable differences across regions, with OECD countries leading in both the number and diversity of policies implemented. According to the PINE database Europe, in particular, accounts for the largest share of policies issued, surpassing all other continents combined. This reflects Europe's long-standing commitment to environmental regulation: since the early 1990s, the European Union (EU) has presented itself as a leader on climate change [48], driven by strong institutional frameworks, international agreements, and public demand for action and is now setting some of the world's most comprehensive and ambitious environmental regulations, including frameworks like the European Green Deal, the Emissions Trading System (ETS), and the Circular Economy Action Plan.

In contrast, non-OECD countries tend to rely more heavily on simpler tools, such as taxes and fees, due to resource and capacity constraints. This geographical disparity highlights the role of economic development and institutional strength in shaping the scale and sophistication of environmental policymaking worldwide.

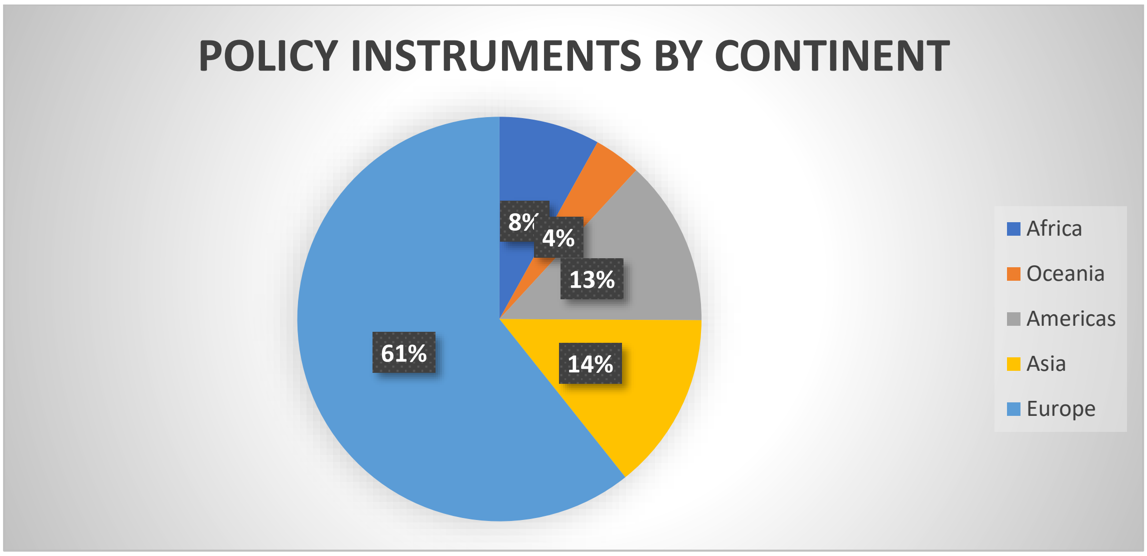

Figure 6-Number of policy instruments by continent

6.3.2 Policy Instruments by Type & Subtype

Countries can choose between different types of policies; however, the dataset clearly shows that taxes and fees constitute the largest share of instruments adopted by governments to implement environmental policies, accounting for over 60% of all policies. This predominance can be attributed to their cost-effectiveness, flexibility, and ability to achieve multiple objectives simultaneously: mitigating environmental damage while generating public revenue. Their widespread use, as reflected in the PINE database, highlights their central role in contemporary environmental policymaking, where balancing economic growth with sustainability remains a priority.

The second-largest category consists of subsidies and payments, emphasizing the critical role of financial support in promoting green energy projects, sustainable technologies, and environmentally friendly practices. By providing economic incentives, governments encourage key sectors to adopt greener commitments and technologies.

The remaining portion of the graph represents other types of policies, which occupy a significantly smaller share. This suggests their comparatively lower relevance in governmental decision-making processes, likely due to perceived limitations in their effectiveness relative to taxes, fees, and subsidies. These aspects, including their efficacy, will be examined further in the subsequent sections of this document.

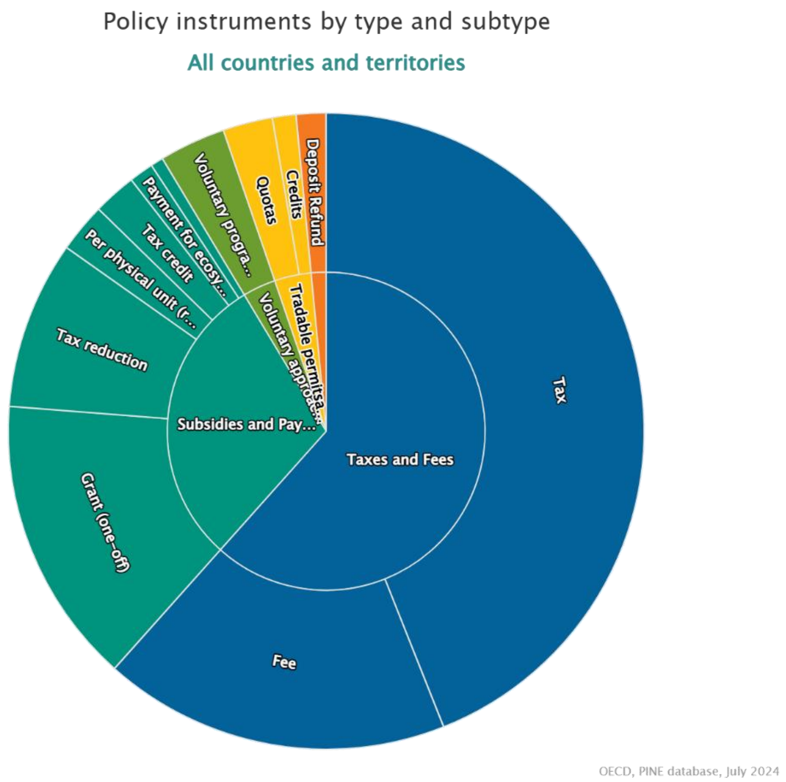

Figure 7-Policy instruments by type and subtype

The dataset also displays a significant distinction between OECD and non-OECD countries: by analyzing the distribution of those policies in those countries, some interesting patterns could be described. The pictures below will show the different distributions.

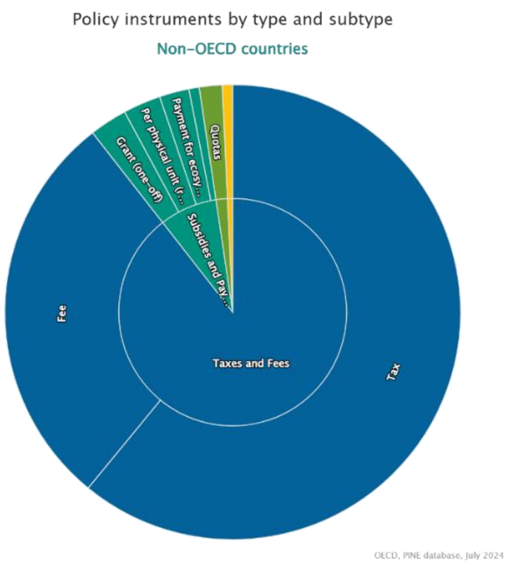

Figure 9-Policy instruments by type and subtype for non-OECD countries

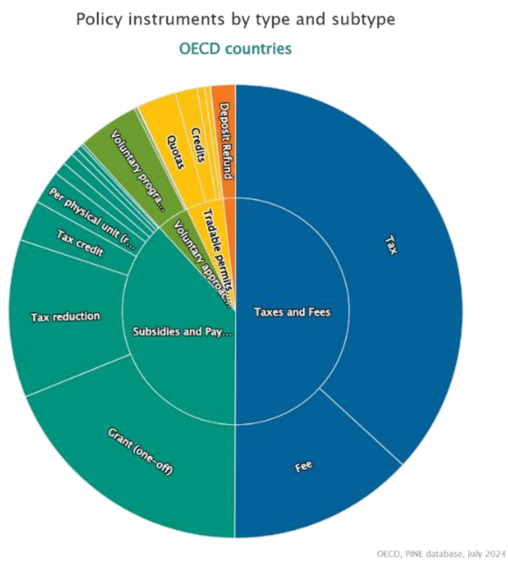

Figure 8-Policy instruments by type and subtype for OECD countries

While the prevalent type of policies remains the same between those clusters of countries, OECD countries rely on a much broader use of subsidies and payments. This could be explained by several economic, institutional, and developmental factors:

- OECD countries generally have higher fiscal capacity and stronger economies, enabling them to allocate substantial public funds to subsidies and incentives. Subsidies—such as grants, tax reductions, and credits—require significant financial resources to implement and maintain OECD governments can absorb the fiscal burden of incentives more easily due to larger tax bases and more efficient financial systems. In contrast, many non-OECD countries face budgetary constraints and may prioritize policies that generate revenue (e.g., taxes and fees) over those that require expenditure
- OECD countries often use subsidies to promote green innovation and accelerate the transition to sustainable economies. They prioritize incentives to encourage investment in clean technologies, energy efficiency, and environmental

conservation. Non-OECD countries, on the other hand, may prioritize more immediate challenges, such as infrastructure development, poverty alleviation, and resource management

- Implementing subsidies and payments often requires strong administrative capacity to ensure transparency, proper allocation, and monitoring. OECD countries typically have well-developed institutions and regulatory frameworks, which enable them to efficiently manage complex subsidy programs. In contrast, non-OECD countries may face institutional limitations, such as weaker governance, corruption risks, or challenges in program implementation
- Subsidies in OECD countries are often designed to drive private sector investment in green technologies and sustainable practices. By lowering costs or providing financial incentives, governments can encourage businesses to adopt cleaner technologies and innovate. This aligns with OECD countries' goals of decarbonizing their economies and meeting international climate commitments, while non-OECD countries can be focused more on economic development, rather than decarbonization.

6.3.3 Policy Instruments by Geographical Scope

The **geographical scope** of policies in the PINE database reveals that most environmental policies have national coverage, rather than referring to a smaller portion of the territory of the country, whether provincial, regional or state. This trend can be explained by several factors:

- **Centralized Decision-Making**: National governments typically have the authority and responsibility to design and implement broad environmental strategies. Issues like climate change, air pollution, and energy use often require coordinated, large-scale action that goes beyond regional or local boundaries.
- **Uniformity and Consistency**: National policies ensure a consistent approach across the entire country. This avoids regional disparities and ensures that environmental regulations, taxes, or incentives are applied evenly, which is crucial for issues like emissions standards, taxation, or resource management.

- **International Commitments**: Many national policies stem from international agreements, such as the **Paris Agreement** or other global climate frameworks. To meet these commitments, governments often implement nationwide policies that align with global targets.
- **Resource Allocation**: National governments have greater fiscal and administrative capacity to implement policies compared to provincial or regional authorities. They can mobilize resources, coordinate across sectors, and enforce compliance more effectively.

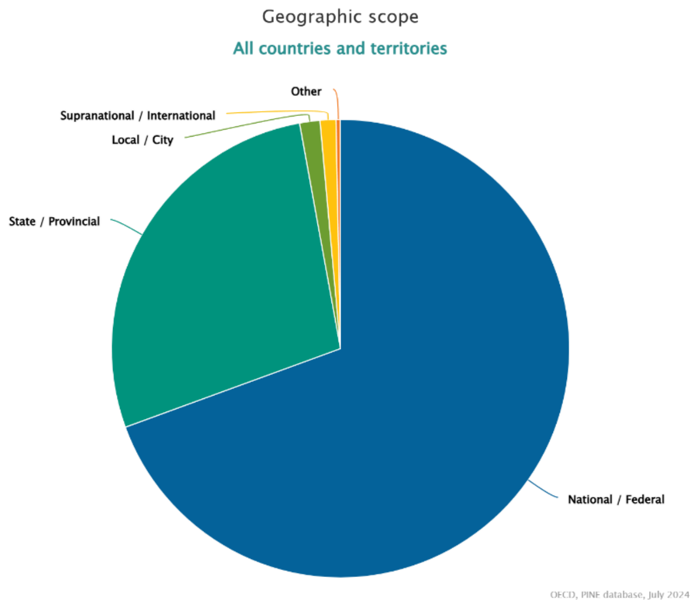

Figure 10-Geographic scope for policies

6.3.4 Policy Instruments by Type & Environmental Domain

Policies adopted by governments can target a wide range of domains, however some of them are the more regulated. The domains with the highest number of policies are climate change mitigation, air pollution, biodiversity, circular economy, fossil fuels, solid waste and energy efficiency, because they address the **most pressing environmental and economic challenges** faced by governments today. There are many reasons why those are the most targeted: **climate change mitigation** is a global priority, as it directly impacts ecosystems, economies, and societies. Governments focus on this domain to meet international commitments, such as the Paris Agreement, and to reduce greenhouse gas emissions. **Air pollution** is a critical public health issue, causing millions of premature deaths annually, especially is certain areas, for example Northern Italy. Policies targeting this domain aim to improve air quality and reduce related healthcare costs; **Circular economy** policies address resource efficiency and waste reduction, promoting sustainable production and consumption practices while reducing environmental degradation. **Fossil fuels** are the major contributor to greenhouse gas emissions, inducing governments to regulate the sector, while transitioning to more sustainable sources of energy. **Solid waste** management is vital for reducing pollution, minimizing landfill use, and supporting recycling initiatives, which align with sustainable development goals. **Energy efficiency** is targeted as it offers a cost-effective way to reduce energy consumption, lower emissions, and improve energy security. All these domains also represent issues that are widespread in all the world, and not related to specific areas, thus they represent the biggest stake in the dataset.

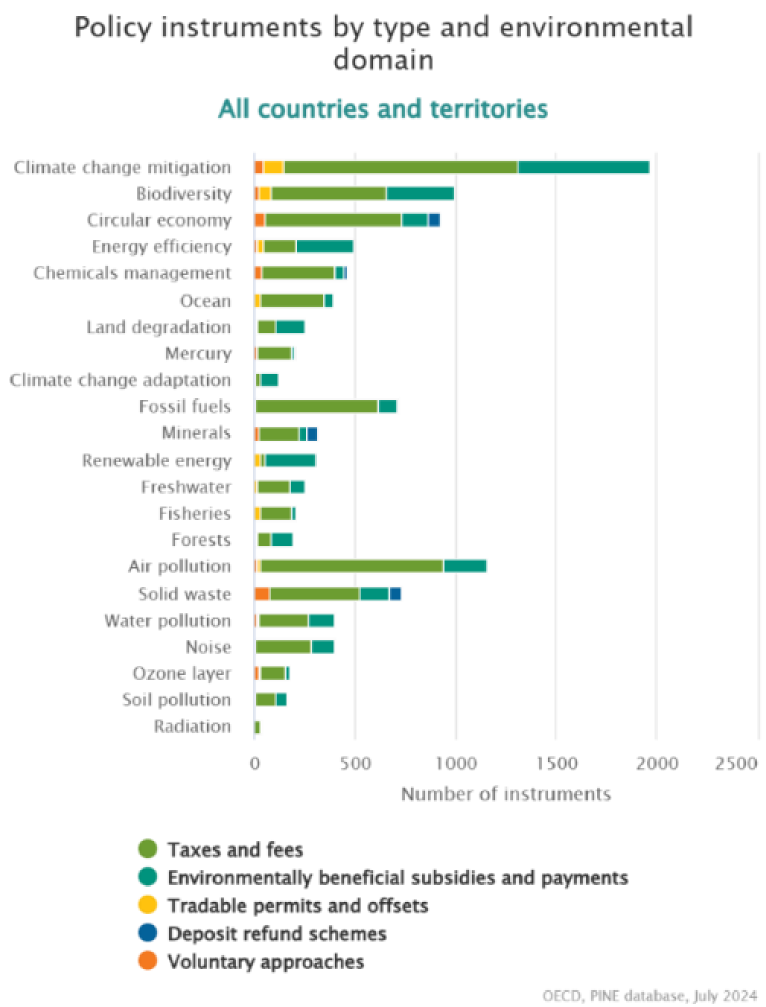

Figure 11-Policy instruments by type and environmental domain

7. CO_2 Emission and R&D Expenses

7.1 Dataset: CO2 Emissions

Global greenhouse gas (GHG) emissions, primarily driven by human activities such as fossil fuel combustion, deforestation, industrial processes, and agriculture, are the leading contributors to climate change. Over the past century, emissions have risen exponentially, with CO_2, methane (CH_4), and nitrous oxide (N_2O) being the most prevalent. These emissions have far-reaching consequences, including rising global temperatures, extreme weather events, biodiversity loss, and disruptions to ecosystems and economies worldwide. According to the latest data, global GHG emissions in 2023 reached 53.0 Gt CO_{2eq} (without Land Use, land Use Change and Forestry). The 2023 data represent the highest level recorded and experienced an increase of 1.9% or 994 Mt CO_{2eq} compared to the levels in 2022 [49].

In this framework, cleantech startups have emerged as critical drivers of innovation and change, developing cutting-edge technologies such as renewable energy systems, carbon capture and storage (CCS), energy-efficient products, waste-to-energy solutions, and digital tools for monitoring and optimizing emissions. Without innovation driven by those, reducing emissions could be an impossible mission. Analyzing the correlation between cleantech startups and GHG emissions could lead to interesting findings.

The EDGAR is a multipurpose, independent, global database of anthropogenic emissions of greenhouse gases and air pollution on Earth. EDGAR provides independent emission estimates using international statistics and a consistent IPCC methodology [49].

This dataset helps tracking GHG emission with different level of details, starting from the total national amount, diving deeper by dividing emissions into the following sectors: Power Industry, Industrial Combustion and Processes, Buildings, Transport, Fuel Exploitation, Agriculture and Waste. The dataset also provides GHG divided by each country's GDP and population, highlighting the carbon intensity of each country, which means how much of GHG is necessary to produce a unit of GDP, and the per-capita GHG emissions. Those indicators are useful because carbon intensity helps countries assess their progress toward climate goals (such as the Paris Agreement's target to limit global temperature rise) and formulate strategies for further reducing emissions while maintaining economic growth and can help assessing whether innovation by cleantech startups can improve those indicators, while still helping growth.

7.2 Dataset: Investment and R&D

Investments in Research and Development (R&D) play a critical role in creating a favourable environment for startups by enabling innovation that can drive economic growth. As countries face increasing pressure to address climate change and transition to sustainable energy sources, R&D investments become essential for developing advanced technologies that reduce carbon emissions, enhance energy efficiency, and promote renewable energy solutions.

Governments, private enterprises, and academic institutions that prioritize R&D contribute to building a robust ecosystem where startups can thrive, attract investors, and scale their solutions globally. By examining the level of investment in R&D across countries and various indicator, we can gain insights into which regions are better positioned to support cleantech innovation and economic development in the transition to a sustainable future.

The OECD Main Science and Technology Indicators (MSTI) is a database provided by the OECD which focuses principally on tracking financial and human resources devoted to research and experimental development (R&D), complemented by additional indicators of outputs and potential outcomes of S&T activities, namely patent data and international trade in R&D-intensive industries [50].

The key main indicators of this dataset are:

- **Gross Domestic Expenditure on R&D (GERD)**, which measures the total expenditure on research and development activities carried out within a country's borders, regardless of the funding source. GERD can be expressed as an absolute value in monetary term, or as percentage of GDP (known as R&D intensity), allowing for comparison of a country’s R&D commitment relative to its economic output.

- **Business Enterprise Expenditure on R&D (BERD)**, which measures the total expenditure on research and development performed by the business sector within a country. It is a subset of the Gross Domestic Expenditure on R&D (GERD) and focuses specifically on R&D activities carried out by private enterprises, regardless of the source of funding.
- **Higher Education Expenditure on R&D (HERD),** which measures the total expenditure on research and development performed within the higher education sector of a country. This includes R&D activities carried out by universities, colleges, and other tertiary education institutions, regardless of the source of funding.
- **Government Expenditure on R&D (GOVERD)** measures the total expenditure on research and development performed directly by the government sector. This includes R&D activities carried out in government-owned research institutions, laboratories, and agencies, regardless of the source of funding.
- **R&D personnel,** which refers to the individuals directly involved in Research and Development (R&D) activities, including researchers, technicians, and supporting staff. These personnel are a critical component of the innovation ecosystem, as they are the driving force behind the creation, development, and application of new knowledge, technologies, and solutions. In this dataset there is the same distinction as mentioned before, with separation of personnel active in business enterprise, higher education and government sectors.

Analyzing this dataset, along with the other dataset mentioned above, can help analyzing factors that can influence the birth, growth and consolidation of cleantech startups, by using statistical methods for analyzing all the data.

8. Venture Capital Investments in the Cleantech Sector

Venture capital (VC) is a form of private equity financing provided to early-stage, high-growth startups and businesses with strong potential for innovation and scalability. Venture capitalists are the primary source of early-stage funding targeted at young companies with the potential for rapid growth and high returns [51]. VC firms invest in these companies in exchange for equity, aiming to generate significant financial returns when the businesses succeed and either go public or are acquired.

Investment in sustainable startups drives the transition to cleaner production [52][53]. In this context, Venture Capitalists (VCs) are increasingly interested in cleantech startups due to the growing demand for sustainable solutions, the acceleration of global climate change initiatives, and the economic potential of innovative clean technologies. VC funding is particularly suited for startups in sectors like technology, biotechnology, and cleantech, where high risk and capital requirements often deter traditional financing options. At the start of the century, VC investments in clean energy experienced a boom-and-bust cycle. From 2005 to 2008, the share of VC investments going to clean energy technologies more than tripled, spurred by growing societal interest in environmental issues.

However, the returns on these investments proved quite poor, with investors losing more than half of the money they invested in cleantech startups between 2006 and 2011 [54]. After a boom-and-bust cycle in the early 2010s, venture capital (VC) investments have, once again, been flowing towards some green businesses since 2015 [55]. In recent years, VC investments have grown exponentially. 2022, for example, was an enormous year for Climate Tech VC. The US alone invested more Climate Tech VC in 2022 than the entire 2006-2011 Clean Tech 1.0 Boom and overall, the world delivered $70.1B of investment, defying gravity in a broader market that had fallen significantly. While it is still very early in the year, based on Q1 2023 deal activity and the broader economy, we're forecasting around $36B of full year 2023 Climate Tech VC investment, a little over half of the record levels of 2022 [56].

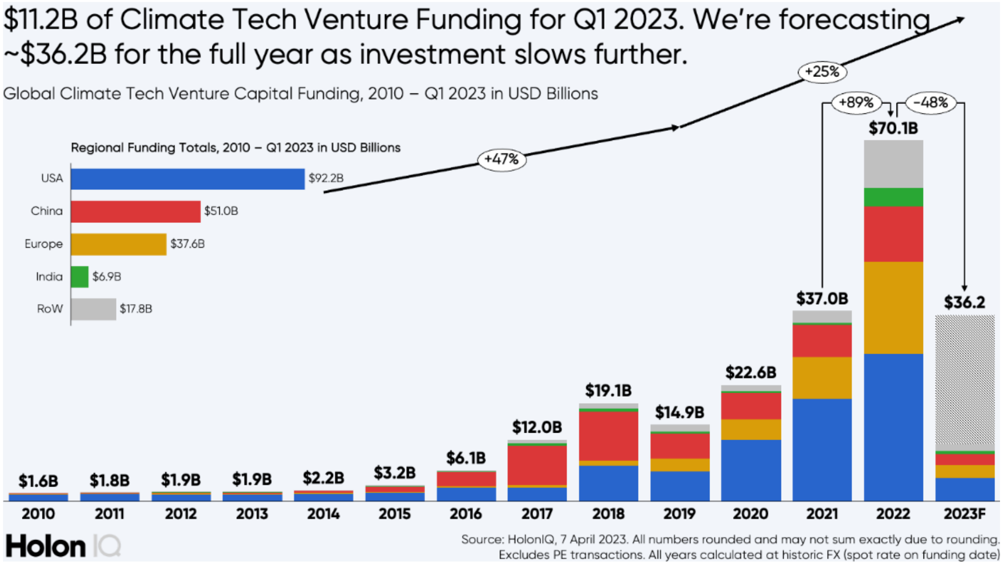

Figure 12-Venture Capital funding for Cleantech

However, Venture capital (VC) remains crucial in the cleantech sector because it provides the funding and support needed to develop and scale innovative solutions that address environmental challenges.

9. Research Question

Starting from the analysis of existing literature and datasets available, the aim of the research is to find whether some correlations may exist between the size and sales of the startups in cleantech sector and the issuance of environmental policies and government expenditures in R&D in the EU, with a focus on five main countries, namely Italy, France, Germany, Denmark and The Netherlands.

Those countries have been chosen since the former three are the biggest economies by GDP in the EU, while the latter two are widely recognized as leaders in innovation and green policies.

The analysis will be conducted both on a country level, and at an aggregate level, encompassing different levels of details.

9.1 Analysis of correlation between policies, government R&D expenditures and cleantech startups

The work will start by analyzing simple correlations, as mentioned before, of the singles variables of the dataset of cleantech against the other variables, and a further analysis conducted with a linear regression will be put in place in order to model and analyze the relationship between the dependent variable of interest of the cleantech dataset and the other independent variables from all other datasets. This will help to predict the value of the dependent variable based on the values of the independent variables and quantifies the magnitude of the effect of each independent variable on the dependent variable, while controlling for the influence of other variables, trying to find any evidence of casual relationship.

The datasets that will be used in order to conduct this analysis will be the OECD Pine Dataset, which contains information about all of environmental policies issued by the countries, the MSTI Dataset, which contains information about the government R&D expenditures, and the dataset provided by the professor, which contains data about the cleantech startups, as already analyzed in detail above in this paper.

Firstly, all the useful data for the analysis has been put together, to be properly utilized in the statistical software Stata, on a year-to-year basis, and divided by each country of interest.

Each country of interest will be analyzed in all its factors potentially influencing the Cleantech sector.

9.1.1 Italy

Italy has implemented green policies over the past decades, but challenges remain in fully integrating sustainability into its economic and industrial framework. The country has committed to the European Green Deal's objectives, aiming for carbon neutrality by 2050, and has implemented various legislative measures to promote renewable energy, circular economy principles, and environmental protection. Another big source of fundings in recent years comes from the National Recovery and Resilience Plan (PNRR), funded by the EU's Next Generation EU program, which allocates a substantial portion of its resources to ecological transition, focusing on energy efficiency, sustainable transport, and biodiversity conservation.

However, Italy faces several obstacles in implementing green policies effectively. Bureaucratic delays, regional disparities, and resistance from traditional industries slow down progress. Moreover, balancing environmental sustainability with economic growth remains a complex challenge, particularly in sectors like manufacturing and agriculture.

Italy also faces challenges in the academic sector, where funding to universities and research institutions still remains below European average, reducing opportunities for green innovation and investments.

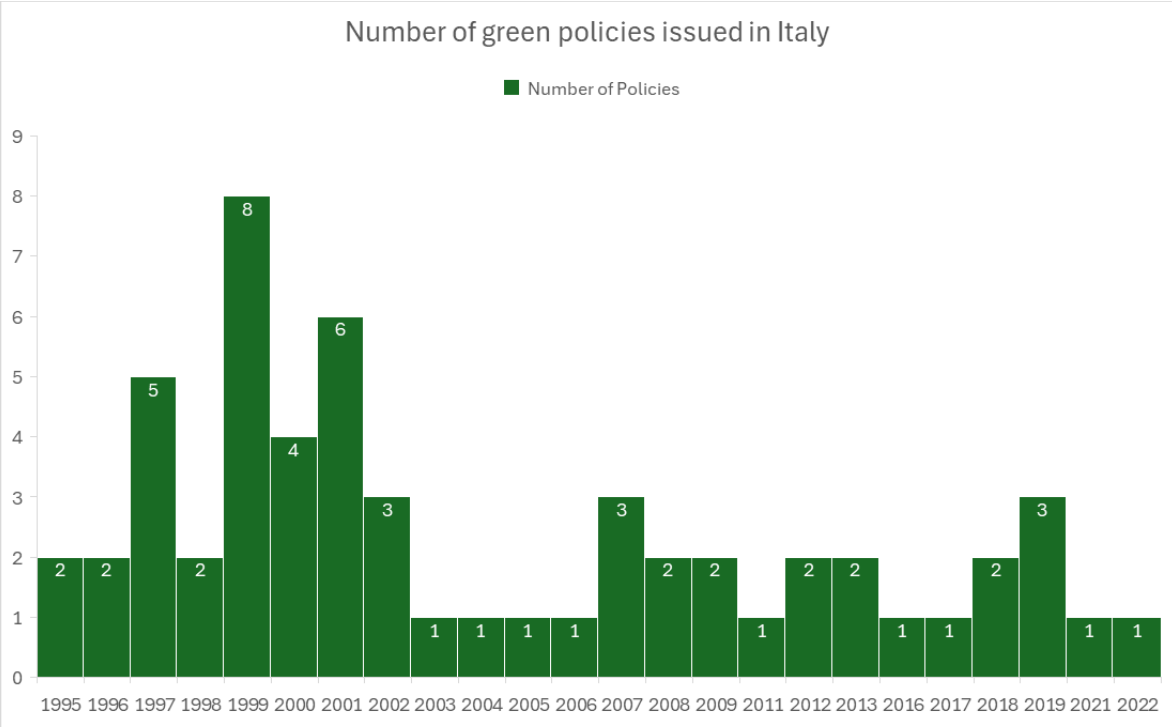

Figure 13-Number of green policies in Italy

The distribution of the green policies issued in Italy shows a spike in the decade between 1995 and 2005, with the highest number of issuing of new policies. This peak can be attributed to several factors, including EU influence, international commitments, and domestic environmental concerns. Here's why this decade saw a surge in policy activity, while the slow-down after this period could be due to the 2008 crisis and the shift of the focus towards the implementation of them.

Italy also has a peculiar distribution of the typology of green policies issued, with high predominance of voluntary approaches, as well as taxes and fees and subsidies.

While a predominance of taxes and fees can be highly expected, due to their efficacy, the high number of voluntary approaches present in Italy could be done to several factors, including complex bureaucratic and administrative structure, which often makes command-and-control regulations (e.g., strict environmental laws with strong enforcement) harder to implement and many key industries in the Italian economy, including manufacturing, automotive, and agriculture, have historically opposed rigid environmental regulations, fearing higher costs and reduced competitiveness, with their high influence they have at the legislative power level.

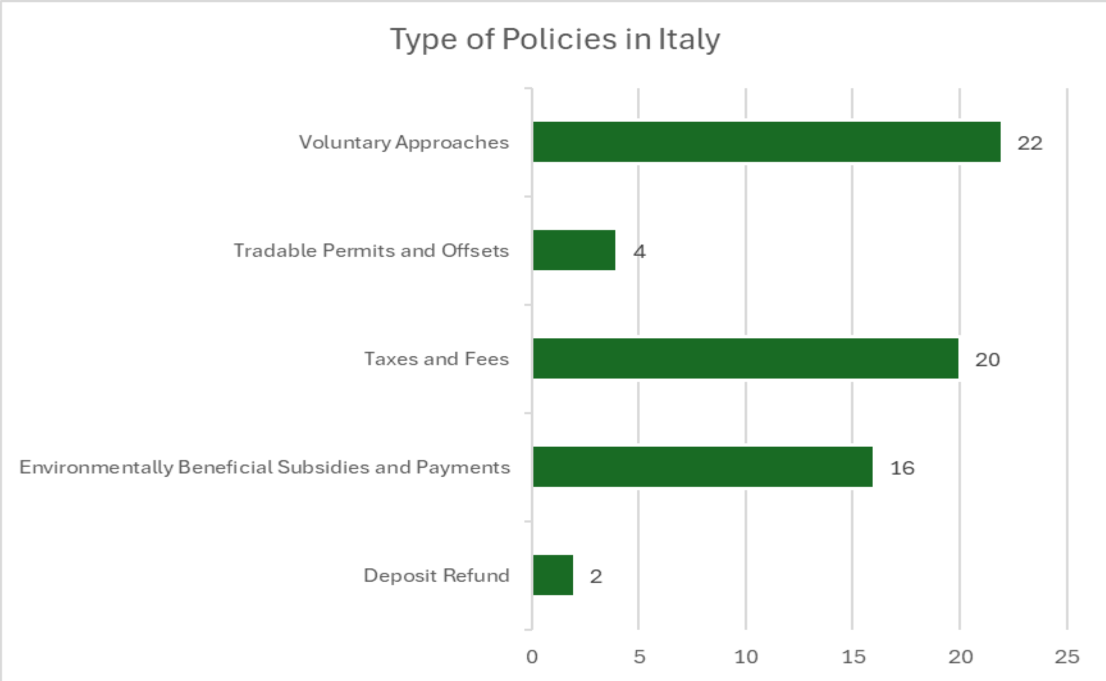

Figure 14-Type of policies in Italy

The analysis dives deep further into the Expenditures in R&D, divided into total expenditures, government expenditures and higher education expenditures, which could prompt a favorable environment for the birth of cleantech startup and its prosperity, especially the higher education ones.

In order to see if any correlation exists, data has been put into Stata.

First, the analysis focuses on the effects of the number of policies on the indicators of the cleantech dataset. The output of Stata is reported below, with Pearson correlation index and its p-value.

	Ysales5Y afterFY	Ysalesg5Y afterFY	Ysales5Y after	Ysalesg5Y after	Y_n_comp born	YEmp5Y afterFY	YEmpg5Y afterFY	YEmp5Y after	YEmpg5Y after
Number of Policies	0.7676	-0.1056	0.5158	0.1990	0.3475	0.6765	0.5436	0.2048	-0.1036
p-value	0.0000	0.5855	0.0042	0.3006	0.0647	0.0001	0.0023	0.2865	0.5929
GERD as percentage of GDP	-0.6117	0.5313	-0.7325	-0.4341	-0.6274	-0.5874	-0.5491	-0.6368	-0.3431
p-value	0.0004	0.0030	0.0000	0.0186	0.0003	0.0008	0.0020	0.0002	0.0684
HERD as percentage of GDP	-0.1524	0.0560	-0.7262	-0.4718	-0.1807	-0.0445	-0.7131	-0.8165	-0.7441
p-value	0.4300	0.7731	0.0000	0.0098	0.3483	0.8189	0.0000	0.0000	0.0000

Table 4-Correlation table for Italy

The table shows that only some financial indicators show a correlation or even a strong correlation with the number of policies. Considering a significance p-value of 0.05, we have statistical significance with the sales five years after the foundation, employees' number and growth five years, both from the year and the year of the foundation. The highest score is between the number of policies and the sales 5 years after the foundation, with a correlation index of 0.7676, and another good score of 0.6765 with the number of employees. Thus, the policies issued in Italy have a positive impact on those indicators, while having a negligible impact on others. This can represent the fact that in Italy new policies issued creates the demand for new employees, absorbing the need of new opportunities arising from the policies itself, and the growth of newly born cleantech startups, stimulating the market for these types of companies.

The next variables analyzed are the Gross Expenditures in R&D (GERD) and Higher Education Expenditures in R&D (HERD) and their impact on the variables of the cleantech sector.

As the table clearly shows, the effects of R&D expenditures have a negligible impact on all those indicators, while most of them even showing a negative correlation with statistical significance. These can be explained by the fact that, even if both indicators (GERD and HERD) have both continued to increase in the analyzed years, despite Italy's financial difficulties and the international crisis of 2008, public R&D spending does not translate into commercial innovation that can benefit cleantech startups, with sales having a general descending trend; the weak industry-university collaboration and the utilization of those funds in other sectors, that are not correlated to the cleantech startup sector.

The other statistical instrument used for analyzing correlation is regression. Two independent variables in two different analyses have been chosen, the ones with the highest value of correlation: Sales and employees five years after birth, with the three independent variables being the number of policies, GERD and HERD.

The regression equation has the following formula:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$, with

Y= independent variable (sales and employees)

β_0= constant of the model

β_1= first independent variable (number of policies)

β_2= second independent variable (GERD)

β_3= third independent variable (HERD)

The results are shown below.

Source	SS	df	MS			
Model	6.1632e+10	3	2.0544e+10	Number of obs	=	29
Residual	2.5404e+10	25	1.0162e+09	F(3, 25)	=	20.22
				Prob > F	=	0.0000
				R-squared	=	0.7081
				Adj R-squared	=	0.6731
Total	8.7036e+10	28	3.1084e+09	Root MSE	=	31877

SumofYsales5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	18076.16	3589.827	5.04	0.000	10682.77	25469.55
GERDasapercentageofGDP	-139756.8	44367.84	-3.15	0.004	-231134	-48379.47
HERDasapercentageofGDP	258205.4	215515	1.20	0.242	-185656.1	702066.9
_cons	87151.41	64633.4	1.35	0.190	-45963.58	220266.4

Figure 15-Regression analysis of sales for Italy

Source	SS	df	MS			
Model	583738.936	3	194579.645	Number of obs	=	29
Residual	337781.666	25	13511.2666	F(3, 25)	=	14.40
				Prob > F	=	0.0000
				R-squared	=	0.6335
				Adj R-squared	=	0.5895
Total	921520.602	28	32911.4501	Root MSE	=	116.24

SumofYEmp5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	47.68973	13.08995	3.64	0.001	20.73047	74.64899
GERDasapercentageofGDP	-557.4203	161.783	-3.45	0.002	-890.6186	-224.2221
HERDasapercentageofGDP	1637.886	785.8543	2.08	0.048	19.38873	3256.383
_cons	178.3625	235.6794	0.76	0.456	-307.0282	663.7532

Figure 16-Regression analysis of employees for Italy

The first model, for the sales, shows that the values of R square and Adjusted R square are rather good, indicating that the model explains approximately 70% of the total variability. Also, the F-statistic indicator shows that the model is statistically significant, with a p-value close to zero.

The second model, for employees, shows that R square and Adjusted R square are slightly lower than the first model, however a good fit can be seen also here, even if the F-statistic is lower.

However, in both models, only two variables show statistical significance, being the number of policies and GERD, one with positive sign and the other with a negative sign, and HERD for second model being at the edge of significance.

This reflects the observations done before: while for Italy the policies show a positive impact with the indicators of the cleantech sector, GERD shows a negative impact. This fact reconciles with the reasons mentioned above, where despite GERD having continued to increase over the years, the cleantech sector has seen a steady decline, and the prevalence of policies being issued between the end of the 90s and the start of 2000s, where the cleantech sector was at its high. No more observation can be drawn from the data above: the situation depicted remains as before.

9.1.2 France

France has been proactive in integrating environmental considerations into its legal and policy frameworks. A significant milestone was the adoption of the Charter for the Environment in 2005, which enshrined environmental rights and duties into the French Constitution.

In 2007, the Grenelle de l'Environnement marked another pivotal step. This extensive multi-party dialogue brought together government entities, local authorities, industry representatives, labor unions, and non-governmental organizations to collaboratively define France's environmental policies. The initiative led to ambitious commitments across various sectors, aiming to enhance sustainability and reduce environmental impacts.

As we can see from the graph below, France saw a significant spike in green policies issued around the years of those two big legislative acts, highlighting their big impact on the national awareness of the problem:

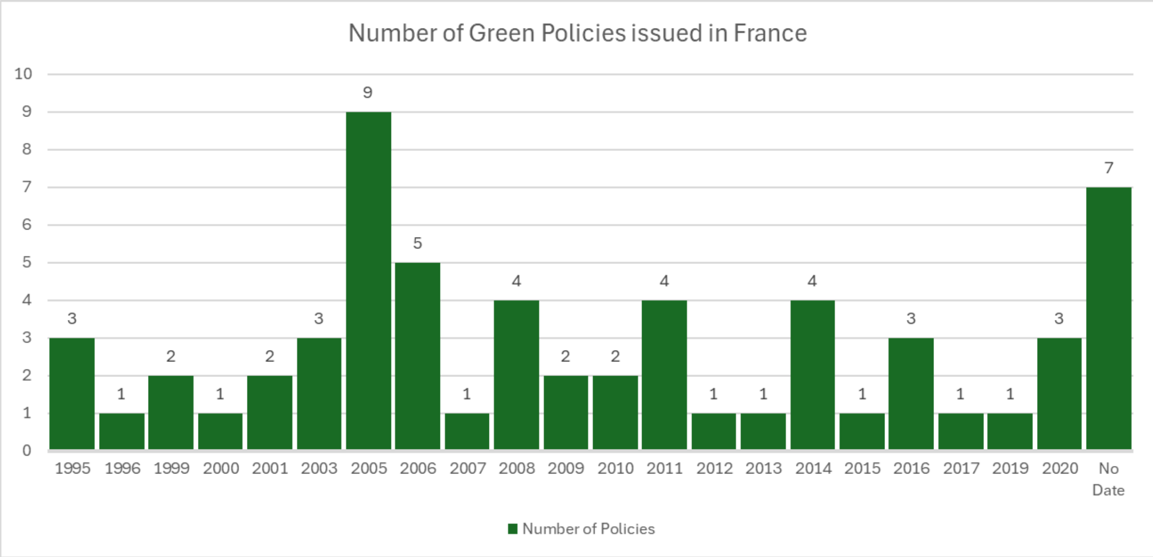

Figure 17-Number of green policies in France

Recent policy developments have set even more ambitious targets. The French government has launched public consultations on the third national low-carbon strategy (SNBC) and the third multiannual energy program (PPE), aiming for carbon neutrality by 2050, aligning with the commitment of the European Green Deal, which aims to make the EU carbon-neutral by 2050. These plans outline targets for reducing greenhouse gas emissions in key sectors such as transport, housing, and food.

France has established a robust framework for environmental protection through constitutional provisions and collaborative policy initiatives, and this can be reflected also on the distribution of the type of policies, which follows a completely different pattern than Italy. In France there is a strong predominance of Taxes and Fees and Subsidies, which are the most effective.

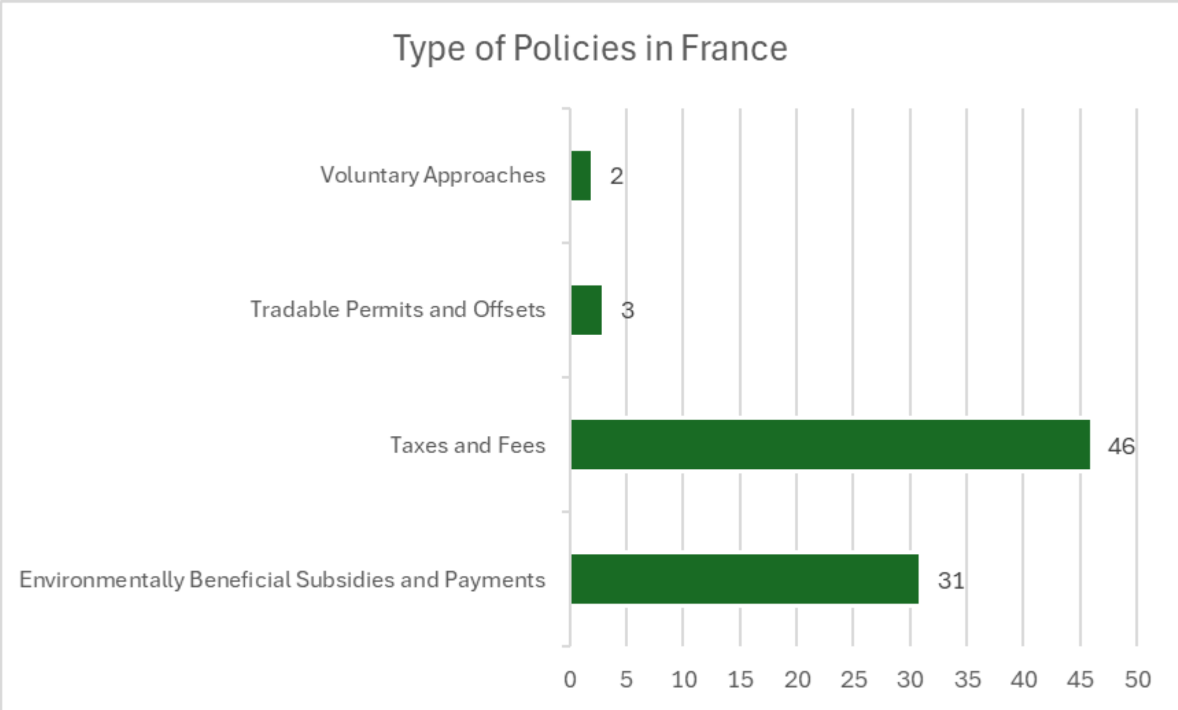

Figure 18-Type of policies in France

The analysis for France of the effects of the number of policies on the indicators of the cleantech dataset is reported below, with Pearson correlation index and its p-value, as the output of Stata.

	Ysales5Y afterFY	Ysalesg5Y afterFY	Ysales5Y after	Ysalesg5Y after	Y_n_comp born	YEmp5Y afterFY	YEmpg5Y afterFY	YEmp5Y after	YEmpg5Y after
Number of Policies	-0.2529	-0.3098	0.3098	-0.4298	-0.1444	-0.2519	0.0610	-0.3007	-0.3245
p-value	0.1857	0.1020	0.1019	0.0200	0.4550	0.1874	0.7534	0.1129	0.0859
GERD as percentage of GDP	0.1418	0.5450	0.0903	0.0078	0.0859	0.1415	0.1677	0.1185	0.0874
p-value	0.4631	0.0022	0.6413	0.9679	0.6576	0.4639	0.3847	0.5405	0.6519
HERD as percentage of GDP	-0.6738	0.4106	0.6518	-0.5980	-0.0221	-0.6796	0.5571	-0.6453	-0.6381
p-value	0.0001	0.0269	0.0001	0.0006	0.9094	0.0001	0.0017	0.0002	0.0002

Table 5-Correlation table for France

Despite the abundance of taxes and subsidies, in France there is a completely different situation than Italy, where no statistical significance of correlations between those variables can be found. This fact states that the issuing of policies has little to no influence in France, where other factors could influence this sector.

As the table clearly shows, similarly to what we can see in Italy, also in France the effects of R&D expenditures have a negligible impact on all those indicators, while HERD even showing a negative correlation with statistical significance. There only is a very weak positive correlation between GERD and financial indicators of cleantech, however without showing any statistical significance. Differently to what we can see in Italy, France had a stable value of expenditures over the years, as a percentage of GDP, with a higher amount than Italy. However, this stability cannot explain any variation in the indicators of the cleantech startup sector of France.

The regression analysis is conducted also for France, with the same model and variables used for Italy.

Source	SS	df	MS			
				Number of obs	=	29
				F(3, 25)	=	42.05
Model	1.2317e+14	3	4.1055e+13	Prob > F	=	0.0000
Residual	2.4409e+13	25	9.7637e+11	R-squared	=	0.8346
				Adj R-squared	=	0.8147
Total	1.4757e+14	28	5.2705e+12	Root MSE	=	9.9e+05

SumofYsales5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	-41162.48	98256.02	-0.42	0.679	-243524.5	161199.6
GERDasapercentageofGDP	2.30e+07	3277698	7.02	0.000	1.62e+07	2.97e+07
HERDasapercentageofGDP	-6.08e+07	5655977	-10.75	0.000	-7.24e+07	-4.91e+07
_cons	-2.29e+07	6109643	-3.74	0.001	-3.55e+07	-1.03e+07

Figure 19-Regression analysis for sales in France

Source	SS	df	MS			
				Number of obs	=	29
				F(3, 25)	=	46.00
Model	9.9488e+09	3	3.3163e+09	Prob > F	=	0.0000
Residual	1.8022e+09	25	72086664.9	R-squared	=	0.8466
				Adj R-squared	=	0.8282
Total	1.1751e+10	28	419678462	Root MSE	=	8490.4

SumofYEmp5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	-341.2127	844.2677	-0.40	0.690	-2080.014	1397.589
GERDasapercentageofGDP	206672	28163.72	7.34	0.000	148667.7	264676.3
HERDasapercentageofGDP	-546927.9	48599.15	-11.25	0.000	-647019.8	-446836.1
_cons	-205300.6	52497.29	-3.91	0.001	-313420.8	-97180.4

Figure 20-Regression analysis for employees in France

Both the models, for sales and employees, show very good level of fit, with R squared and Adjusted R square having a high value, indicating that the models explain approximately 84% of the total variability. Moreover, it can be noted that the F-statistics are higher than 40 and p-values are close to 0.

However, for both models, the variable of the number of policies is not significant at all, with a p-value close to 0.70, while GERD and HERD variables have a statistical significance, with opposite signs for them: GERD shows a positive impact while HERD has a negative impact.

The conclusions that can be drawn from these models are that in France the policies have no statistical impact on indicators of cleantech, while the dichotomy between GERD and HERD is hard to explain. The stagnancy of those indicators over the years may have an impact, with small fluctuation in one direction rather than the other can have a big impact on those statistics.

9.1.3 Germany

Germany has always been one of the countries with the highest effort to combat climate change and promote environmental sustainability. Green policies are a cornerstone of the country's political and economic agenda, driven by ambitious national targets, EU commitments, and a strong public awareness of environmental issues.

Germany has set legally binding targets to drastically reduce its greenhouse gas emissions. The overarching goal is to achieve net greenhouse gas neutrality by 2045, with significant interim targets for 2030 and 2040. These targets are enshrined in the Climate Action Law, a key piece of legislation that shapes Germany's climate policy framework.

The Energiewende: Germany's "Energiewende" (energy transition) is a flagship initiative aimed at transforming the country's energy system. It focuses on phasing out fossil fuels and nuclear power and transitioning to renewable energy sources, with the phasing out of nuclear power already completed. This involves promoting wind, solar, and other renewable technologies, as well as increasing energy efficiency.

However, according to PINE Dataset, Germany is the country with the lowest amount of green policies issued.

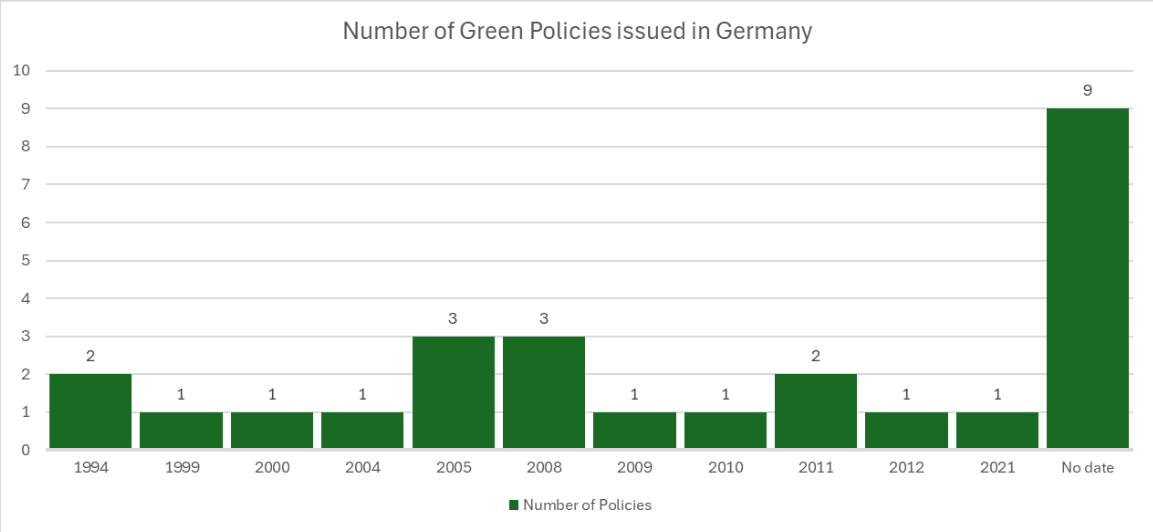

Figure 21-Number of green policies in Germany

This fact could be due to several factors, like the more comprehensive policy design that addresses multiple environmental objectives simultaneously. This approach can result in fewer individual instruments being recorded, as a single policy may encompass various measures, and the Germany's federal system, which grants significant autonomy to its states (Länder) in implementing environmental policies, with some regional initiatives that may not be fully captured in the PINE dataset, potentially underrepresenting the total number of instruments.

Germany has a similar situation of France, with taxes and fees representing the biggest part of green policies issued, and subsidies representing the second most used policy; only one voluntary approach has been issued.

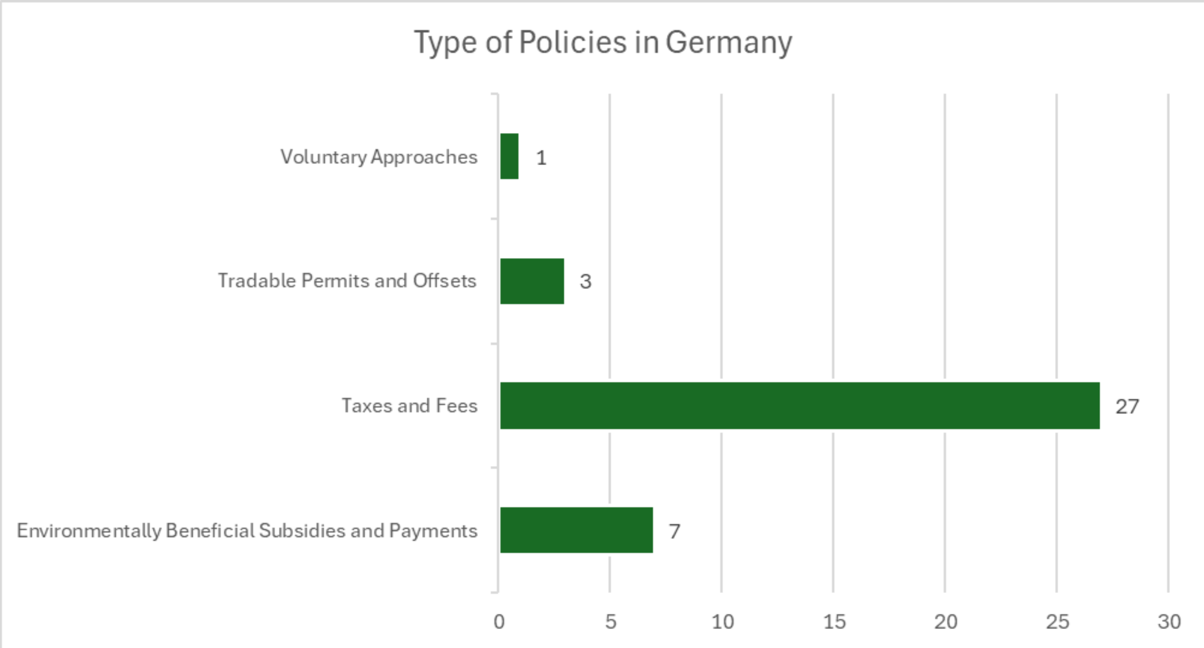

Figure 22-Type of green policies in Germany

The analysis for Germany of the effects of the number of policies on the indicators of the cleantech dataset is reported below, with Pearson correlation index and its p-value, as the output of Stata.

	Ysales5Y afterFY	Ysalesg5Y afterFY	Ysales5Y after	Ysalesg5Y after	Y_n_comp born	YEmp5Y afterFY	YEmpg5Y afterFY	YEmp5Y after	YEmpg5Y after
Number of Policies	-0.0063	0.0578	0.1602	-0.2800	-0.0933	0.0232	-0.2517	-0.0536	0.0159
p-value	0.9742	0.7660	0.4064	0.1412	0.6303	0.9050	0.1878	0.7825	0.9347
GERD as percentage of GDP	-0.8045	0.0888	0.2981	-0.3216	0.1774	-0.7913	0.0313	-0.8274	-0.8816
p-value	0.0000	0.6469	0.1162	0.0889	0.3572	0.0000	0.8718	0.0000	0.0000
HERD as percentage of GDP	-0.7355	0.0220	0.2246	-0.2516	0.1452	-0.6670	0.0205	-0.7385	-0.7836
p-value	0.0000	0.9098	0.2414	0.1880	0.4523	0.0001	0.9158	0.0000	0.0000

Table 6-Correlation table for Germany

As we can see from the table, Germany shows a common trend with France, with no clear correlation between the number of policies and the performance of the cleantech sector. This result can be expected due to the low number of policies per year, thus not having a large enough number of observations.

The table of correlations between GERD, HERD and cleantech performances indicators shows see again a very similar trend to what we could see in other European countries, where no correlation can be found at all. By looking at the data, we can see that Germany has increased its expenditures on R&D and in Higher Education with an increasing trend, passing from 2.13% of GDP in 1994 to 3.13% in 2022 for GERD and from 0.39% to 0.57% for HERD, while indicators from the cleantech startups have seen a decline over the years. Thus, those indicators cannot explain any variation into the trends that the cleantech startup sector has faced over the years.

The regression analysis is then conducted also for Germany, with the same model and variables used above.

Source	SS	df	MS			
				Number of obs	=	29
				F(3, 25)	=	18.45
Model	7.0871e+13	3	2.3624e+13	Prob > F	=	0.0000
Residual	3.2002e+13	25	1.2801e+12	R-squared	=	0.6889
				Adj R-squared	=	0.6516
Total	1.0287e+14	28	3.6740e+12	Root MSE	=	1.1e+06

SumofYsales5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	-221932.3	240811.1	-0.92	0.366	-717892.1	274027.4
GERDasapercentageofGDP	-8076577	2513693	-3.21	0.004	-1.33e+07	-2899530
HERDasapercentageofGDP	1.83e+07	1.28e+07	1.43	0.164	-7995675	4.46e+07
_cons	1.47e+07	1774718	8.26	0.000	1.10e+07	1.83e+07

Figure 23-Regression analysis for sales in Germany

Source	SS	df	MS			
				Number of obs	=	29
				F(3, 25)	=	30.98
Model	591326700	3	197108900	Prob > F	=	0.0000
Residual	159085610	25	6363424.4	R-squared	=	0.7880
				Adj R-squared	=	0.7626
Total	750412310	28	26800439.6	Root MSE	=	2522.6

SumofYEmp5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	-224.7087	536.9154	-0.42	0.679	-1330.507	881.0894
GERDasapercentageofGDP	-35151.99	5604.56	-6.27	0.000	-46694.8	-23609.18
HERDasapercentageofGDP	120824.9	28469.64	4.24	0.000	62190.59	179459.2
_cons	40634.67	3956.933	10.27	0.000	32485.21	48784.13

Figure 24-Regression analysis for employees in Germany

Both the models, for sales and employees, show very good level of fit, with R squared and Adjusted R square having a high value, indicating that the models explain approximately 68%

of the total variability for the sales and 78% for the employees. The F-statistics both have good values, with 18 in the first case and 31 in the second case.

However, for both models, a common pattern with France can be identified, where the variable of the number of policies is not significant at all, with a p-value much bigger than 0.05, indicating that the variable is not significant, while GERD shows statistical significance with a negative sign, and HERD showing a positive impact only for employees in the second case (with sales the statistics is not significant, with a p-value higher than 0.05).

Similar conclusions can be drawn from these models, where policies have no statistical impact on indicators of cleantech, and GERD having a negative impact and HERD only a positive impact for employees. The steady increase of GERD over the years, with a decline of cleantech indicators can explain this situation, which is very common with other countries: more expenses in R&D did not result in a better situation for the cleantech startups.

9.1.4 The Netherlands

The Netherlands is a country actively engaged in addressing climate change and promoting sustainability, driven by a combination of national ambition, EU obligations, and its unique geographical vulnerabilities.

Similarly to other European countries, the Netherlands is aiming for climate neutrality by 2050, following the European Green Deal framework. These targets are formalized in the Dutch Climate Law, which provides a legal framework for the country's climate action. There is also a judiciary focus on this topic, with the district court of The Hague ordered the Dutch government to reduce its emissions by a minimum of 25% by 2020 compared to 1990 [57].

A key policy instrument is the National Climate Agreement, which involves collaboration between various sectors (including electricity, industry, built environment, traffic and transport, and agriculture) to achieve the climate goals. This agreement emphasizes a cost-effective transition and seeks to distribute the financial burden fairly.

The country is currently investing heavily in renewable energy sources, particularly offshore wind power, and exploring other options like solar, hydrogen, and nuclear energy. There's a strong focus on phasing out fossil fuels. A study found out that more renewable energy in power and heat generation has the potential for creating jobs and growth for the Dutch economy, with around 50 000 new full-time jobs that can be created by 2030 and the GDP expected to increase by 0.85% relatively to the baseline scenario [58].

The country's green policies are shaped by its ambitious targets, collaborative approach, and the urgency of addressing its environmental vulnerabilities.

The Netherlands, according to PINE Dataset, have issued fewer green policies than France and Italy. Reasons of this could be the same of Germany, with the implementation of broader measures, overarching environmental strategies rather than numerous fragmented policies, such as the Dutch Climate Agreement (Klimaatakkoord), which includes emission reduction targets across multiple sectors.

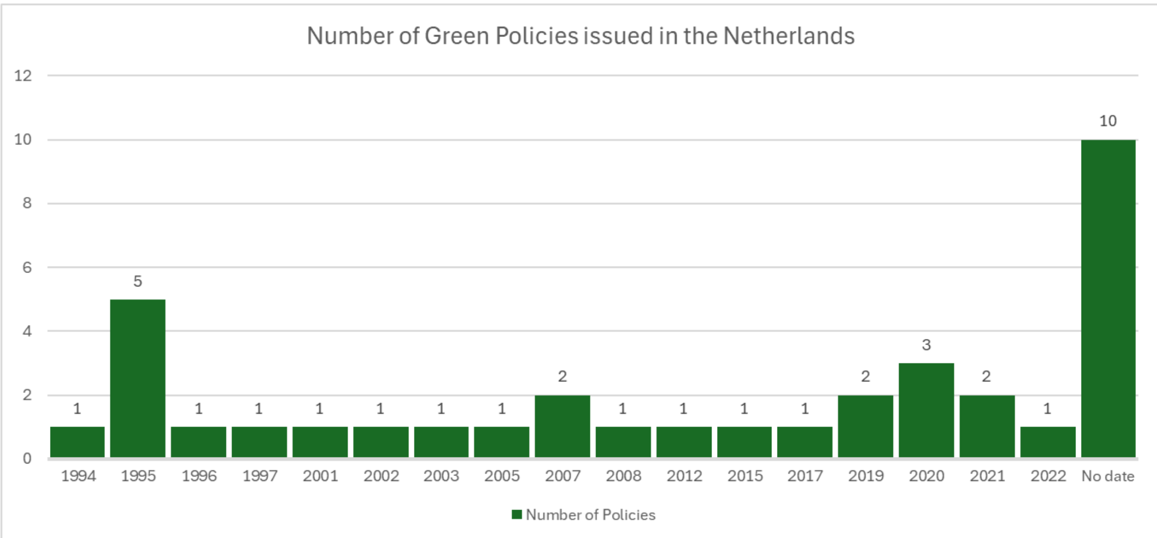

Figure 25-Number of green policies in the Netherlands

The type of policies adopted follows a common pattern, with taxes and fees and subsidies being the prevalent ones adopted by policymakers:

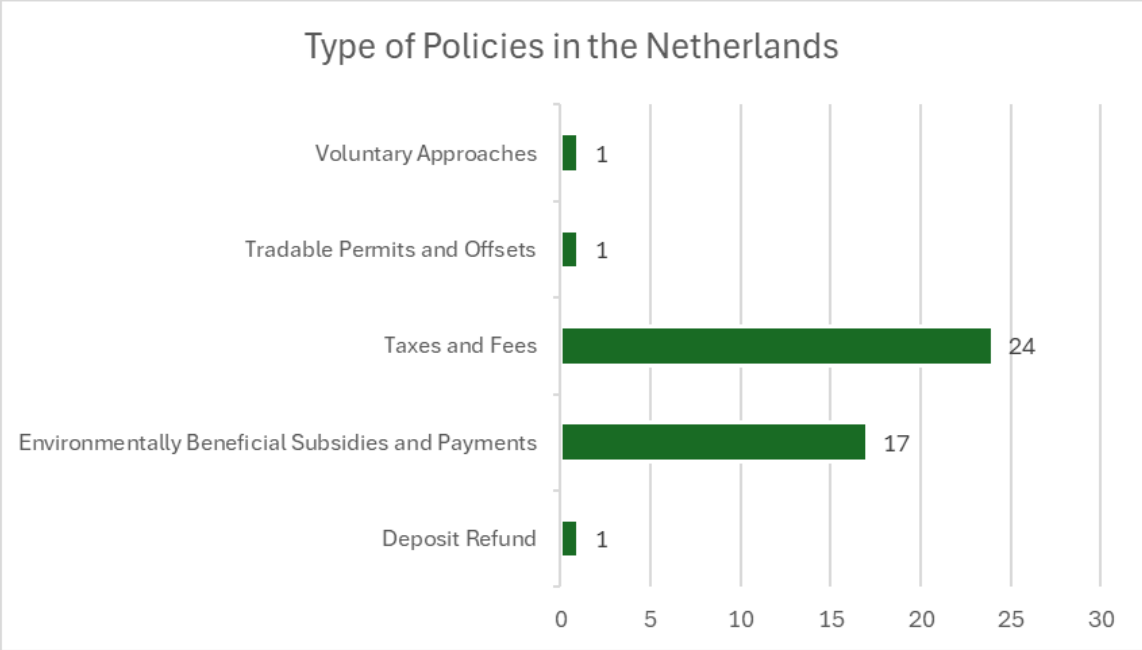

Figure 26-Type of green policies in the Netherlands

The analysis for the Netherlands of the effects of the number of policies on the indicators of the cleantech dataset is reported below, with Pearson correlation index and its p-value.

	Ysales5Y afterFY	Ysalesg5Y afterFY	Ysales5Y after	Ysalesg5Y after	Y_n_comp born	YEmp5Y afterFY	YEmpg5Y afterFY	YEmp5Y after	YEmpg5Y after
Number of Policies	-0.1584	-0.0587	0.1144	0.1733	0.2293	-0.1552	-0.1824	0.1273	-0.0979
p-value	0.4118	0.7622	0.5545	0.3687	0.2316	0.4215	0.3437	0.5104	0.6133
GERD as percentage of GDP	-0.3777	0.6577	0.0712	0.0614	0.3440	-0.3691	0.2912	-0.2928	-0.5264
p-value	0.0434	0.0001	0.7135	0.7515	0.0676	0.0488	0.1253	0.1233	0.0034
HERD as percentage of GDP	-0.5671	0.1398	0.6019	-0.6952	0.0969	-0.5671	0.4106	-0.8193	-0.3878
p-value	0.0013	0.4694	0.0006	0.0000	0.6171	0.0013	0.0269	0.0000	0.0376

Table 7-Correlation table for the Netherlands

As the table show, the common pattern with other countries can be seen again also in the Netherlands, where the issuing of new policies has little to zero effect on the cleantech startup sector, thus highlighting no statistical significance between those indicators.

The table of correlations between GERD, HERD and cleantech performances indicators depicts a common trend with what we can see in other European countries, where no correlation can be found at all.

By looking at the data, we can see that the Netherlands has increased its expenditures on R&D, passing from 1.81% of GDP in 1994 to 2.30% in 2022 for GERD while maintaining a more stable expenditure for HERD, passing from 0.52% in 1994 to just 0.63% in 2022. The Netherlands is not immune from the steady decline of indicators of the cleantech sector, starting at the beginning of the new decade, despite the increase in R&D related expenses. Statistical relevance cannot be drawn from those indicators.

The regression analysis is then conducted also for the Netherlands, with the same model and variables used above.

Source	SS	df	MS		
Model	6.8541e+12	3	2.2847e+12	Number of obs =	29
Residual	1.0277e+13	25	4.1109e+11	F(3, 25) =	5.56
				Prob > F =	0.0046
				R-squared =	0.4001
				Adj R-squared =	0.3281
Total	1.7131e+13	28	6.1184e+11	Root MSE =	6.4e+05

SumofYsales5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	-136309.9	112109.9	-1.22	0.235	-367204.6	94584.86
GERDasapercentageofGDP	-634868.3	601413.1	-1.06	0.301	-1873502	603765.2
HERDasapercentageofGDP	-8410660	2619124	-3.21	0.004	-1.38e+07	-3016473
_cons	6968630	1597191	4.36	0.000	3679154	1.03e+07

Figure 27-Regression analysis for sales in the Netherlands

Source	SS	df	MS		
Model	80227683.2	3	26742561.1	Number of obs =	29
Residual	122416797	25	4896671.88	F(3, 25) =	5.46
				Prob > F =	0.0050
				R-squared =	0.3959
				Adj R-squared =	0.3234
Total	202644480	28	7237302.87	Root MSE =	2212.8

SumofYEmp5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	-465.3853	386.9232	-1.20	0.240	-1262.269	331.498
GERDasapercentageofGDP	-2068.325	2075.647	-1.00	0.329	-6343.201	2206.55
HERDasapercentageofGDP	-29080.27	9039.34	-3.22	0.004	-47697.14	-10463.4
_cons	23740.71	5512.359	4.31	0.000	12387.79	35093.62

Figure 28-Regression analysis for employees in the Netherlands

Both models show a much lower level of fit compared to previous ones, with R squared and Adjusted R square having a very poor value around 0.40, indicating that the models are not that good for explaining variability, even if F-statistics both are good enough, and p-value being below 0.05.

For both models, as a common pattern with France and Germany, the variable of the number of policies is not significant at all, with a p-value much bigger than 0.05, and GERD following the same trend, being not significant at all. However, HERD is showing statistical significance, even if the sign of the variable is negative.

Again, for these models, similar conclusions to previous countries can be drawn policies and GERD have no statistical impact on indicators of cleantech, while HERD is showing a negative impact for both indicators. The increase of HERD over the years, with a decline of cleantech indicators can explain this situation, which follows a very common pattern with other countries: more expenses in R&D did not result in a better situation for the cleantech startups.

9.1.5 Denmark

Denmark is widely recognized as a global leader in green policies and sustainable development. The country has a long-standing commitment to environmental protection and has implemented ambitious measures to address climate change and promote a green transition.

Denmark has set legally binding climate targets, demonstrating its strong commitment to reducing greenhouse gas emissions. The Climate Act is a key piece of legislation, which states that its purpose is to reduce greenhouse gas emissions in 2030 by 70% compared to the level of emissions in 1990, and for Denmark to achieve a climate-neutral society by 2050 at the latest, taking into account the Paris Agreement target of limiting the global temperature rise to 1.5 degrees Celsius [59]. The realization of these objectives must be as cost effective as possible, fostering sustainable business development and competitiveness.

Denmark has been a pioneer in the development and deployment of renewable energy technologies, particularly wind power. The country has made significant investments in offshore wind farms and is actively pursuing other renewable energy sources like solar and biogas. The transition to renewable energy is a central pillar of Denmark's green policies.

Denmark actively engages in international cooperation on climate change and sustainable development. The country is a strong supporter of international agreements and initiatives aimed at addressing global environmental challenges. The country is striving to be a frontrunner in the transition to a sustainable and climate-neutral society.

This situation is reflected in the number of policies, with the highest amount of all of the countries analyzed so far, with a total of 77.

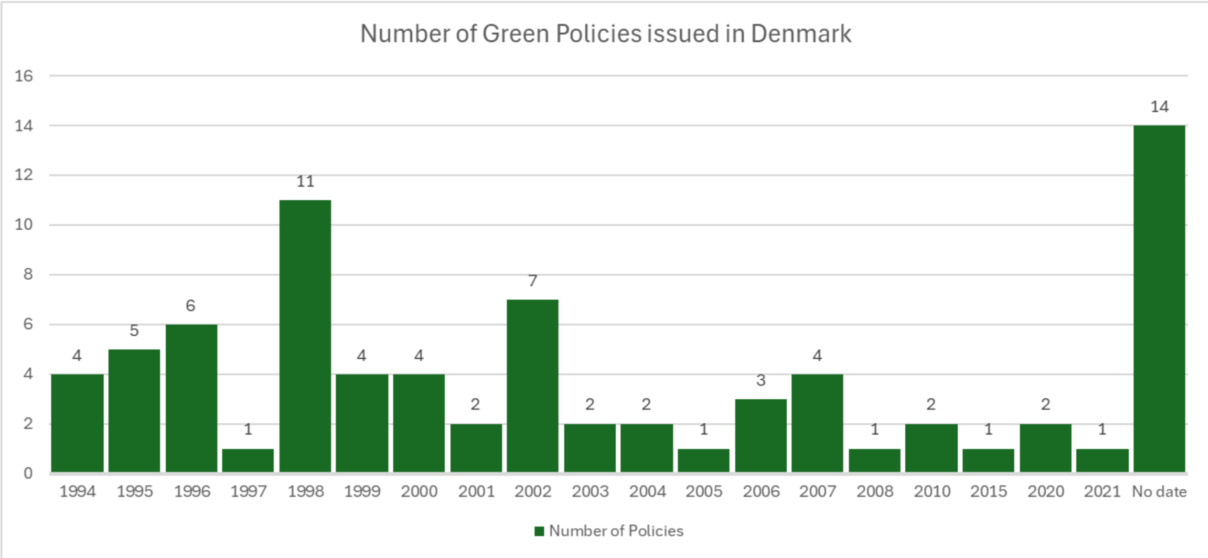

Figure 29-Number of green policies in the Netherlands

The type of policies follows a common pattern with the other European countries, with taxes and subsidies being the majority, with a slight increase in voluntary approaches.

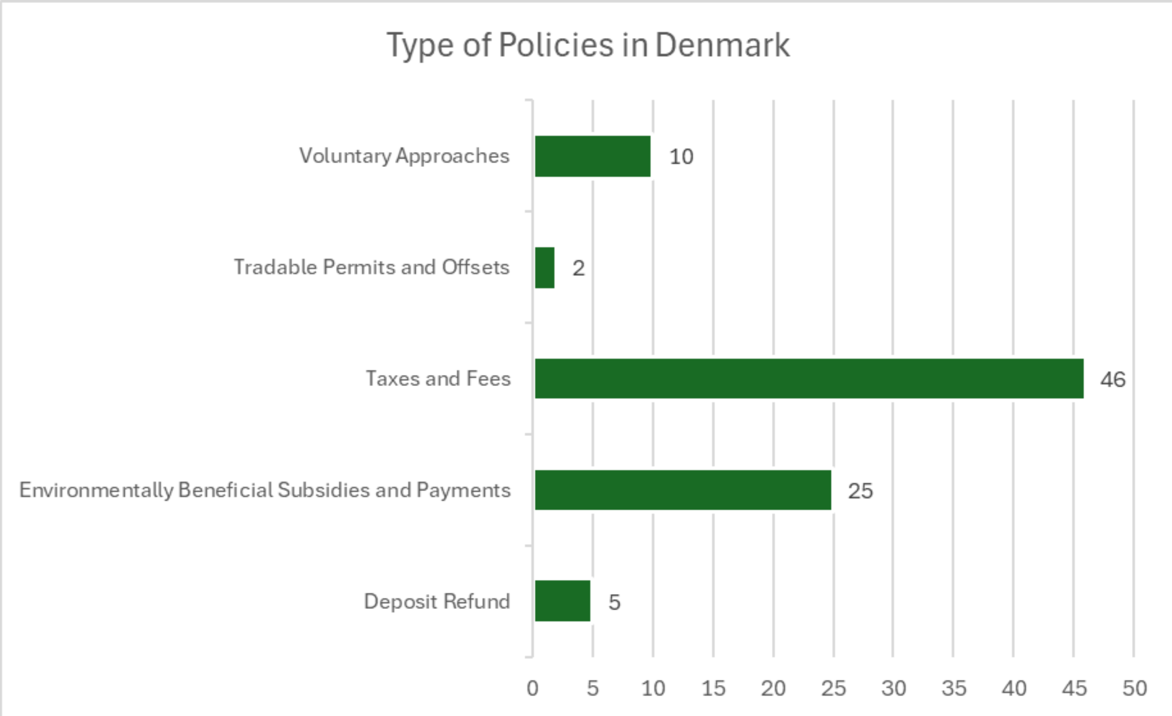

Figure 30-Type of green policies in Denmark

The analysis for the Netherlands of the effects of the number of policies on the indicators of the cleantech dataset is reported below, with Pearson correlation index and its p-value, as the output of Stata.

	Ysales5Y afterFY	Ysalesg5Y afterFY	Ysales5Y after	Ysalesg5Y after	Y_n_comp born	YEmp5Y afterFY	YEmpg5Y afterFY	YEmp5Y after	YEmpg5Y after
Number of Policies	0.4140	0.1737	0.3267	0.5086	-0.2108	0.6987	0.6987	0.6131	0.5133
p-value	0.0256	0.3675	0.0837	0.0048	0.2724	0.0000	0.0000	0.0004	0.0044
GERD as percentage of GDP	-0.3831	-0.1273	0.2298	-0.3569	0.2005	-0.7111	-0.7111	-0.6205	-0.4399
p-value	0.0402	0.5105	0.2304	0.0574	0.2971	0.0000	0.0000	0.0003	0.0169
HERD as percentage of GDP	-0.6573	-0.1373	0.4874	-0.6277	0.3874	-0.9404	-0.9404	-0.8253	-0.7295
p-value	0.0001	0.4777	0.0073	0.0003	0.0379	0.0000	0.0000	0.0000	0.0000

Table 8-Correlation table for Denmark

The tables of Denmark depicts a slightly different situation than previous countries analyzed, with a similar situation to Italy: a moderate correlation, with statistical significance, can be found with the sales of the startups, despite a low value of 0.4140 for the sales, and a value of 0.5086 for the growth of sales, both with a statistical significance (p-value lower than 0.05). A good correlation can be found with the employees and growth of employees, with correlation around 0.7 and p-value lower than 0.05. This indicates that in Denmark, issuing of new policies has had a moderate effect on cleantech indicators, while a bigger number of observations can certainly have had a positive impact on the analysis, since this country has the largest number of green policies issued.

The results of GERD and HERD in Denmark is very similar to the other countries analyzed: no positive correlation can be found, and the slightly negative correlation can be explained with the fact that, similar to the other European countries, expenditures in R&D for both the government and high education have continued to increase over the years, with GERD passing from 1.79% of GDP in 1995 to 2.89% in 2022, with a peak of 3.09% in 2016, and HERD passing from 0.44% to 1.02% in the same timeframe, while the indicators of the cleantech have seen a steady decline, so no statistical correlation can be drawn from those indicators.

The regression analysis is then conducted also for Denmark, with the same model and variables used above.

Source	SS	df	MS			
				Number of obs	=	29
				F(3, 25)	=	9.28
Model	7.6425e+12	3	2.5475e+12	Prob > F	=	0.0003
Residual	6.8613e+12	25	2.7445e+11	R-squared	=	0.5269
				Adj R-squared	=	0.4702
Total	1.4504e+13	28	5.1799e+11	Root MSE	=	5.2e+05

SumofYsales5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	-27578.17	51534.31	-0.54	0.597	-133715.1	78558.72
GERDasapercentageofGDP	510670.4	230042.9	2.22	0.036	36888.3	984452.6
HERDasapercentageofGDP	-3088251	754962.5	-4.09	0.000	-4643126	-1533377
_cons	1892699	461423.5	4.10	0.000	942379.7	2843019

Figure 31-Regression analysis of sales for Denmark

Source	SS	df	MS			
				Number of obs	=	29
				F(3, 25)	=	81.45
Model	112998041	3	37666013.7	Prob > F	=	0.0000
Residual	11561654.4	25	462466.174	R-squared	=	0.9072
				Adj R-squared	=	0.8960
Total	124559695	28	4448560.55	Root MSE	=	680.05

SumofYEmp5YafterFY	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NumberofPolicies	79.65973	66.89649	1.19	0.245	-58.11618	217.4356
GERDasapercentageofGDP	606.3765	298.6178	2.03	0.053	-8.638382	1221.391
HERDasapercentageofGDP	-8079.067	980.0141	-8.24	0.000	-10097.44	-6060.69
_cons	6323.324	598.9721	10.56	0.000	5089.718	7556.93

Figure 32-Regression analysis for employees in Denmark

The situation for Denmark is slightly different than previous countries: the model for sales show a quite low level of fit, with R squared and R squared adjusted being around 0.50, even if p-value is lower than 0.05, while the model for employees shows a very good fit, with R squared and R squared adjusted being around 0.90, and the F-statistic is as high as 81.

However, despite the fit, especially for the second case, the same common pattern with other countries can be seen here: the variable of the number of policies is not significant at all, with a p-value much bigger than 0.05, while GERD being only slightly significant for the first case and at the edge for the second case, with a positive sign, indicating a weak correlation. HERD is showing statistical significance in both models, again with a negative sign of the variable, indicating that as the expenditures increase, the indicators of cleantech are decreasing.

Even the last country shows very common pattern with the others, thus conducting to the same conclusions, where the increase over the years of R&D expenditures haven't influenced the cleantech market at all, which also in this country has seen a steady decline in its indicators.

9.1.6 All countries

Further analysis can be conducted by grouping all the policies of all countries above against their cleantech indicators, in order to see if more observations could lead to better results in terms of correlations, and to see whether any trend can be identified. By summing up all the policies we have a total number of 217 observations, instead of an average of around 40 per single country, helping to reduce random noise and making the correlation estimate more stable.

The indicators of the cleantech dataset have been grouped following this logic: all the sales and the number of new cleantech born have been summed up, while all the growth percentage have been grouped with their average.

The output of Stata is reported below:

	Ysales5Y afterFY	Ysalesg5Y afterFY	Ysales5Y after	Ysalesg5Y after	Y_n_comp born	YEmp5Y afterFY	YEmpg5Y afterFY	YEmp5Y after	YEmpg5Y after
Number of Policies	0.6032	-0.1955	0.3488	0.3126	0.0340	0.4849	0.6092	0.5371	0.5146
p-value	0.0005	0.3095	0.0637	0.0987	0.8608	0.0077	0.0005	0.0027	0.0043

Table 9-Correlation table for all countries

As the values reported in the table show, there is a statistically significant correlation between the number of policies and the sales five years after the foundation, with a p-value below the 0.05 threshold, even if the value of 0.6032 is not very high. The other variables which show statistically significant correlation are the indicators related to employees: they all have a p-value below 0.05 with correlation values similar to the one of the sales at around 0.5.

Even if the correlation is not very strong, this could imply that the creation of policies, at a general level, create a positive momentum for cleantech startups, and they increase the number of employees in their organization in order to exploit the opportunities provided by the issuing of new policies. However often this momentum does not translate into a consolidation of the growth towards bigger opportunities, and the data could only be explained with the fact that the biggest number of policies have been issued before the first decade of the 21st century, where the growth has been higher than the years following, where we can see a steady decline in sales and employees.

10. Conclusions and future developments

The results of the analysis conducted in this paper show that many common trends can be found in all countries, with little to no evidence that the number of policies has had an impact on the cleantech startup sector, except for Italy and all the countries grouped together, where statistical significance has been found in both models utilized: simple correlation and regression analysis.

Studying the correlation of public expenditures in R&D, both from the government (GERD) and from the higher education (HERD) has revealed that no correlation at all can be found with these indicators, and in many cases, they are even showing negative correlation with the cleantech, with both models utilized.

The limited number of observation in the number of policies can certainly have had an impact on the goodness of the analysis, however the trend depicted is clear: the number of policies issued in the countries has had little to no effect on the cleantech sector, and the negative correlation with some indicators of the cleantech with research expenditures can be easily explained with the fact that, while the public expenditures for R&D have seen a steady increase in all of the countries, the indicators of cleantech have seen a robust decline over the years, starting from their peak during the early 2000s to the low of the last years.

In conclusion, no statistical instrument can highlight any type of correlation in this research, while some common trends can be seen in public expenditures in R&D, highlighting a positive increase over the years, indicating that research has gained attention and public relevance over the years, with benefits that don’t translate over this sector. However, public focus on the environment with the issuing of new policies should not be questioned, given their importance also on established sectors, where big companies have the biggest part in the industry.

Future developments can focus on why this type of indicators has little effect on the cleantech startup sector, and whether money spent on research can even have an influence, or if the benefits from this expenses are captured by incumbent firms; or which other variable can have positive interactions with those variables, such as the availability of capital and the choices of big funds.

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