



**UNIVERSITY
OF TURKU**

Turku School of
Economics

Public Innovation Funding for the Green Transition

Evidence from Business Finland

Economics/Department of Economics

Master's thesis

Author:

Mikaela Joensuu

Supervisor:

Prof. Timo Kuosmanen

13.6.2025

Helsinki

The originality of this thesis has been checked by the University of Turku quality assurance system using the Turnitin Originality Check service.

Master's thesis

Subject: Economics

Author: Mikaela Joensuu

Title: Public Innovation Funding for the Green Transition: Evidence from Business Finland

Supervisor: Prof. Timo Kuosmanen

Number of pages: 77 pages + appendices 6 pages

Date: 13.6.2025

This study investigates how Business Finland's innovation funding has supported Finland's green transition between 2000 and 2025. Using a keyword-based method rooted in climate and sustainability discourses, the analysis maps the volume, structure, and thematic orientation of funded RDI projects.

The results show climate-related funding has consistently increased throughout the 2000s, with a significant rise in project share since 2019. The study indicates that over 75% of funding from 2022 to 2024 will likely be directed toward green transition initiatives. This shift supports national policy goals that became more prominent under the Sanna Marin government. However, the relatively stagnant share of program-linked projects may suggest that Business Finland's funding has aligned more with firms' bottom-up interests than with a coordinated or directive policy agenda.

The analysis also highlights large firms' dominant role in total funding volume. Medium-sized companies continue to receive a relatively small share of funding, reflecting broader patterns in Business Finland's overall allocation practices. When examined by sector, scientific research and development dominate funding distribution, suggesting that many green transition efforts remain in early-stage research rather than in commercially mature applications. Findings may partly explain Finland's weak productivity trends if investments focus on emerging themes that are still in the invention stage, and firms cannot fully leverage them in their business activities. The green transition requires substantial investments over several years before firms can expect significant commercial benefits.

While the findings based on keyword analysis suggest alignment with mission-oriented policy goals, it remains unclear to what extent the funded projects have substantively contributed to sustainability outcomes. The keyword-based approach identifies thematic associations but does not capture the depth, effectiveness, or practical implementation of green objectives. As such, further research is needed to assess whether these projects have genuinely advanced the green transition or merely adopted climate-related language at a superficial level. A more in-depth assessment of project outcomes, policy tools, and the broader innovation ecosystem is needed to better understand how effectively public funding supports Finland's green transition.

Key words: green transition, public RDI funding, innovation policy, Business Finland, sustainability

Acknowledgements

Thank you to those who supported me in completing this thesis.

I am particularly thankful to Professor Timo Kuosmanen for initially proposing the idea that inspired this research and for his insightful guidance during the early stages of topic formulation.

I am also grateful to Business Finland for providing access to anonymized project-level funding data, a key foundation for the empirical analysis. Due to access restrictions, a data expert at Business Finland assisted with the internal keyword-matching process. However, this study was conducted independently and was not commissioned or carried out on behalf of Business Finland.

I have used AI-assisted tools to support language refinement and programming-related tasks throughout the writing process. These tools serve as technical aids only. All analytical decisions and interpretations are my own.

TABLE OF CONTENTS

1	Introduction	8
1.1	Background and Motivation	8
1.2	Research Objectives and Methodology	9
1.3	Scope and Structure of the Study	10
2	Innovation and the Innovation Process	12
2.1	Defining Innovation	13
2.2	Innovation as a Driver of Growth: The Schumpeterian Framework	15
2.3	The Evolution of Innovation and Disruptive Innovation	18
3	The Role and Evolution of Public Support in R&D	23
3.1	The Evolution of Innovation Policy: From Market Failures to Systemic Approaches	24
3.1.1	R&D Tax Credits and Direct Subsidies	27
3.1.2	University Research, Human Capital, and Collaborative Networks	29
3.2	Mission-Oriented Innovation Policy and Societal Challenges	30
3.3	EU State Aid Rules for R&D: Regulations, and Objectives	33
3.4	Finland's Innovation System: Strengths, Challenges, and Policy Developments	34
3.4.1	Business Finland	38
4	Research Methodology	42
4.1	Research Design	43
4.2	Data Collection and Processing	44
4.2.1	Theoretical Grounding of Keyword Selection	45
4.3	Keyword Validation Process	47
4.4	Data Analysis at Business Finland	49
4.5	Limitations and Robustness	50
5	Empirical Results	52
5.1	Climate-Related Projects in Business Finland Programs	52
5.2	Green Transition Funding Over Time	55
5.3	Funding Allocation by Firm Characteristics, Sector, Instrument, and Region	58
5.3.1	Firm Size Distribution	58

5.3.2	Sectoral Funding Distribution	60
5.3.3	Funding by Instrument Type	61
5.3.4	Regional Concentration of Innovation Funding	63
6	Conclusions	65
	References	68
	Appendices	78
	Appendix 1: Keyword List Based on Academic Papers and IPCC Reports	78
	Appendix 2: Final Keyword List with Regex	81

LIST OF FIGURES

Figure 1: Stages of Innovation Dynamics: Product and Process Innovation (Utterback & Abernathy, 1975)	18
Figure 2: The Evolution of Disruptive and Sustaining Technologies (Christensen, 1997)	21
Figure 3: Selected Business Finland and Tekes Programs Related to Climate Change or Sustainability, 2000–2023 (Luoma et al., 2017; Business Finland, n.d.-c)	41
Figure 4: Annual Number of Climate-Related and Total Projects Linked to Business Finland Programs, 2000–2023 (Keyword-identified = projects matched with climate-related keywords)	53
Figure 5: Share of Climate-Related Projects out of All Program-Linked Projects by Year, 2000–2023, with Key Policy Milestones	54
Figure 6: Number of Projects Related to Climate Change and the Green Transition	55
Figure 7: Total Funding Allocated to Climate Change and Green Transition Initiatives	56
Figure 8: Development of the Funding Share (%) in Relation to Key Climate Policy Events	57
Figure 9: Number of Projects by Firm Size, 2016–2025	58
Figure 10: Total Funding by Firm Size, 2016–2025	59
Figure 11: Trends in Annual Funding Share by Industry Sector	60
Figure 12: Number of Projects by Instrument Type, 2016–2024	61
Figure 13: Total Funding by Instrument Type, 2016–2024	62
Figure 14: Share of Total Funding (€) Across the Top 10 Finnish Cities	64

LIST OF TABLES

Table 1: Three Key Theoretical Frameworks Explaining the Evolution of Innovation Policies (Adapted from Schot & Steinmueller, 2018)	24
Table 2. Innovation Types, Market Failures, and Policy Responses (Martin & Scott, 2000)	26
Table 3: Finland's Innovation System: Key Actors and Their Roles in R&D and Business Development (OECD, 2017; Suomen Akatemia, 2024)	35

1 Introduction

Since the 2008 global financial crisis, Finland has faced prolonged weak economic growth. Experts have not reached a clear consensus on the reasons behind this trend. However, they consider slow productivity growth one of the most significant challenges for the Finnish economy. (Ministry of Finance, 2024.) At the same time, the urgency of addressing climate change has intensified. According to the IPCC (2023), it is unequivocal that human activity is the cause of global warming. Between 2011 and 2020, global temperatures were approximately 1.1°C higher than in pre-industrial times. Current climate policies are insufficient to keep warming below 1.5°C.

This study investigates how Business Finland has directed public innovation funding to support the green transition between 2000 and 2025. The central research question is to what extent and in what ways Business Finland's funding portfolio has aligned with climate-related and sustainability goals. Furthermore, it will analyze how this support has been distributed across firms, regions, and instruments.

1.1 Background and Motivation

In Finland, the Ministry of Finance (2024) points out that structural issues drive weak productivity growth, global disruptions like the COVID-19 pandemic, and geopolitical tensions. While they acknowledge that neglecting climate action could undermine long-term productivity and economic output, allocating funds to climate initiatives also represents an opportunity cost for other priorities.

Kuosmanen et al. (2022) suggest that the ongoing energy transition and broader green investments partly explain the slowdown in productivity growth. Since the 2000s, businesses and societies have allocated resources to reducing greenhouse gas emissions. However, conventional productivity metrics do not account for the positive externalities associated with these efforts. As a result, the use of production factors appears to increase without a corresponding rise in measured output. This discrepancy may lead to underestimating economic performance in Finland and other Western economies.

The Finnish Government (2023) acknowledges that tackling climate change requires rapidly restructuring the economy toward greater environmental sustainability. However, globally and in Finland, financial flows continue to be directed more toward fossil fuel subsidies and other emission-increasing activities than climate action and green support (IPCC, 2023; Kässi, 2024). IPCC (2023) argues that investments in low-emission technologies and renewable energy hold

significant potential to reduce emissions and drive systemic change. The transition to a green economy requires substantial resources from private investors and public decision-makers, which can be supported through macroeconomic policies (Braga & Ernst, 2023).

The Finnish Ministry of Finance (2022) emphasizes the importance of economic policy instruments, such as emissions trading, taxation, and regulation, in promoting the green transition. Research, development, and innovation (RDI) can also support long-term green growth. Bambi et al. (2025) also point out that R&D investments are widely recognized enablers of innovation, reinforcing the foundations for sustainable growth.

Although technological and economic solutions to reduce emissions exist, the transition to sustainable development continues to be hindered by political, institutional, and financial barriers (IPCC, 2023). In Finland, green transition investments are largely expected from the private sector. Public funding from innovation agencies can help mitigate investment risks and encourage private sector participation in sustainable projects. (Ministry of Finance, 2023.)

Business Finland plays a central role in advancing the green transition in Finland by facilitating funding for RDI activities (Business Finland, n.d. -a), green subsidies (Kässi, 2023), and by implementing Finland's Sustainable Growth Program (Business Finland b, n.d. -b). Despite Business Finland's central role in promoting the green transition, through RDI funding, green subsidies, and implementation of the Sustainable Growth Program, there is still a lack of comprehensive research on how its funding is allocated to support these goals.

This study addresses the need to understand this allocation better. The study aims to identify how much funding is explicitly allocated to green transition projects compared to other RDI initiatives. By analyzing funding distribution across sectors and firm sizes, the study also provides insights into the magnitude and focus of public funding in green R&D.

1.2 Research Objectives and Methodology

This research examines Business Finland's funding for climate change mitigation through research, development, and innovation (RDI) activities. It analyses how much funding has been directed toward this theme, how it is distributed across industries and firm sizes, and how these patterns have evolved. Rather than evaluating individual project effectiveness, the focus is on the overall direction and magnitude of public RDI support for climate-related objectives.

The main research questions are:

- i. How much funding has Business Finland allocated to research, development, and innovation (RDI) activities related to the green transition?
- ii. How is the funding distributed across different industries and firms?
- iii. How has the allocation of funding changed over time?

The study adopts a multi-phase methodology. Drawing on the theoretical framework, the first step involves identifying terminology related to climate change and the green transition, based on academic literature and IPCC reports. These terms are validated against publicly available project descriptions from Business Finland's programs. The result is a refined set of keywords that captures the language firms use in their funding applications.

In the second phase, a Business Finland expert conducts a database search using the validated keywords. For data protection reasons, the researcher cannot access individual project plans or firm-specific information. Instead, the expert compiles a dataset based on the keyword matches and provides anonymized, project-level data to the researcher. This dataset includes the amount of funding allocated to each project, the sector, the size of the recipient organization, and the timing of the funding decision.

The funding data from Business Finland qualifies as public information under the Finnish Act on the Openness of Government Activities (621/1999). Accordingly, the dataset used in this study contains no confidential information and consists exclusively of publicly accessible material. Although the underlying data is publicly available, it has been compiled and structured specifically for this analysis. The study focuses on the overall volume of green R&D funding, its distribution across sectors and firm sizes, and broader temporal trends.

A more detailed methodological framework will be presented in Chapter 4.

1.3 Scope and Structure of the Study

The scope of this study is limited to the R&D activities of firms operating in Finland that have received public funding from Business Finland as one of the funding sources. The rationale for selecting Business Finland as the primary data source stems from its central role as a public funding agency that supports R&D and innovation. Focusing on Business Finland-funded projects, the study provides a comprehensive overview of public investment in green R&D in Finland.

The dataset includes only projects funded by Business Finland, thereby excluding R&D activities financed solely through private or other public funding mechanisms. This focus enables a detailed examination of how Business Finland's funding has been allocated to climate-related R&D, but the generalizability of the findings is also limited.

Anonymized data may limit the analysis, as more granular insights into project-specific characteristics or strategic priorities are inaccessible. Hence, the study's findings focus on the overall distribution of funding rather than examining project-level dynamics.

Six main sections form the structure of the study. The following section explores the theoretical foundations of innovation, emphasizing Schumpeter's framework and the evolution of innovation. The third section examines public funding for R&D, considering EU state aid regulations and the Finnish innovation system. The methodology section explains how search terms were chosen, validated, and how funding data was collected. The fifth section presents the findings on funding trends, distribution across firms, and changes over time. The final section summarizes key findings and suggests areas for future research.

2 Innovation and the Innovation Process

Innovation is the driving force behind economic progress, shaping industries, businesses, and societies. While productivity gains can be achieved through efficient resource allocation (Kuusmanen et al., 2022), long-term economic renewal depends on continuously creating and diffusing new ideas (Schumpeter, 1942). This process is not isolated; it is shaped by market dynamics, firm strategies, and policy interventions (Kuusmanen et al., 2022).

Productivity improvements may lead to short-term efficiency gains, but sustainable economic growth requires more than resource optimization. Innovation – new technologies, processes, and business models – drives long-term renewal across industries (Nelson & Rosenberg, 1993). Traditional theories viewed innovation as a straightforward, linear process in which scientific discoveries translated directly into market applications. However, as markets have evolved and globalization has accelerated, innovation is now understood as a more dynamic and interactive system, influenced by multiple stakeholders and knowledge flows. (OECD/Eurostat, 2018.)

Innovation emerges in imperfect market conditions, where firms' capabilities and strategic investments shape the competitive environment (Aghion & Howitt, 1992). This challenges the neoclassical economic assumption of perfect competition, where market forces alone drive efficiency. Instead, firms and industries build competitive advantages through innovation, utilizing complex networks and ecosystems (Nelson & Rosenberg, 1993).

The rise of open innovation has been a significant shift in innovation research. Unlike the traditional closed innovation model, where firms rely solely on internal research and development activities, open innovation emphasizes the importance of knowledge mobility, globalization, and venture capital markets in shaping competitive advantage. (Chesbrough, 2003.)

This chapter examines the role of innovation in economic growth and the adaptation of firms and industries to technological change. It begins by defining innovation and its various forms, including the significance of open innovation. The discussion then moves to Schumpeter's theory of creative destruction, the relationship between competition and innovation, and the role of green innovation in mitigating climate change. Finally, the chapter examines how disruptive innovation reshapes markets and economic structures.

2.1 Defining Innovation

In economics, technological development is often considered a limitless resource, as new technologies enable developments that were once beyond imagination (Schumpeter, 1942). This development and the resulting innovations significantly impact individuals, industries, and nations (OECD/Eurostat, 2018). Scientific literature offers various definitions of innovation, but this study views innovation from a broader perspective.

Innovation is a process in which an idea is generated and transformed into a business or a practical application. This definition covers the entire process from the initial development of an invention to its successful commercialization. (Roberts, 1988.) Innovation is based on knowledge (OECD/Eurostat, 2018) that society generates through education, workplace training, research, and experience (Aghion & Howitt, 1992). Ideas utilize new knowledge, leading to new or improved products, manufacturing processes, or services. These ideas are transformed into prototypes and adopted in business or other contexts. (Roberts, 1988.) Unlike invention, innovation requires practically applying an idea or making it available to others. In other words, it must create or retain value. (OECD/Eurostat, 2018.)

Nelson and Rosenberg (1993) define innovation as the process by which firms derive economic benefits from an invention, even if they are not its original developers. This provides an opportunity to explore national technological capabilities rather than concentrating exclusively on the pioneering firms in global technology. This approach also aligns with the OECD/Eurostat's (2018) definition of innovation activity, which encompasses "*all developmental, financial, and commercial activities undertaken by a firm that is intended to result in an innovation for the firm.*"

Sometimes it is necessary to categorize innovation based on its context. One common approach is distinguishing between product and business process innovations (Schmidt & Rammer, 2007). According to OECD/Eurostat (2018), a product innovation is defined as "*a good or service that differs significantly from the firm's previous goods or services and has been introduced on the market.*" In contrast, a business process innovation is a "*process for one or more business functions that differ significantly from the firm's previous business processes and that have been brought into use by the firm.*" Technological development is often seen as the driver behind these innovations, which is why this approach has been criticized for limited applicability to service innovations and for not covering all innovation efforts (Schmidt & Rammer, 2007).

Innovations can be classified by their novelty into incremental and radical innovations. Radical innovations drive revolutionary change, while incremental innovations involve minor technological improvements upon existing technologies. The main difference between these two types lies in the extent of new technology used and the amount of new knowledge applied. However, there is no clear boundary between radical and incremental innovations; they represent the opposite ends of a theoretical spectrum. (Dewar & Dutton, 1986.)

This study does not categorize innovation in any of these ways, as it aims to examine the efforts of firms engaged in research and development. Innovation involves several scientific, technical, commercial, and economic phases. Research and development (R&D) is one of these stages, along with other factors like design, engineering, and marketing. (Marques and Monteiro-Barata, 2006.) Focusing on these efforts makes it possible to understand the progress made by individual firms and industries and their impact on the broader economic context.

The study aims to determine how much firms have invested in research and development related to climate change mitigation and the green transition. Aghion and Howitt (2023) argue that green innovation is the most promising approach to combat climate change because it enables us to align climate protection with continuous economic growth and well-being. Green innovation includes cleaner energy sources, products, and processes.

Similarly, Goeschl and Perino (2017) assert that the success of global climate policies depends on the widespread adoption of green technologies within the next 20 to 25 years. Empirical research also supports these claims, as innovations aimed at mitigating climate change are positively associated with reductions in greenhouse gas (GHG) emissions (Kim, 2021). It has also been shown that green processes and product innovations can improve a firm's financial performance (Xie et al., 2019).

However, green innovation does not occur in isolation but is shaped by external institutional factors, such as government policies and public funding. Research on firms in Oman demonstrates that trust in government and satisfaction with sustainability policies significantly enhance firms' commitment to investing in green R&D. This finding suggests that firms' willingness to innovate in environmentally sustainable ways depends not only on internal capabilities but also on the perceived reliability and consistency of government support. (Abdelfattah et al., 2025.)

Furthermore, recent studies highlight that firms investing in green product and process innovation strengthen their environmental core competencies, making them more likely to allocate resources to

sustainable R&D. This implies that firms with established environmental capabilities are not only better positioned to drive green innovation but also to integrate sustainability into their business strategies. As a result, companies that proactively embrace green innovation can achieve long-term competitive advantages while aligning with broader economic and regulatory trends. (Abdelfattah et al., 2025.)

2.2 Innovation as a Driver of Growth: The Schumpeterian Framework

Classical and neoclassical models of economic growth (Ramsey, 1928; Solow, 1956; Swan, 1956; Cass, 1965) often assume perfect competition where no consumer or firm has the power to influence the price of a good, and there are no barriers to entry or exit in the market. However, few markets meet the criteria for perfect competition, as market power impacts many of them. Schumpeter (1942) argues that even in markets approaching the case of perfect competition, introducing new technology temporarily disrupts the equilibrium. Temporary disruption here refers to a situation in which the market takes time to adapt and integrate into the change caused by innovation.

Schumpeter (1942) takes the idea even further by describing economic growth through the concept of creative destruction. While perfect competition assumes equilibrium, creative destruction suggests that the economy is constantly evolving. New technologies and innovations gradually replace outdated economic structures. Firms invest in new technologies to remain competitive, resulting in the destruction of old jobs and even entire industries. Consequently, creative destruction creates instability in the economy while simultaneously driving long-term growth.

Building on Schumpeter's (1942) insights, Aghion and Howitt (1992) developed the endogenous growth model, emphasizing innovation as the key driver of long-term economic growth. In contrast to Solow's (1956) framework, which treats technological progress as an exogenous factor, their model places innovation at the centre of economic advancement. Their model highlights the importance of firms investing in new technologies, suggesting innovation is a vital factor influencing economic growth.

Aghion's and Howitt's model underlines how new technologies increase productivity by replacing outdated technologies. This creates a dynamic cycle where innovations constantly crowd out old technologies, promoting firms' market entry and exit while accelerating economic renewal.

Macroeconomic growth depends on the number of innovations created. These innovations are based

on the knowledge produced by past innovators. The model captures innovations that improve existing technologies and adopt already developed ones. (Aghion & Howitt, 1992.)

Schumpeter (1942) argued that monopolistic firms enhance innovation due to their advantages in R&D. Temporary market power, such as patents and long-term contracts, provides firms with the stability needed for innovation without immediate competition. These firms also have better opportunities to adopt technologies, secure funding for large-scale projects, and allocate resources more effectively. However, research suggests that the relationship between market dominance and innovation is more complex. For example, Blundell et al. (1995, 1999) found that while dominant firms often engage in more innovation, higher industry concentration can reduce innovation efforts.

Aghion and Howitt's (1992) endogenous growth model presents a different perspective, suggesting that innovations are not necessarily created by established firms but by passive or emerging ones. Their model assumes increased competition reduces potential returns on innovation, weakening firms' incentives to invest in new technologies. Building on this contradiction, Aghion and Howitt (2023) suggested that industries typically include different types of firms that respond to competition in varied ways.

Proactive and innovative leading firms drive profits through advanced innovation, while those falling behind must catch up technologically to remain competitive. As competition increases, firms near the technological forefront will innovate more to meet this competition. Meanwhile, firms further from the technological leaders may be discouraged from increased competition and will innovate less. This behaviour aligns with the mechanism described in the original Aghion and Howitt (1992) model, where innovation is primarily driven by the need to catch up rather than to maintain technological leadership. (Aghion & Howitt, 2023.)

Aghion et al. (2009) findings support this view, as they show that stronger competition increases innovation in firms close to the technological front but can undermine innovation in lagging firms. Recent research adds complexity to this perspective. Akcigit et al. (2023) suggest that larger firms often innovate less efficiently because they focus on market dominance. They may prioritize defending their position with defensive strategies instead of driving technological progress. In contrast, smaller firms tend to be more agile, investing in R&D more efficiently (Akcigit & Kerr, 2018).

Aghion and Howitt (2023) note that this contradiction reveals a tension in their endogenous growth model. While temporary benefits encourage R&D, they can also prevent innovations that challenge

market dominance. Therefore, policymakers and businesses must foster innovation and competition to sustain economic growth.

Beyond firm-level dynamics, Aghion and Howitt (1992) extend their analysis to the macro level, emphasizing the impact of technological gaps between countries and their economic performance. Countries with a technological gap can advance by adopting cutting-edge technologies from others. As these countries approach the technological frontier, they must shift from adopting technology to fostering domestic innovation to sustain long-term growth. In the 21st century, this process has become more challenging as leading nations have discovered ways to restrict the diffusion of knowledge, such as by granting patents for defence purposes (Akcigit & Ates, 2021). Additionally, dominant firms in advanced economies have been able to create business models, logistics (Aghion et al., 2019), scale advantages, and networks that smaller firms struggle to replicate (Autor et al., 2020).

As a result, some middle-income countries like South Korea have struggled to keep up with technological pioneers. This middle-income trap can occur when a fast-growing country closes the technological gap by adopting innovations but fails to shift to policies and institutions that foster innovation-driven development. (Aghion & Howitt, 2023.) This phenomenon emphasizes the need for policies that promote innovation within firms and establish broader institutional frameworks that allow economies to adapt consistently.

While Schumpeter's theory of creative destruction highlights firm-driven innovation, von Hippel (2005) argues that innovation does not always originate from firms. Instead, users play a crucial role in identifying and developing new solutions, particularly in sectors where firms have yet to recognize emerging needs. This perspective broadens the traditional firm-centered innovation model and highlights the decentralized nature of innovation.

Chesbrough (2003) suggests that modern economies are increasingly driven by open and collaborative innovation. Open innovation enables firms to integrate external knowledge and adapt rapidly to technological change rather than relying solely on internal R&D efforts. A well-known example is the Xerox PARC research center, which developed groundbreaking technologies such as Ethernet and the graphical user interface but failed to capitalize on them, allowing companies like Apple and Microsoft to leverage these innovations instead (Chesbrough, 2003a, pp. 3–5).

Recent research has deepened the understanding of open innovation, particularly in managing disruptions and uncertainty. Chesbrough (2025) introduces the concept of the "Open Innovation

System," which provides a framework for handling decentralized innovation and swiftly responding to market and technological disruptions. This shift underscores that competition in innovation is no longer confined to individual firms but extends across entire innovation ecosystems.

2.3 The Evolution of Innovation and Disruptive Innovation

It is widely recognized that innovations drive economic growth. However, understanding how they evolve and impact firms remains an important area of study. Utterback and Abernathy (1975) propose a dynamic framework in which firms' operational environment, growth strategies, and technological maturity shape their innovation process. Their model links product and process innovation to different stages of development, illustrating how firms transition from early experimentation to structured production processes.

Initially, firms concentrate on product innovation by improving performance or launching new variations. As markets mature and dominant designs - widely accepted standards such as touchscreen devices in smartphones - emerge, firms' focus shifts to process innovation. This stage emphasizes efficiency improvements and cost reduction to maintain competitiveness. Figure 1 illustrates this dynamic relationship between product and process innovation across different stages of development. (Utterback and Abernathy, 1975.)

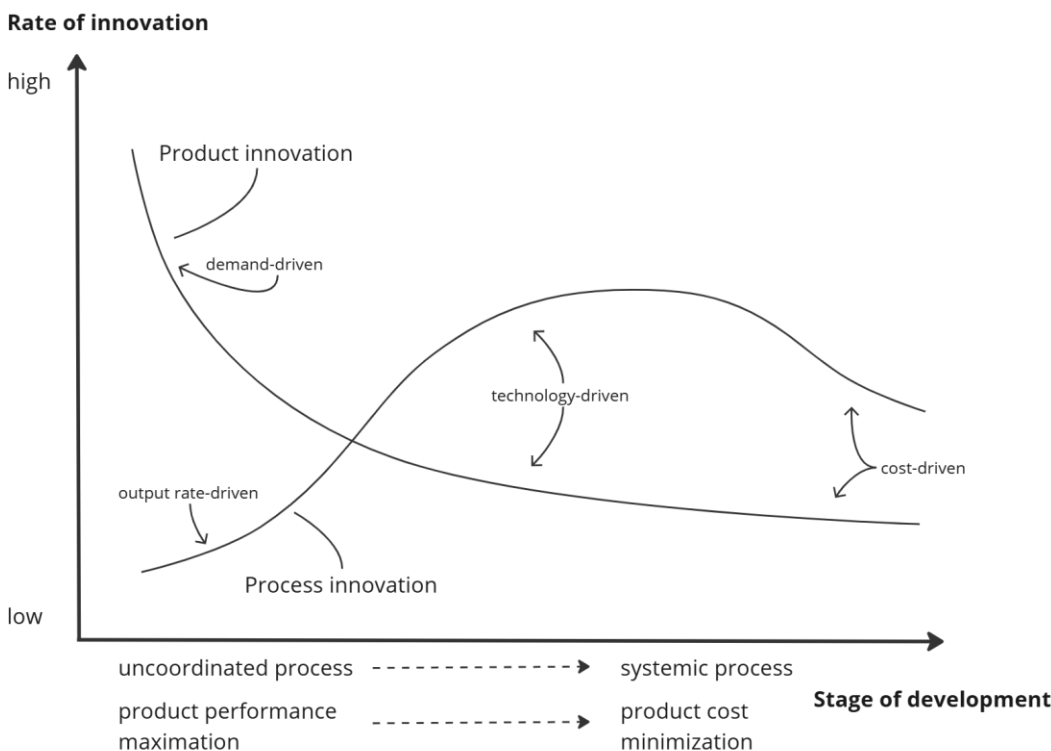


Figure 1: Stages of Innovation Dynamics: Product and Process Innovation (Utterback & Abernathy, 1975)

In addition to illustrating the innovation dynamics, the framework provides a detailed perspective on how product and process innovations develop over time. Product innovation follows a three-stage process: performance enhancement, sales growth, and cost reduction. Initially, firms concentrate on improving the product's functionality and quality. As markets evolve, the focus shifts towards increasing market share and reducing production costs while maintaining quality. (Utterback & Abernathy, 1975.)

Similarly, production processes evolve gradually through distinct phases. In the uncoordinated stage, firms experiment with diverse approaches to enhance production. As they transition to the segmented stage, the processes become more organized, paving the way for the systemic phase. Here, comprehensive integration and standardization lead to enhanced efficiency and productivity. (Utterback & Abernathy, 1975.)

While these structured stages provide a framework for understanding innovation development, Utterback and Abernathy (1975) emphasize that innovation is not a linear process but operates in cycles. Firms may revisit earlier stages as new technologies emerge and market demands shift. Over time, as processes become increasingly standardized, competition tends to shift from product differentiation to cost reduction. However, an excessive focus on efficiency and cost-cutting can reduce flexibility and slow the adoption of new innovations.

Utterback and Abernathy (1975) also argue that the sources of innovation evolve throughout the stages of process development. In the early stages, innovative ideas typically emerge from individuals or organizations that understand processes but may lack the technical expertise to develop them. As needs become more precise and processes more standardized, innovation increasingly comes from technological experts, such as engineers and R&D teams. Empirical research supports this finding, showing that established firms with diverse product portfolios invest in incremental product development. In contrast, new firms and some established firms focus on creating entirely new products or services. (Akcigit & Kerr, 2018).

Because the sources of innovation evolve, the focus of R&D also shifts. Since most R&D efforts focus on later stages of innovation, scientists and firms generally produce incremental improvements. While these innovations can lead to significant technological advancements, they rarely result in radical breakthroughs. (Roberts, 1988.) Established and well-managed firms often pioneer new technologies, but their innovations typically aim to serve existing customers rather than disrupt markets (Bower & Christensen, 1995).

As R&D activities typically concentrate on refining existing solutions, investment decisions tend to prioritize mainstream markets. Consequently, firms may overlook emerging technologies that initially fail to meet mainstream customer demands. These technologies are not always radical or high-tech but often introduce features that established customers initially undervalue. However, as their capabilities improve, they can disrupt the market, leaving established firms struggling to compete with new dominant technologies. (Bower & Christensen, 1995.)

Developing new technologies alone does not guarantee a firm's long-term market position. Christensen's (1997) disruptive innovation framework explains why leading firms can lose market dominance despite investing in new technologies. The theory distinguishes between two types of technologies: sustaining and disruptive technologies. Sustaining technologies can be incremental or radical innovations, but their primary function is to enhance existing products. In contrast, disruptive technologies initially underperform but appeal to new customer segments. Generally, they are more affordable and simpler, enabling them to develop over time and eventually compete with conventional solutions.

Firms' investment strategies often reinforce this pattern, prioritizing advanced technologies tailored to their most demanding customers. While this strategy drives product improvement, it may also create opportunities for disruption - technologies that initially seem inferior but steadily evolve. Eventually, these innovations can enter mainstream markets and challenge established firms. (Christensen, 1997.)

Christensen (1997) argues that firms' reluctance to invest in disruptive technologies is economically rational. Since these innovations are introduced in niche markets and do not immediately appeal to the most profitable customers, leading firms often hesitate to adopt them. To remain competitive, firms must protect emerging technologies from internal constraints by establishing independent units dedicated to their development and commercialization (Bower & Christensen, 1995).

Unlike the structured development phases described by Utterback and Abernathy (1975), Christensen's (1997) theory of disruptive innovation does not follow a cyclical pattern. Instead, disruptive technologies emerge in overlooked market segments, evolve incrementally, and eventually challenge dominant firms. This shift can reshape market structures and create new business opportunities. Figure 2 illustrates this process: while sustaining technologies continue to evolve to serve the most demanding customers, disruptive technologies initially gain momentum in smaller market segments. Although they do not initially compete directly with mainstream products,

their gradual improvement allows them to reach a broader customer base and, ultimately, displace market leaders.

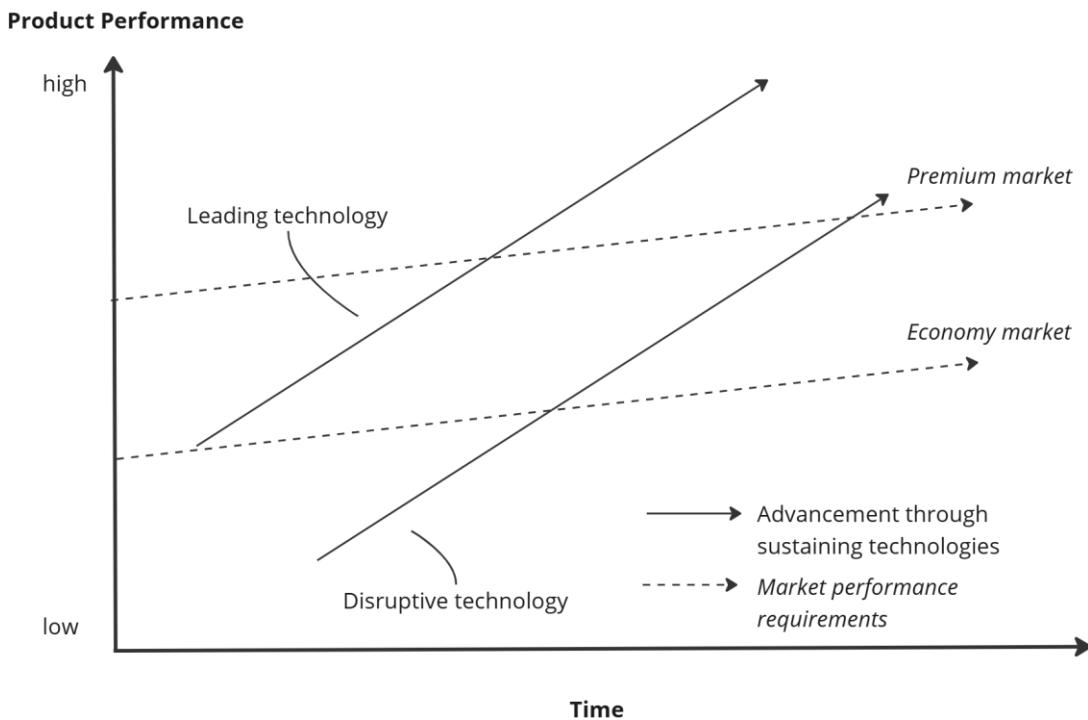


Figure 2: The Evolution of Disruptive and Sustaining Technologies (Christensen, 1997)

In 2014, Harvard professor Jill Lepore published a widely discussed article in *The New Yorker* criticizing disruptive innovation's broad acceptance and application, particularly in technology and startup firms (Lepore, 2014). While similar critiques had been made before (Danneels, 2004; Tellis, 2006), Lepore's argument gained significant attention due to its publication in a mainstream magazine rather than a peer-reviewed journal (Weeks, 2015). Lepore (2014) specifically questioned Christensen's research methodology, arguing that his selective use of case studies and timelines led to inconsistent applications of the theory.

Weeks (2015) also raises concerns about Christensen's reliance on platforms such as *Harvard Business Review* rather than peer-reviewed academic journals, questioning the rigor of his research approach. While he acknowledges that Christensen's case study method is a valuable tool for theory-building, he argues that disruptive innovation's broad and sometimes vague definition has led to inconsistencies in its application across academic and business contexts.

Beyond methodological concerns, critics have also questioned the theory's applicability to real-world cases. For instance, the success of the iPhone and the failure of Kodak do not fit neatly within

Christensen's framework, raising doubts about its universal applicability (Weeks, 2015). Markides (2006) further argued that the original theory applies strictly to disruptive technologies, not all forms of disruptive innovation. This distinction is particularly relevant in clean energy transitions, where market forces alone may not be sufficient to drive large-scale change without regulatory support and government intervention (Johnstone et al., 2020).

McDowall (2018) expands on this critique, arguing that disruptive innovation alone cannot explain low-carbon transitions. Instead, he views it as one of many mechanisms influencing technological change, rather than the dominant explanation. This perspective aligns with Johnstone et al. (2020), who emphasize that clean energy transitions require a broader theoretical framework that considers not just market dynamics but also political interventions, infrastructure shifts, and institutional changes.

Although widely debated, disruptive innovation theory remains a valuable lens for understanding technological change (Weeks, 2015). However, its application to large-scale socio-technical transitions, such as clean energy, requires modifications to account for systemic and policy-driven disruptions (Johnstone et al., 2020).

3 The Role and Evolution of Public Support in R&D

Innovation is a key driver of economic growth and technological progress. However, while firms invest in R&D, they often face significant barriers, such as high risks, uncertain returns, and knowledge spillovers that limit private-sector incentives to fund innovation. These market imperfections can slow technological advancement, making public support a critical enabler of innovation. Governments play a fundamental role in promoting research, development, and technological breakthroughs by addressing market failures through funding mechanisms, regulations, and policy frameworks. (See Martin & Scott, 2000; Becker, 2015.)

Over time, public support for R&D has evolved from direct funding of scientific research to more comprehensive approaches that foster collaboration and systemic change. This shift in the late 20th century emphasized national innovation systems that integrate firms, universities, and research institutions. (Schot & Steinmueller, 2018.) Freeman (1987) introduced the National Innovation Systems (NIS) concept, arguing that innovation occurs within structured ecosystems rather than through individual firms acting alone.

More recently, innovation policy has expanded to incorporate transformative approaches to address global challenges such as climate change (Schot & Steinmueller, 2018). Government policy and regulation are essential in guiding sustainable innovation and ensuring long-term environmental and economic goals (Kuosmanen et al., 2022). Empirical evidence shows that policy stability and institutional trust significantly influence firms' commitment to investing in sustainable R&D (Abdelfattah et al., 2025).

However, public R&D support mechanisms also face challenges. Studies show that some firms receive subsidies for projects they would have undertaken anyway (Becker, 2015). While public funding can stimulate private investment in R&D, it may also result in crowding-out effects, where firms substitute public funds for their investments rather than expanding their R&D efforts (Busom, 2000). Public funding is most effective when it complements rather than replaces private R&D (Hottenrott & Lopes-Bento, 2014).

Different theoretical perspectives have guided public support for innovation to address these challenges. Table 1 summarizes three key frameworks explaining how innovation policy has adapted over time and governments' distinct roles in supporting R&D to provide a structured view of these evolving perspectives (Schot & Steinmueller, 2018).

Table 1: Three Key Theoretical Frameworks Explaining the Evolution of Innovation Policies (Adapted from Schot & Steinmueller, 2018)

Framework	Key Idea	Policy Focus	Dominant period
Market Failure	Markets underinvest in R&D due to spillovers	Direct funding, subsidies, and tax incentives to correct market failures	1950s–1980s
Systems of Innovation	Innovation thrives in collaborative ecosystems	Clusters, networks, and knowledge exchange	1980s–2000s
Transformative Innovation Policy	Innovation should address societal challenges through systemic change	Policy-driven R&D, mission-oriented investments, and system-level transformation	~2010s–present

Each framework complements the previous one – direct government funding remains essential for fundamental research, while systemic approaches foster collaboration, and mission-oriented policies steer innovation toward long-term societal goals (Schot & Steinmueller, 2018). By integrating these approaches, modern innovation policy balances short-term technological progress with broader systemic changes, ensuring that public support remains effective, targeted, and adaptable to economic and societal needs.

This chapter further examines the role of public support in research and development, focusing on its impact on innovation ecosystems and economic growth. It explores R&D funding mechanisms, the role of universities and research institutions, and the broader significance of human capital and knowledge diffusion. Additionally, it assesses the effectiveness of support structures and potential drawbacks, such as the crowding out of private investment. The chapter also examines mission-oriented innovation policies, the implications of EU state aid regulations, and the structure of Finland’s innovation system.

3.1 The Evolution of Innovation Policy: From Market Failures to Systemic Approaches

The first innovation policy framework emerged after World War II, when governments institutionalized support for science and R&D to promote economic reconstruction and growth. Public investment was assumed to generate innovations that would drive economic growth and societal well-being. As a result, innovation policy was focused mainly on science and technology. (Schot & Steinmueller, 2018.)

The framework assumed that without government support, market failures would result in inadequate investment in research (Schot & Steinmueller, 2018). Financial constraints and the risky nature of R&D restrict firms' capability to sustain long-term projects. Moreover, the societal benefits of innovation often exceed the private returns firms could capture, leading to a gap in socially optimal investment levels. This failure justified public support and government intervention in market operations to ensure adequate innovation funding. (Martin & Scott, 2000.)

The second framework, the system of innovation, began to take shape in the 1980s as globalization accelerated and international competition intensified. While the market failure approach effectively supported fundamental research and early technological advancements, public funding alone was insufficient to drive innovation in an increasingly complex and interconnected global economy. Firms needed continuous innovation to succeed in international markets, making competitiveness the primary objective. (Schot & Steinmueller, 2018.)

Despite the availability of R&D funding, firms struggled to thrive due to significant obstacles in creating and utilizing knowledge (Schot & Steinmueller, 2018). A key barrier to technological development was the lack of collaboration between firms in research (Martin & Scott, 2000). Over time, innovation has been recognized as a systemic phenomenon, arising from interactions among various actors instead of in isolation. (Schot & Steinmueller, 2018).

Consequently, innovation policy needed to move beyond direct funding and focus on building networks and clusters, strengthening interaction and peer learning, and encouraging entrepreneurship. The state's role shifted to a facilitator, fostering favourable conditions for innovation ecosystems. This was achieved through initiatives such as funding collaborative projects, establishing technology centres, improving the patent system, and ensuring the education of a skilled workforce. (Schot & Steinmueller, 2018.)

It is also important to recognize that different types of innovation encounter distinct challenges, and no single approach can effectively address them all. Table 2 summarizes these challenges and the corresponding policy measures, illustrating how public intervention has evolved to tackle various market failures. (Martin & Scott, 2000.)

Table 2. Innovation Types, Market Failures, and Policy Responses (Martin & Scott, 2000)

Innovation Method	Interpretation	Sources of Market Failures	Typical Industries	Recommended Policy Actions
Development of inputs	Creating new components, materials, or technologies for use in other industries.	Financial constraints for SMEs Risks related to technology standardization Limited commercialization of generic technologies	Software, equipment, instruments	Supporting venture capital availability for SMEs Supporting the adoption of technology standards
Application of inputs	Adopting and integrating supplier-developed inputs into production processes.	Resource constraints of small firms High societal benefits but low private incentives Limited technology adoption	Agriculture, light industry	Technology transfer facilitators Advisory services for technology adoption
Development of complex systems	Designing and innovating large-scale, interconnected systems.	High investment costs High risk Slow adoption of technology	Aerospace, electrical and electronics technology, telecom/computer technologies, semiconductors	R&D collaboration Innovation and development grants/subsidies Organizations supporting infrastructure technology development
Application of knowledge-intensive technologies	Utilizing advanced scientific discoveries and research-driven innovations in industry.	Knowledge originates outside the commercial sector. Developers do not recognize application opportunities or fail to communicate discoveries effectively	Biotechnology, chemistry, materials, pharmaceuticals	High-tech intermediaries facilitating research transfer and application

Modern governments recognize the importance of R&D investments for economic and technological development (Becker, 2015), as evidenced by substantial public R&D support (Howell, 2017). However, public support is not a replacement for private investment but rather a catalyst that encourages firms to invest in R&D. Given the constraints of public funding, ensuring its efficient allocation and strategic use is essential (Becker, 2015.)

To achieve these objectives, modern public R&D policy relies on key instruments such as:

- R&D tax credits and direct subsidies
- Supporting university research and the development of highly skilled human capital
- Promoting R&D collaboration among various institutions. (Becker, 2015.)

Public intervention should also consider structural and strategic factors, as they impact the efficiency of R&D investments. Market position, internationalization, and R&D intensity are crucial in determining how firms benefit from innovation efforts. Firms with high R&D intensity may face short-term profitability declines, but these investments typically yield long-term advantages. Conversely, while the internationalization of R&D activities can enhance exports, its impact on firm profitability remains more limited. (Leung & Sharma, 2021.)

While factors like R&D intensity and internationalization influence firm outcomes, a firm's market position is equally critical in shaping how it utilizes R&D grants. Firms with a strong market presence typically increase their R&D expenditure and overall employment but make only modest additions to their R&D workforce, indicating an already substantial resource base. Moreover, their productivity levels are statistically comparable to those of firms that do not receive grants, suggesting that funding helps sustain their competitive position rather than directly driving productivity growth. (Hogan et al., 2022.)

This underscores the need for well-designed innovation policies to maximize the impact of R&D investments. The following sections explore key policy instruments, including R&D tax credits, direct subsidies, university research, the development of skilled human capital, and collaborative networks.

3.1.1 R&D Tax Credits and Direct Subsidies

Economists have traditionally been sceptical of R&D tax credits (Becker, 2015). One reason for this scepticism is that R&D spending is relatively fixed in the short term and does not quickly adapt to demand shocks. This limits firms' ability to adjust their investments based on short-term incentives, such as tax credits. (Resutek, 2022.) Moreover, most public funding typically goes to large firms that would likely engage in R&D efforts even without support. Tax credits can still be an effective policy tool in these cases by encouraging firms to invest beyond their baseline funding level. (Becker, 2015.)

While tax credits can encourage immediate R&D investment decisions, direct subsidies are often more effective for generating longer-term impacts (Becker, 2015). Subsidies' effects tend to grow over time, whereas the impact of tax credits remains static. Both instruments encourage private R&D investment, though neither consistently outperforms the other. Although their effects may seem modest, they are not insignificant: every additional dollar of public R&D support increases private R&D spending by approximately 7.5 cents. (Dimos et al., 2022.)

This increase in private R&D spending is known as the additionality effect, where public support leads firms to expand their R&D investments beyond what they would have otherwise. The level of additionality varies across firms and projects. (Takalo et al., 2013.) Research shows that public R&D incentives are particularly effective for firms that have not previously engaged in innovation. Rather than strengthening existing R&D activities, public support is crucial in attracting new firms to the innovation process. (Iversen et al., 2025.) The additionality effect is particularly noticeable for SMEs engaging in international collaboration (Hottenrott & Lopes-Bento, 2014), as they often face significant challenges in securing external financing (Becker, 2015).

However, in cases where R&D projects generate substantial spillovers, firms may not necessarily increase their investments even when receiving public support. In such cases, the additionality effect remains minimal, especially for projects with the highest societal benefits. (Takalo et al., 2013.) Some studies suggest that public funding can partially replace private R&D investments rather than stimulate entirely new investments, reducing its net impact (Takalo et al., 2013a).

The effectiveness of R&D subsidies depends heavily on their design. Research suggests that targeted subsidies – allocated based on firm characteristics and project potential – can significantly enhance overall welfare. (Dimos et al., 2022.) Optimally designed subsidies may increase welfare by up to 80%, whereas uniform subsidies, which are distributed more broadly, result in only a 4% improvement (König, Liu & Zenou, 2019). In addition to improving welfare, targeted subsidies help reduce technological uncertainty, making supported firms more attractive for external investors (Howell, 2017).

However, the extent to which firms benefit from subsidies depends on their characteristics and market position. For instance, dominant firms receiving public R&D grants tend to outperform others in future R&D spending, growth, and employment gains. However, they do not show a substantial productivity advantage compared to similar non-funded firms, indicating that grants help maintain their market position rather than foster innovation. Additionally, dominant firms tend to

employ fewer internal R&D staff, suggesting they rely on public funding to solidify their current advantages instead of investing in human capital growth. (Hogan et al., 2022.)

The level of public support is also a critical factor. Moderate levels of support encourage private investment, whereas excessively high levels may crowd out private R&D funding (Becker, 2015). Certain firms, especially those with profitable R&D initiatives, might skip applying for subsidies. This choice often stems from the high costs associated with the application and bureaucratic challenges, which can diminish the overall impact of public funding. (Takalo et al., 2013a.)

To ensure effective public R&D funding, it is crucial to balance tax credits as short-term incentives with subsidies that drive long-term growth (Foray et al., 2012). However, poorly targeted subsidies risk funding projects that would have been pursued regardless, reducing their net impact (Takalo et al., 2013a). Strategic targeting of subsidies ensures that public investment leads to firm-level success and broader societal benefits. Furthermore, the outcomes of publicly funded research should be widely accessible rather than monopolized by the private sector to ensure widespread innovation diffusion. (Foray et al., 2012.)

3.1.2 University Research, Human Capital, and Collaborative Networks

Beyond funding mechanisms, public R&D policy fosters the broader innovation ecosystem. Investments in university research, skilled human capital, and collaborative networks strengthen private-sector R&D by providing the necessary knowledge base and talent for innovation (Becker, 2015). Public policy should actively encourage R&D collaboration to maximize these benefits, particularly in high-risk sectors where individual firms may struggle to innovate alone (Martin & Scott, 2000).

A crucial way to foster collaboration is through university research, which improves regional technological opportunities and enhances private-sector R&D productivity. Knowledge spillovers from universities stimulate private R&D investments by facilitating the exchange of expertise and innovation. The spillovers occur through personal contacts, university spin-off firms, consulting, and the availability of highly skilled labour. To maximize these benefits, regional R&D policy aims to develop innovation clusters that strengthen the connection between universities and the private sector. Policymakers can further enhance knowledge dissemination by fostering formal R&D collaboration agreements, such as joint research institutes. (Becker, 2015.)

R&D collaboration can increase firms' production and innovation efficiency, but market competition can limit the full realization of these benefits. To maximize impact, the structure of

innovation networks and firms' roles within them should be carefully considered when targeting subsidies. Understanding these networks is crucial for policymakers and firms seeking to foster innovation and economic growth. (König, Liu & Zenou, 2019).

R&D collaboration and participation in innovation networks can also serve as a positive quality signal for firms. Receiving R&D support or engaging in horizontal R&D collaboration can facilitate access to private funding and mitigate the adverse effects of imperfections in capital markets. (Becker, 2015.) Additionally, shared infrastructure and common standards, particularly in critical sectors such as telecommunications and semiconductors, are vital in ensuring efficiency and preventing market fragmentation. Strategic public sector investments in these areas can further strengthen the innovation ecosystem and support long-term technological development. (Martin & Scott, 2000.)

As multinational firms expand their R&D networks and emphasize global expertise mobility, governments are increasingly responsible for ensuring that innovation ecosystems remain competitive and well-integrated (Papanastassiou et al., 2020). This growing role calls for policies that support market-driven innovation and actively direct research and technological development toward addressing major societal challenges.

3.2 Mission-Oriented Innovation Policy and Societal Challenges

As governments take on a more active role in shaping innovation ecosystems, there is a growing recognition that traditional market-driven policies alone are insufficient for tackling large-scale societal challenges. This has led to a shift toward mission-oriented innovation policies, emphasizing proactive government intervention to drive technological development in a direction that addresses critical global issues, such as climate change, sustainability, and energy transitions. (Kattel & Mazzucato, 2018.) This approach addresses common weaknesses in national innovation policies, such as the lack of strategic direction and policy coordination (Larrue, 2021).

Unlike past policies primarily focused on enhancing economic competitiveness, mission-oriented approaches aim to create and shape new markets that drive systemic transformation (Schot & Steinmueller, 2018). This requires long-term policy commitments, coordinated efforts between governments and private-sector actors, and strategic frameworks integrating technological, economic, and social dimensions (Foray et al., 2012).

Technological development is crucial in tackling today's global challenges (Foray et al., 2012), but innovation alone does not guarantee societal well-being. The climate crisis and ecological

sustainability concerns highlight that an innovation system without purposeful direction may not always lead to desirable outcomes. Success is increasingly measured by system-level transformation rather than incremental technological progress, shifting the focus beyond GDP or R&D intensity to include broader indicators such as emission reductions, well-being impacts, and the emergence of sustainable markets. (Schot & Steinmueller, 2018.)

Mission-oriented policy can be categorized into three generations. The first generation focused on modernization and national development, the second on technology-driven missions such as space and military advancements, and the third on socio-technological missions that address societal challenges like climate change. (Kattel & Mazzucato, 2018.)

As Kattel and Mazzucato (2018) note, socio-technological missions require cross-sector collaboration, strong regulatory frameworks, and consistent policy direction. Empirical research suggests that firms with strong green innovation capabilities are more likely to invest in sustainable R&D when supported by clear and consistent policy frameworks (Abdelfattah et al., 2025).

Previous frameworks and approaches have even contributed to unsustainable production and consumption patterns (Schot & Steinmueller, 2018). Firms with a history of environmentally harmful innovation tend to persist in that pattern, whereas firms already engaged in clean innovations are more likely to continue focusing on sustainable technologies (Aghion et al., 2016). This suggests that firms alone cannot be relied upon to drive clean innovation without policy intervention (Aghion & Howitt, 2023).

However, external factors such as consumer preferences and regulatory pressure also play a role. Responsible attitudes and market competition can accelerate clean innovation as consumers become more conscious of their environmental impact. These factors can sometimes be as effective as direct policy interventions. (Aghion et al., 2021.) Still, without consistent policy frameworks, such market-driven incentives may remain insufficient for long-term systemic transformation.

Mission-oriented innovation policies can be categorized into three main types:

- *Strategic frameworks* – broad initiatives that coordinate the actions of various stakeholders over the long term (e.g., Horizon Europe, the Netherlands' Topsector policy).
- *Challenge-driven programs* – targeted at specific and urgent societal challenges (e.g., the UK's Industrial Strategy Challenge Fund).

- *Ecosystem-based programs* – focused on regional or sector-specific ecosystems where different actors, such as businesses and research institutions, collaborate. (Larrue, 2021.)

Mission- or challenge-oriented programs integrate research, businesses, and societal actors to develop solutions (Schot & Steinmueller, 2018). Publicly funded R&D programs can steer technological development toward societal benefits. However, such programs require long-term commitment, as challenges like climate change demand sustained efforts. (Foray et al., 2012.) To ensure continuity, consistent policy guidance – through taxation, regulation, and public procurement – is essential in supporting sustainable innovation pathways while facilitating the controlled phase-out of outdated structures (Schot & Steinmueller, 2018).

While transformative innovation policy is not as institutionally developed as traditional models, its success, like its predecessors, depends on strong research capacity and well-functioning innovation systems (Schot & Steinmueller, 2018). Implementing mission-oriented policies requires dynamic public-sector capabilities to create and drive markets while fostering innovation from the private and third sectors. Addressing societal challenges effectively demands public-private partnerships, strategic planning, and adaptability. (Kattel & Mazzucato, 2018.)

Mission-oriented innovation policy emphasizes system-level changes, where governments and institutions steer technological development through strategic objectives (Kattel & Mazzucato, 2018). This approach aims to create and shape markets that enable long-term investments in sustainable development. For example, Germany's *Energiewende* program has demonstrated how government-defined climate and energy targets can guide industrial innovation processes (Mazzucato, 2018).

Although the mission-oriented approach is not entirely new, its successful implementation requires strategic vision and political will (Mazzucato, 2018). Without such policies, innovation strategies remain inadequate in addressing today's complex challenges (Schot & Steinmueller, 2018). However, this approach also faces obstacles, such as high costs, multi-level governance complexities, and difficulties in scaling up (Larrue, 2021). While this study does not evaluate the broader effectiveness of mission-oriented policies, it provides a quantitative overview of how Business Finland-funded R&D investments contribute to the green transition.

3.3 EU State Aid Rules for R&D: Regulations, and Objectives¹

While innovation policies emphasize proactive public-sector intervention to guide technological progress, their implementation is subject to legal and financial constraints. In the European Union, state aid rules regulate how public funding can be allocated to R&D activities, ensuring that support promotes innovation without distorting market competition.

The European Union (EU) competition law restricts state aid to prevent firms from gaining an unfair advantage in the internal market. State aid refers to public funding granted to a firm or a good, providing them with a competitive advantage over others. (Article 107(1) TFEU.) Although state aid is generally prohibited, exceptions exist for activities that promote the general economic interest, including support for disadvantaged regions, SMEs, R&D activities, and environmental protection (Article 107(3) TFEU; Commission Regulation (EU) No 651/2014).

In addition to funding for firms, universities and research organizations can receive state aid for independent R&D activities aimed at knowledge generation, scientific advancement, or technology dissemination. Eligible support also includes knowledge transfer activities, such as licensing and establishing spin-off firms that align with research organizations' core missions. (Commission Communication, 2016.)

State aid for R&D aims to increase the EU's total R&D investments to 3% of GDP, supporting sustainable economic growth and technological competitiveness. In Finland, the government has set an even more ambitious goal: raising R&D expenditures to 4% of GDP by 2030, with one-third of the funding expected from the public sector (Valtiovarainministeriö, 2024). Between 2006 and 2023, Finland's R&D expenditure as a percentage of GDP fluctuated between 2.72% and 3.73% (Tilastokeskus, 2024).

While state aid is permitted for R&D projects, the European Commission has imposed strict conditions on its provision. The regulations define:

- Which types of R&D activities qualify for aid
- At which stages of R&D support can be provided

¹ Unless otherwise stated, this section is based on Commission Regulation (EU) No 651/2014.

- Maximum aid intensities depending on firm size and project type

These restrictions are intended to preserve fair competition between EU member states. Since state aid must not distort competition, it should be limited to the minimum necessary to stimulate innovation without replacing private investment. Before approval, the EU assesses the potential impact of each aid package on competition and trade.

Additionally, state aid cannot cover the entire cost of the R&D project—funding must be partial. The level of support varies depending on the type of research:

- *Basic research*, which is purely theoretical and exploratory, may receive up to 100% funding, given its high uncertainty and public benefit.
- *Applied research*, focused on developing new technologies or processes, receives lower funding as its results are more predictable and closer to market application.
- *Experimental development and prototype creation* typically receive 60–75% funding, as these projects involve lower risks and more significant potential for commercialization.

Exceptions exist for higher aid intensities when R&D activities focus on environmental protection, climate change mitigation, or healthcare innovations. However, all forms of aid must ensure that public funding does not crowd out private investment or hinder competition by unfairly benefiting specific firms over others.

While EU regulations shape state aid policies for R&D, Finland has developed its innovation system within these constraints. The country has long prioritized research, technological development, and international collaboration, but its innovation landscape has evolved significantly in response to globalization, economic shifts, and changing policy priorities.

3.4 Finland's Innovation System: Strengths, Challenges, and Policy Developments

Finland's economy is highly innovation-driven, having successfully transitioned to a knowledge-based economy through investments in education, research, and innovation. However, economic renewal has stagnated since the 2009 financial crisis, as the collapse of Nokia's mobile phone business and declining ICT exports significantly weakened productivity and competitiveness. (OECD, 2017.)

Finland's innovation system relies on a highly educated workforce, strong R&D expertise, and advanced technological capabilities, particularly in ICT. However, Finland faces significant challenges, including declining R&D funding, fragmented innovation policy, limited internationalization of firms, and a narrow export base. (OECD, 2017.)

Over the past two decades, globalization and shifting industrial structures have significantly transformed Finland's innovation system. The increasing mobility of firms and research has challenged national innovation strategies, as companies must balance local R&D investments with global expansion. Meanwhile, the growing role of multinational corporations and cross-border knowledge transfer has forced Finland to reassess its innovation policies in an interconnected world. (Lovio, 2009.)

To address these challenges, Finland has implemented several reforms. The 2010 university reform strengthened collaboration between universities and industry, while later changes in universities of applied sciences and state research institutions altered the innovation landscape (Halme et al., 2021). However, budget cuts have impacted universities' ability to collaborate with businesses, and Finnish research organizations increasingly compete for international funding (Lovio, 2009).

Finland's innovation system is structured as a multi-layered ecosystem, where government, academia, and businesses interact closely (OECD, 2017). Research, development, and innovation policy is guided by the Research and Innovation Council, led by the Prime Minister, which develops long-term science, technology, and innovation policy strategies. Table 3 outlines Finland's key innovation policy actors and their roles. (OECD, 2017; Academy of Finland, 2024.)

Table 3: Finland's Innovation System: Key Actors and Their Roles in R&D and Business Development (OECD, 2017; Suomen Akatemia, 2024)

Innovation System Component	Key Actors and Roles
Government Administration and Strategic Coordination	<ul style="list-style-type: none"> - Research and Innovation Council (RIC): Provides strategic guidance for research and innovation policy, chaired by the Prime Minister. - Ministry of Economic Affairs and Employment (TEM): Responsible for innovation policy and business development. - Ministry of Education and Culture (OKM): Oversees the funding and development of higher education and research institutions. - Other ministries, such as the Ministry of the Environment, support sector-specific innovation initiatives, including the green transition.
Key Funding Organizations and Development Agencies	<ul style="list-style-type: none"> - Business Finland (formerly Tekes): Finland's central innovation funding agency, supporting business growth, innovation, and internationalization.

	<ul style="list-style-type: none"> - Academy of Finland: Focuses on funding basic research and strategic research programs. - <i>Finnvera:</i> Provides financial services, loans, and export guarantees to businesses - TESI (Finnish Industry Investment Ltd): Supports business growth through venture capital investments. - ELY Centers (Centers for Economic Development, Transport, and the Environment): Regional innovation support organizations.
Research Organizations and Higher Education Institutions	<ul style="list-style-type: none"> - 14 universities and 24 universities of applied sciences (UAS): Conduct research and innovation activities, often in collaboration with businesses. - 12 government research institutes play a role in national R&D efforts. - VTT (Technical Research Centre of Finland): Finland's largest applied research institute, conducting industry-oriented research.
Companies and the Private Sector	<ul style="list-style-type: none"> - Large corporations and SMEs are actively involved in R&D and innovation, particularly in ICT, cleantech, and bioeconomy. - Startups are increasingly crucial in Finland's innovation landscape. - SMEs' innovation capacity and internationalization are major policy focus areas, but Finland has lower SME participation in R&D than other OECD countries.
Other Innovation Actors	<ul style="list-style-type: none"> - Sitra (Finnish Innovation Fund): A key driver of sustainability and the green transition, funding projects related to resource efficiency and new economic models. - Team Finland: A network coordinating Finnish business internationalization and innovation programs under six themes, including bioeconomy, cleantech, digitalization, and health.

Since innovation, internationalization, and growth are closely interconnected, their promotion is most effective through centrally coordinated policy measures (Halme et al., 2018). Given Finland's small domestic market and the increasing globalization of innovation, effective internationalization policies are critical to enhancing firms' competitiveness. As Lovio (2009) argues, Finland must embrace a more global perspective in its innovation policies, recognizing the growing importance of international cooperation and the integration of Finland into global value chains. Establishing the Team Finland network in 2012 was a key step in addressing the fragmentation of Finland's business and innovation support system and facilitating the internationalization of Finnish companies (OECD, 2017).

Team Finland network operates under the Ministry of Economic Affairs and Employment (TEM), the Ministry of Education and Culture (OKM), and the Ministry for Foreign Affairs (UM), reporting to the Prime Minister's Office. Team Finland aims to provide firms with the necessary resources to scale internationally by integrating business support services across ministries and agencies. (OECD, 2017.) Key actors include Business Finland, Finnvera, TESI, VTT, and ELY Centers,

which provide businesses with funding, advisory services, and support services (Team Finland, 2019).

While Team Finland seeks to streamline business and innovation support, persistent coordination challenges limit its effectiveness. Ensuring seamless collaboration among different actors and minimizing service overlaps remains difficult. (OECD, 2017). Finland's fragmented approach weakens overall efficiency compared to countries with centralized and clearly defined support systems (Halme et al., 2018). An unclear strategy, overlapping responsibilities, and inconsistent coordination among different actors have also led to inefficiencies. While individual organizations such as Finnvera, Finpro, and Tekes have been successful in their respective roles, the overall coherence of the support system remains an area for improvement. (OECD, 2017; Halme et al., 2018.)

Finnish firms still face challenges securing sufficient R&D funding to scale globally despite efforts to enhance internationalization. Firms finance approximately 55–70% of Finland's total R&D expenditures (OECD, 2017), while the public sector contributes about one-third. Major public funders include the Academy of Finland, Business Finland, and the EU (Tiede ja Tutkimus, 2025). According to the SME Barometer (2024), 25% of Finnish SMEs engage in R&D activities, with the highest participation in the industrial sector and the lowest in construction. Among public funding sources, 65% of SMEs seek support from local and regional government organizations, 39% apply for Business Finland funding, and only 4% from the EU's Horizon Europe program.

Over the past two decades, corporate R&D expenditures have declined, partly due to the shrinking of Nokia and its subcontractor network. Additionally, Finnish SMEs exhibit lower innovation activity than the OECD average, and the private sector's role in supporting innovation and internationalization remains limited. Access to growth-stage venture capital is challenging, making public-sector support critical for international expansion and business scaling. (OECD, 2017).

Although Finland invests significantly in R&D, it has not reached the level of OECD's top-investing countries, such as the United States, South Korea, and Israel. Instead, it ranks around or slightly above the OECD average. Public sector contributions to corporate R&D funding have declined but remain significant (OECD, 2024). Since 2016, public R&D funding has started to grow again. The end of SHOK funding in 2015 changed the funding structure. It shifted the focus to supporting rapid growth and internationalization and replaced direct grants with loans and equity financing.

At the same time, funding has been increasingly directed toward strengthening platforms and ecosystems, particularly capital-based financing for growth engines and lead company competition. EU programs such as Horizon 2020 have complemented national R&D funding, particularly benefiting SMEs. Over 50% of EU structural funds are allocated to research and innovation, but only a small percentage directly supports business R&D. Nevertheless, these funds contribute significantly to the SME development, investment, and internationalization. (Halme et al., 2021.)

In 2021, Finland introduced R&D tax incentives, primarily targeting research and development cooperation. However, their scope remains significantly smaller than in many other OECD countries, where similar incentives can cover up to 80–90% of research costs. (OECD, 2023).

While Finland excels in incremental innovation, its corporate sector has yet to produce radical, globally transformative innovations. This challenge has been linked to limited international networking among Finnish companies, as only a few SMEs actively pursue global markets. Business Finland supports private-sector innovation by funding startups and growth companies. However, further efforts are needed to enhance internationalization and international competitiveness. (OECD, 2017.)

As Finland strengthens its innovation ecosystem, policies must align with green transition goals to ensure long-term success in global markets. The green transition requires system-level solutions, long-term funding, and extensive collaboration between the public and private sectors. Key areas of development include low-carbon energy systems, transportation, the circular economy, and smart cities, which can make urban production and consumption more sustainable. Finland also participates in OECD country experiments that utilize new policy tools, such as regulatory models and cluster policies, to support the green transition. (OECD, 2017.)

Although funding for green innovations has increased in Finland, it remains insufficient compared to climate targets and environmentally harmful "brown" subsidies, which still make up a significant portion of total support. Finland should strategically invest in green growth sectors with the highest potential to become an international leader. Business Finland, Finnvera, and ELY Centers support companies investing in renewable energy and green technologies. However, a broader regional and sectoral allocation of support could enhance effectiveness (Kässi, 2024).

3.4.1 Business Finland

This section is based on Halme et al.'s (2018) assessment of Business Finland for the Ministry of Economic Affairs and Employment unless otherwise stated.

Business Finland began operations in 2018, taking over the responsibilities of Tekes (the Finnish Funding Agency for Technology and Innovation) and Finpro Oy. Business Finland operates under the Ministry of Economic Affairs and Employment (Työ- ja elinkeinoministeriö, TEM) and is a central player in the RDI landscape in Finland. It functions as a government agency and a state-owned assignment company, aiming to integrate public funding with business environment development. Until 2025, Business Finland also had venture capital operations, which were later integrated into TESI (Business Finland, 2024).

Business Finland offers funding, export support, internationalization assistance, and ecosystem development programs, especially for SMEs, research organizations, and growth companies. While SMEs primarily receive funding for research, product development, and business growth, larger firms are supported in market expansion and international R&D collaboration. Additionally, Business Finland promotes collaborative projects between businesses and research institutions to strengthen Finland's innovation ecosystem.

Over the past decade, Business Finland's role and funding mechanisms have changed significantly. Budget cuts to Tekes in 2015 impacted its operations from 2018 onward. This shifted the funding focus from direct grants to loans while prioritizing projects that support growth, exports, and internationalization. A key objective of the 2018 reform was to enhance SMEs' internationalization by integrating Finpro's export and internationalization services into Business Finland. This restructuring aligned innovation support with export promotion, reinforcing a dual-purpose approach in which long-term RDI funding was directed toward ecosystems rather than individual firms.

While Business Finland's core goals - internationalization, growth, and a competitive operating environment - have remained stable, its funding priorities have shifted. Past mentions of "strategically important growth sectors" have been removed from the performance goals, highlighting a shift in funding towards supporting innovation regardless of sector.

Global economic and innovation policies have recently addressed societal challenges, including climate change, sustainability, and digital transformation. This trend is also visible in Finland, requiring Business Finland to implement broad-based programs and collaborate with stakeholders. However, its ability to influence system-level challenges is limited.

At the same time, the growing need to support business renewal, exports, and internationalization has created pressure for more targeted and large-scale services. Business Finland's funding model

has prioritized short-term results and incremental development, raising concerns about the long-term renewal. Addressing this issue requires closer cooperation with other research funders, such as the Academy of Finland. EU research and development funding has grown faster than national investments in recent years. The InvestEU program and the Recovery and Resilience Facility (RRF) have become key instruments for growth financing, necessitating the integration of EU funding into the national financial system.

Alongside its core functions, Business Finland has taken on other economic policy responsibilities, such as energy subsidies, incentives for audiovisual production, and innovation support for the shipbuilding industry. While these expansions align with broader policy objectives, they blur the clarity of Business Finland's role.

Public funding for R&D covers less than 3% of firms' R&D expenditures, the majority of which is provided by Business Finland. This limited scope suggests that public funding must be carefully targeted to be effective. Business Finland primarily supports firms with the highest growth potential. As a result, many companies fall outside this framework and rely instead on support from organizations such as Finnvera, ELY Centers, and regional development agencies.

In addition to direct funding instruments, Business Finland uses programmatic activities as a strategic tool to focus its limited resources more effectively. These programs are designed for fields with significant market potential for Finnish firms. They aim to alert firms to market disruptions and improve their understanding of the latest trends affecting future business. They integrate a critical mass of stakeholders and create a collective Finnish offering for strategically chosen sectors and markets. Business Finland believes that firms can boost their international business and renew Finnish society through this approach. (Business Finland, n.d. -c)

In early 2025, eleven (11) programs are ongoing, of which four (36 %) are related to this study's theme. Additionally, Business Finland provides funding from the EU's Recovery and Resilience Facility (RRF) and investment aid for large clean transition projects. (Business Finland, n.d.-c).

Figure 3 illustrates Tekes and Business Finland programs related to climate change, green transition, or other sustainability-related initiatives from 2000 to 2023. The length of each bar represents the program's duration, while color coding indicates the primary thematic focus of each program. Thematic focus areas are organized into five categories:

- Energy (e.g., smart energy systems, low-carbon energy solutions),
- Bioeconomy and Circular Economy (e.g., bioproducts, biomass utilization),

- Materials and Manufacturing (e.g., sustainable industrial processes, green mining),
- Water (e.g., water management and sustainable use of aquatic resources),
- Other sustainability themes (e.g., decarbonized cities, electric vehicles).

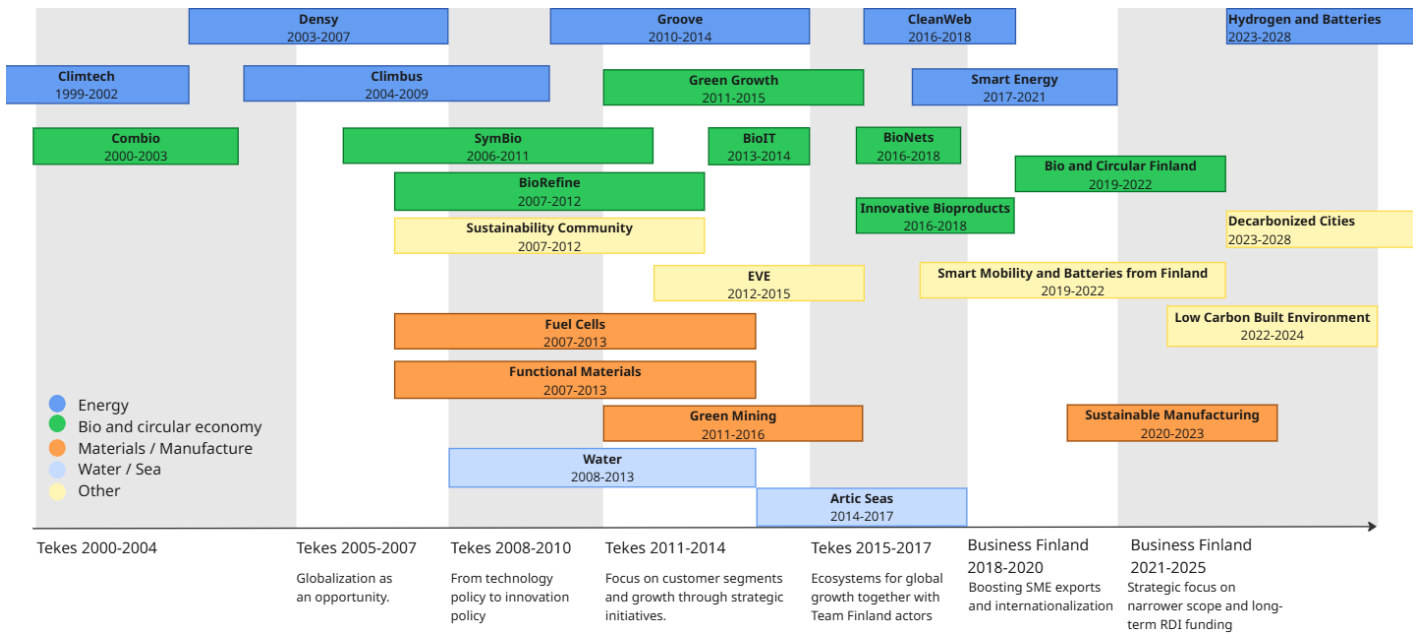


Figure 3: Selected Business Finland and Tekes Programs Related to Climate Change or Sustainability, 2000–2023 (Luoma et al., 2017; Business Finland, n.d.-c)

Business Finland has had initiatives toward the green transition throughout the 21st century. First, initiatives came in the energy sector, as well as the bio and circular economy. After 2007, the focus expanded to cover materials, manufacturing, water, transportation, etc. At the beginning of the 2010s, there was a notable rise in programs on the subject. Though the number of theme-related programs has declined recently, they remain in the portfolio.

Given Business Finland's central role in Finland's innovation ecosystem and the implementation of national policy objectives, its funding mechanisms and priorities can be expected to impact firms' and research institutions' initiatives. Examining the allocation of Business Finland's funding to sustainability-related projects provides valuable insights into how much public funding has supported the green transition.

4 Research Methodology

In the 21st century, climate change has developed into a complex and societal issue (Gjesdal & Andersen, 2023). Research on climate action has expanded significantly during this period, particularly following the 2015 Paris Agreement (Ge et al., 2025). The IPCC (2023) and academic research (Goeschl & Perino, 2017; Aghion et al., 2023) have highlighted that investments in the green transition can contribute to sustainable economic growth in the long term. On the other hand, such investments involve opportunity costs and may even decrease firms' productivity in the short term (Leung & Sharma, 2021).

Public support is crucial in mitigating challenges related to R&D and incentivizing private investment (Hottenrott & Lopes-Bento, 2014). The Finnish government has decided to increase Business Finland's RDI funding authorization to €900 million to promote private investment in innovation (Business Finland, 2024a). However, the effectiveness of public funding depends on its allocation (Becker, 2015) and the stability of policy frameworks (Abdelfattah et al., 2025).

Funding allocation is not isolated; it reflects political priorities and strategic objectives (Halme et al., 2018). Prins et al. (2010) suggested that effective climate policy requires a broad approach that combines technological innovation, energy security, and economic growth. Hence, allocating public RDI funding to support the green transition has become an area of examination.

At the EU level, sustainability policy mainly focuses on economic and technological solutions. Although it aims for sustainable development, it does not deal with the conflict between economic growth and environmental protection. Policymakers often frame sustainability as a technical and economic issue, leading to the ignorance of problems like overconsumption and waste. (Eckert and Kovalevska, 2021.) In Finland, climate policy has shown similar tensions. Kukkonen and Ylä-Anttila (2020) identified two opposing groups: the economic coalition, which focused on growth and called for more research on the economic effects of climate action, and the climate coalition, which supported intense climate action based on scientific evidence.

Although policymakers and researchers often present investments in climate change and the green transition as contributing to long-term sustainable growth (Kuosmanen et al., 2022), there is little empirical evidence on how public RDI funding in Finland has specifically supported this transition. To the author's knowledge, no study has systematically assessed how Business Finland has directed public innovation funding toward climate-related goals. Existing studies have mainly focused on evaluating the effects of individual funding instruments (Business Finland, 2024b; 2022) or

examining innovation policy more broadly (Business Finland, 2023). This chapter describes the methodological choices and data used to answer the research questions presented in Section 1.2. The analysis focuses on the scope, distribution, and development of Business Finland's R&D funding toward the green transition.

4.1 Research Design

This study uses a quantitative, descriptive research design to examine how Business Finland has allocated public RDI funding to climate change mitigation and green transition efforts. The research does not evaluate the effectiveness or outcomes of individual projects. Instead, it focuses on mapping the scope, distribution, and temporal development of climate-related funding at an aggregate level.

A quantitative approach was selected because it allows for systematic examination and comparison of funding patterns across multiple categories, such as sectors and firm sizes (Lim, 2024). Quantitative methods support the analysis of large datasets by treating all observations equally and not prioritizing any single case over others (Mahoney & Goertz, 2006). This approach is especially relevant when the aim is to identify broader trends and distributions rather than analyze individual cases in depth (Georgiadis et al., 2012).

In public funding evaluation, quantitative analysis offers clear benefits. It enables replicable, generalizable, and statistically verifiable insights (Delios et al., 2022). Moreover, it is well-suited for producing policy-relevant knowledge based on observable behavior over time (Bloch et al., 2014). While quantitative research involves numerical data, interpretation relies on contextual understanding, expressed through written analysis and statistical results (Pyo et al., 2023).

The research follows an empirical, data-driven process, carried out in four phases:

1. Identifying relevant keywords from academic literature and IPCC reports.
2. Validating these keywords using publicly available project descriptions from Business Finland's programs.
3. Gathering anonymized funding data at the project level through database searches assisted by an expert from Business Finland.
4. Analyzing the dataset across industries and firm sizes to detect temporal and categorical patterns.

This design supports the research questions by offering a structured framework for exploring the quantity and allocation of green RDI funding in Finland. The dataset includes publicly funded projects between 2000 and 2025, reflecting Business Finland's central role as a public innovation funder. Using quantitative methods ensures that the findings can contribute to evidence-based innovation and climate policy decision-making.

However, a key methodological challenge is that Business Finland does not systematically collect information about the thematic focus of funded projects. The identified projects originate from project plans submitted by firms, which describe their objectives, activities, and expected deliverables. Due to the free-form nature of these documents, the content and style of expression vary across firms, complicating the task of identifying thematic relevance through automated methods.

As no structured thematic coding exists in the dataset, text analysis based on keyword matching remains the only feasible approach for examining climate and green transition-related projects. Another challenge is that the original project plans are unavailable to the researcher due to confidentiality, meaning that the analysis had to be conducted by a Business Finland data expert with access to the internal database. As a result, the researcher has not had direct access to the raw textual data and could therefore not independently verify or interpret the content of individual project descriptions.

To partially address this limitation, publicly available project descriptions were used to validate the selected keywords. These descriptions are only available for projects that have been part of Business Finland's program activities. This validation process helps ensure that the keywords used in the analysis reflect the language firms use to describe projects related to the study's theme.

4.2 Data Collection and Processing

The data for this study were obtained directly from Business Finland. Business Finland provided a dataset specifically compiled for this study, based on publicly available information. Although funding information is public and available on Business Finland's website, the dataset used in this study is not published online in this form.

The study uses two distinct datasets. The first dataset includes public project descriptions from 2000 to 2023. These descriptions are only available for projects linked to Business Finland's programs. This dataset comprises only approved and completed projects. Each project entry also contains

additional information such as funding type, funding service, firm size, funding instrument, project name, public description (in Finnish or English), and year of approval.

The researcher used this material to validate a set of keywords related to climate change and the green transition. The original keyword list was compiled based on academic literature and IPCC reports, ensuring the selection was theoretically grounded and relevant. The researcher then submitted these validated keywords to a Business Finland expert, who performed a targeted search within internal project documentation to identify relevant projects.

The second dataset, also obtained from Business Finland, contains funding data for the projects identified through the keyword search. It includes only projects within the thematic scope and excludes confidential project descriptions or detailed plans. The dataset is anonymized: firm and project names are not included. However, it retains general attributes such as firm size and sector, which are not classified as business secrets under current data-sharing regulations.

While program-based projects include public descriptions, limiting the analysis to only those excludes a significant portion of Business Finland's total funding portfolio. Therefore, the second dataset in this study includes all identified projects, regardless of their connection to specific funding programs. This approach allows for a broader analysis of Business Finland's climate-related RDI funding. However, it also has limitations, such as the researcher's inability to access detailed information about individual projects and check their relevance to the subject.

The search can miss some relevant projects, but the dataset can include projects unrelated to the theme. These factors may affect the overall coverage and accuracy of the data. Since the funding under review covers a broad scope and the analysis focuses on general patterns, individual projects are unlikely to affect the study's results or conclusions significantly.

4.2.1 Theoretical Grounding of Keyword Selection

Keyword selection consists of two main steps to ensure broad coverage and relevance for the study. First, key terms are identified based on academic research and reports from the Intergovernmental Panel on Climate Change (IPCC). These sources are the foundation for compiling a list of terms related to climate change and the green transition. Second, the researcher validates the list using publicly available project descriptions from Business Finland's programs. This approach ensures that the selected terms correspond with the language used in innovation activities.

Rather than analysing discourse or narrative as such, this study relies on established environmental policy discourses to guide keyword selection. These discourses influence sustainability and climate change representation in academic, political, and public arenas. They establish what qualifies as feasible or legitimate climate action and may influence the representation of climate-related RDI efforts in publicly funded projects. New narratives, including the circular economy, bioeconomy, technology optimism, and climate emergency dialogue, are constructed based on earlier frameworks like ecological modernization and sustainable development. (Leipold et al., 2019.)

These discourses serve as a conceptual foundation for identifying relevant terminology, rather than as an analytical framework. Their inclusion helps identify thematically relevant vocabulary used to describe projects related to the theme. The keyword list helps interpret the assumptions and priorities reflected in project descriptions, the data source for identifying climate-related funding. This climate-related vocabulary gives a clear and solid way to find relevant projects in the data.

The idea of transformation has become more common in recent years. People often use it in research and politics to show urgency and ambition, but the meaning is unclear. Academic literature usually describes transformation through sociotechnical, socioecological, or institutional frameworks. At the same time, in politics, the term occurs more often in rhetorical use without a concrete operational definition (Moore et al., 2021). Although this study does not analyze how the concept is used in project content, understanding its ambiguity supports the decision to focus on clearly defined keywords.

The evolution of climate-related terminology reflects broader shifts in how climate change is understood and how political approaches to addressing it have developed (Gjesdal & Andersen, 2023). According to a systematic review by Khojasteh et al. (2024), climate research has shifted since 1990 from foundational scientific inquiry to solution-oriented approaches, with increasing attention to adaptation, sustainability, and climate-smart policies. Over time, previously central terms such as “carbon dioxide” or “methane” have become less prominent as their role has become widely understood.

Climate-related research is inherently interdisciplinary, encompassing environmental science, sustainability studies, ecosystem research, and economics. Key research themes include carbon neutrality, climate governance, renewable energy, and adaptation strategies. (Ge et al., 2025.) At the same time, climate-related terminology often overlaps or remains ambiguous, reflecting geographical and institutional variations in the terms used. Broad sustainability concepts typically encompass ecological, economic, and social dimensions. (Glavič & Lukman, 2007.)

The growing role of green technologies highlights how climate change has become embedded across nearly all sectors of society. These technologies encompass environmental innovations, energy infrastructure, digital solutions, and new economic models (Wu & Strezov, 2023). These thematic developments help understand the terms firms use when describing projects. Therefore, keywords must be broad and appropriately limited to identify relevant projects without including non-related projects.

It is important to note that changes in climate terminology are not solely the result of scientific or political debate. The media also significantly impact how climate issues are understood and framed. In the United States, for example, media framing has shifted from emphasizing economic costs and scientific uncertainty in the 1990s toward highlighting economic opportunities and climate risks since the mid-2000s (Stecula & Merkley, 2019). Cross-national comparisons reveal significant differences between countries. While German and French media often present climate change as a moral and political issue, UK and US media emphasize technical and economic dimensions. (Grundmann & Krishnamurthy, 2010.) Therefore, it is essential to acknowledge the influence of national contexts, such as Finnish institutional and cultural language use, on terminology.

Because scientific reports use neutral language while public communication often relies on more emotional wording (Commerçon et al., 2023), the vocabulary search must go beyond academic sources. This broader approach matters because Business Finland-funded project applications are not scientific documents. Instead, they are practical submissions from firms, leading to considerable variation in terminology. It is, therefore, necessary to supplement the list of keywords with terms commonly used in policy discourse and applied innovation activities.

Appendix 1 includes the complete list of selected keywords and their sources. The list leaves out broad terms like adaptation, mitigation, transition, and resilience. Although these terms appear often in academic and policy contexts, they also describe topics outside the focus of this study. For example, people may use adaptation or resilience when discussing organizational or market changes and transition or mitigation in digitalization or risk management discussions. This study includes only keywords that point to climate change mitigation and the green transition, to keep the search focused and relevant.

4.3 Keyword Validation Process

The keyword-based identification process followed several stages to ensure conceptual precision, linguistic coverage, and thematic relevance. The initial keyword selection was done in English, as

most academic and policy literature is published in that language. Since Business Finland's project descriptions are written in Finnish and English, all validated keywords were translated into Finnish using MOT Kielipalvelu. It offers reliable translations for academic and policy-related terms (MOT Kielipalvelu, n.d). Some English keywords were translated using more than one Finnish equivalent to maintain conceptual accuracy. The aim was to align the vocabulary with commonly used terms in climate-related innovation activities.

The full keyword list was converted into regular expressions (regex) to capture linguistic variation. This allowed the identification of various grammatical forms and orthographic variations, such as inflections, plurals, compounds, and alternate spellings (e.g., *biobased* vs. *bio-based*; *decarbonize* vs. *decarbonise*). This approach enabled a more precise and comprehensive search within unstructured project texts. (Wickham & Grolemond, 2017.)

A validation process was conducted to enhance the relevance of the keyword matches. The original dataset contained 36,471 projects. After removing duplicates and entries without valid public descriptions, the cleaned dataset included 20,334 projects. Using the initial keyword list with regex matching, 4,940 projects (24.3%) were identified as containing at least one keyword.

The original list included 196 keywords (96 English and 100 Finnish). While all English keywords occurred at least once, several Finnish terms, such as *globaali lämpeneminen*, *hiilen poistaminen*, and *hävikkiruoka*, did not appear and were removed. Rare keywords (appearing in five or fewer projects) were examined manually and retained only if thematically relevant and not co-occurring with more common terms. Based on this review, some keywords were refined (e.g., *luonnonsuojelu*) or added (*hybridivoima*), while others were removed due to ambiguity (e.g., *älykäs verkko*) or redundancy (e.g., *ympäristöhaitta* replaced with *ympäristökuorma* and *materiaalitehokkuus*). Additional adjustments included correcting typos (*pääst.* → *päästö*).

The refinement process also addressed overly broad terms such as *bio* and *environment*, frequently appearing in unrelated contexts like biomedical research or general environmental compliance. To reduce false positives and increase thematic clarity, these broad keywords were replaced with more specific alternatives, such as *bioenergy*, *biofuel*, *biomass*, and *environmentally friendly*.

After these refinements, the number of identified projects slightly decreased to 4,809 (23.7%). The final keyword set included 144 terms: 79 in English and 65 in Finnish. All remaining terms appeared in multiple projects, supporting their thematic relevance.

A composite score was calculated for each keyword to identify the most representative terms based on the number of matching projects and total frequency across the dataset. The 50 highest-scoring terms in English and Finnish formed the final keyword list, matching 4,767 projects (23.4%).

A manual inspection confirmed the accuracy of the keyword list. Broad but frequently used terms like *sustainable*, *kestävä kehitys*, *päästöt*, *energiatehokkuus*, and *kierrätys* were typically accompanied by more specific keywords, and their inclusion did not result in off-topic projects. A comparison between general and refined keyword matches showed no significant increase in irrelevant content.

Lastly, 42 projects matched in the original run but were excluded after refinement were reviewed individually. These accounted for approximately 1% of initially matched projects. Most of them lacked explicit references to climate-related themes, instead focusing on digitalization, technical optimization, or general process development. Their removal is unlikely to have meaningfully affected the results. Appendix 2 presents the final keyword set (50 terms in each language) and other manually adjusted terms used in the refined analysis.

4.4 Data Analysis at Business Finland

Due to data restrictions, the next phase of the study was carried out at Business Finland. Their data analyst conducted a data-driven analysis to identify funding applications related to the green transition. The aim was to isolate project texts containing specified keywords using a regular expression (regex) pattern.

The input data consisted of textual records of accepted funding applications, excluding COVID-19 Support Funding. After preprocessing (removal of empty and duplicate entries), the dataset included 45,918 unique projects. The analyst developed a keyword-matching function using regex, which standardized the text (e.g., lowercasing, whitespace cleanup) and identified projects containing green transition-related terms. This resulted in 9,807 keyword-matched projects.

Additional funding-related variables were fetched and merged with the keyword-matched dataset in the next step. These variables included:

- Firm size (EU classification of the grant was accepted)
- Region
- Decision type

- Funding year
- Instrument name
- Industry classification (TOL 2008)
- Funding amount (€)

After merging and final cleaning, the final dataset included 9,716 unique green transition projects. Business IDs were anonymized to ensure confidentiality. Although the keyword search was applied to project records covering the entire 2000s, detailed funding data was available only for 2010–2025. Moreover, project-level funding data were relatively limited before 2016, and only from 2016 onward does the dataset provide sufficiently comprehensive information to support detailed time series analysis.

4.5 Limitations and Robustness

The keyword-based approach in this study was designed to connect broader climate and sustainability discourses with the terminology used in innovation funding applications. The purpose was not to analyze the content of project descriptions but to support a systematic and replicable method for identifying projects related to climate change and the green transition for funding-level analysis. As previously noted, general and ambiguous terms were excluded to enhance the search's accuracy and ensure that the selected terminology more directly reflected the core themes under investigation.

To evaluate potential limitations of this approach, a manual review was conducted on 42 projects that were excluded following the refinement of the keyword list. The analysis showed that these projects generally did not include explicit references to climate change or ecological sustainability in their public descriptions. While some may have touched upon related issues, such as circularity, waste reduction, or resource efficiency, they did so in ways only indirectly linked to climate objectives. Crucially, their focus was not presented as contributing directly to climate change or the green transition. Therefore, it was considered reasonable to exclude them from the keyword list. This decision is further supported by the fact that these excluded cases represent only about 1% of the identified projects and are unlikely to have any meaningful impact on the overall conclusions of a large-scale funding analysis.

The reliability of the keyword selection was further supported through repeated random sample checks. Random sample projects were manually reviewed to verify their thematic relevance. All reviewed cases showed explicit references to climate-related content. Similarly, randomly sampled projects not included in the dataset lacked climate terminology and focused instead on themes such as digitalization, industrial optimization, or general business development. This indicates that the keyword selection process did not result in a notable number of false inclusions or exclusions.

Additional support for the robustness of the method came from an analysis of common keywords such as *sustainable*, *kestävä*, and *päästö*. These terms frequently co-occurred with more specific climate-related terms, suggesting that their inclusion did not compromise the thematic clarity of the dataset. Moreover, the refined keyword list was tested across the whole, preprocessed dataset (over 20,000 projects), and the distribution of matches remained consistent throughout various validation steps. These included quantitative filters (composite scores and frequency thresholds) and qualitative assessments (manual review and random sampling). Together, these layers of verification strengthen confidence in the reliability of the keyword-based identification process while acknowledging the inherent limitations of surface-level text analysis.

It is important to emphasize that the internal keyword search in Business Finland's confidential funding application database was conducted by a data expert employed by the agency. The researcher provided the validated list of keywords but did not have direct access to internal project texts. This external implementation of the keyword-matching process ensured adherence to confidentiality requirements, but also meant that the researcher could not independently verify or interpret the textual content of matched projects. This division of roles represents a methodological limitation but was mitigated through close cooperation and multiple validation steps using publicly available descriptions.

Despite the methodological limitations, the validated dataset enables a comprehensive and reliable overview of Business Finland's green transition funding landscape. While individual project details remain inaccessible, the aggregate-level data is sufficient to identify broad patterns in funding distribution, target groups, and thematic focus areas. The following chapter presents the empirical results from this dataset, offering insights into how public innovation funding reflects and supports the green transition in practice.

5 Empirical Results

This chapter presents the study's empirical findings. Drawing on project-level data from Business Finland's internal funding records, the analysis examines how public RDI funding was allocated to support the green transition between 2000 and 2025. The focus is on climate-related projects' volume, distribution, and thematic orientation in line with the study's research questions.

Information on the funding instruments and their characteristics is based on publicly available descriptions provided by Business Finland². Data on the general distribution of funding is sourced from Business Finland's funding statistics³.

Special attention is given to identifying which types of firms and sectors have benefited from green transition funding, how funding patterns have evolved, and whether structural imbalances are present in the distribution of public support. By shedding light on these aspects, the analysis provides insight into the practical implementation of Finland's climate and innovation policy at the project level. The results are organized into three thematic subsections, starting with long-term trends in climate-related funding within Business Finland programs.

5.1 Climate-Related Projects in Business Finland Programs

The empirical analysis begins by examining project-level descriptions to validate the relevance and functionality of the climate-related keyword set. While this dataset does not include financial information, it provides important thematic insight into Business Finland's program activities. These programs are a strategic tool for guiding firms toward specific innovation priorities and broader policy objectives. As such, they offer a helpful entry point for observing how climate-related themes have been integrated into public RDI funding over time and how the agency's thematic focus has evolved in response to national and EU-level climate goals.

Figure 4 shows the total number of projects (orange) and those that matched the climate keywords (blue). The number of projects linked to Business Finland programs has varied significantly over the period under review. In the early 2000s, approximately one thousand projects were connected to these programs annually. At the turn of the 2010s, this number nearly doubled but gradually declined, falling below 1,000 in recent years.

² [Funding - Business Finland](#)

³ [Funding information - Business Finland](#)

A slightly different trend can be observed when examining the keyword-identified projects. Climate-related (keyword-identified) projects have grown significantly from a marginal role in the early 2000s to an established part of Business Finland’s program-linked funding. The first noticeable increase occurs between 2008 and 2011, followed by a stronger surge around 2019–2021, coinciding with Finland’s carbon neutrality target and the EU’s recovery funding. Although the number of projects slightly declined in 2022–2023, the overall presence of climate themes has remained high and stable.

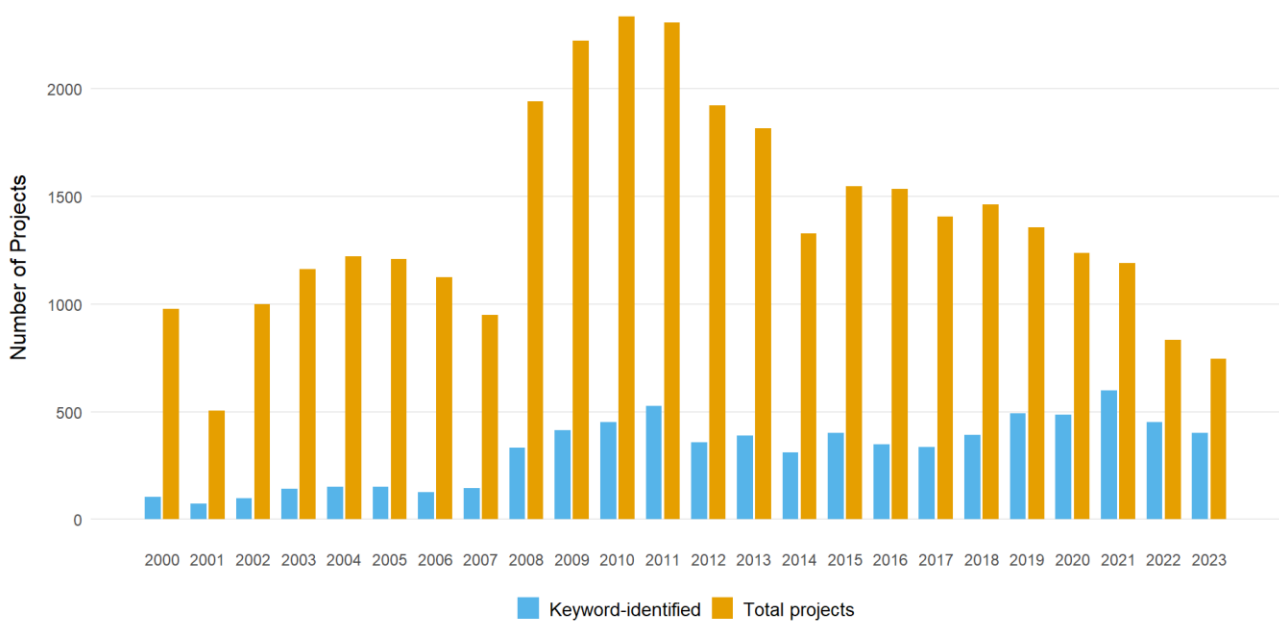


Figure 4: Annual Number of Climate-Related and Total Projects Linked to Business Finland Programs, 2000–2023 (Keyword-identified = projects matched with climate-related keywords)

Figure 5 presents the share of identified climate-related projects (%) of all projects linked to Business Finland programs. This share has increased consistently over the observation period, from approximately 10% in 2000 to over 50% since 2021. The trend suggests a long-term shift toward climate-oriented innovation activity and public RDI policy priorities.

However, as the dataset includes only program-linked projects and excludes actual funding volumes, the figures reflect thematic orientation rather than growth in climate-related funding. While the rising share of climate-related projects appears promising, it is important to note that the absolute number of program-linked projects has declined in recent years. The increase in share, therefore, reflects a relative shift in emphasis, not a growth in total project volume. This distinction

reinforces the need to interpret the figure as an indication of changing policy priorities rather than expanding activity.

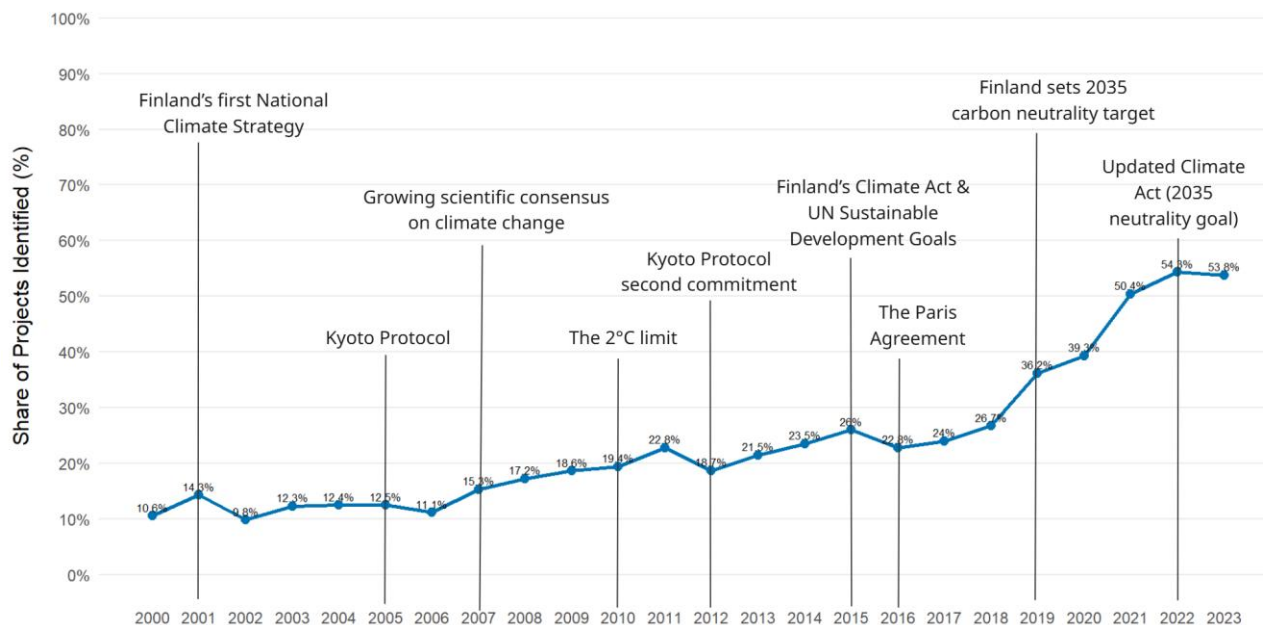


Figure 5: Share of Climate-Related Projects out of All Program-Linked Projects by Year, 2000–2023, with Key Policy Milestones

Several peaks in the share of climate-related projects coincide with major climate policy decisions. For example, a moderate increase follows the Kyoto Protocol (2005) and the adoption of the 2°C target (2010). The effects of these policy actions appear to be delayed at the project level, which may indicate a time lag between political decision-making and observable changes in the RDI field. Another apparent increase can be seen after the Paris Agreement (2016).

The most significant growth occurred after Finland set its carbon neutrality target for 2035 in 2019. This suggests that national climate policy has influenced the project level. Between 2019 and 2022, the share of climate-related projects has risen rapidly from 27% to 55%, nearly doubling in three years. This trend may reflect the green transition's growing urgency and climate policy's influence on RDI orientation. From December 2019 to June 2023, Finland was governed by Prime Minister Sanna Marin's centre-left coalition, which emphasized sustainability, climate action, and the green transition in its political agenda. These priorities may partly explain the notable increase in climate-related project activity during this period.

Since 2021, the share of climate-identified projects has stabilized above 50%, indicating that climate-related content has become an established part of Business Finland's program-linked

projects. However, in absolute terms, climate-related projects have declined in recent years. In practice, funding advisors do not consistently link projects to relevant programs retrospectively. As a result, program-based project data may underestimate the actual thematic alignment of funded projects.

5.2 Green Transition Funding Over Time

The second dataset comprises 9,716 projects identified through a validated set of climate-related keywords. Based on this classification, approximately 21% of all Business Finland-funded projects during the review period can be considered linked to the green transition. The dataset covers only projects funded by Business Finland, and figures for 2025 reflect funding decisions made up to May.

Contrary to the impression given by Figure 4, which identifies projects throughout the 2000s, the funding data only begins to systematically capture projects related to the green transition from 2016 onwards. However, a similar upward trend emerges when examining project volumes in Figure 6. The funding data reveals more green transition projects, suggesting that firms increasingly undertake such R&D efforts independently of formal program structures.

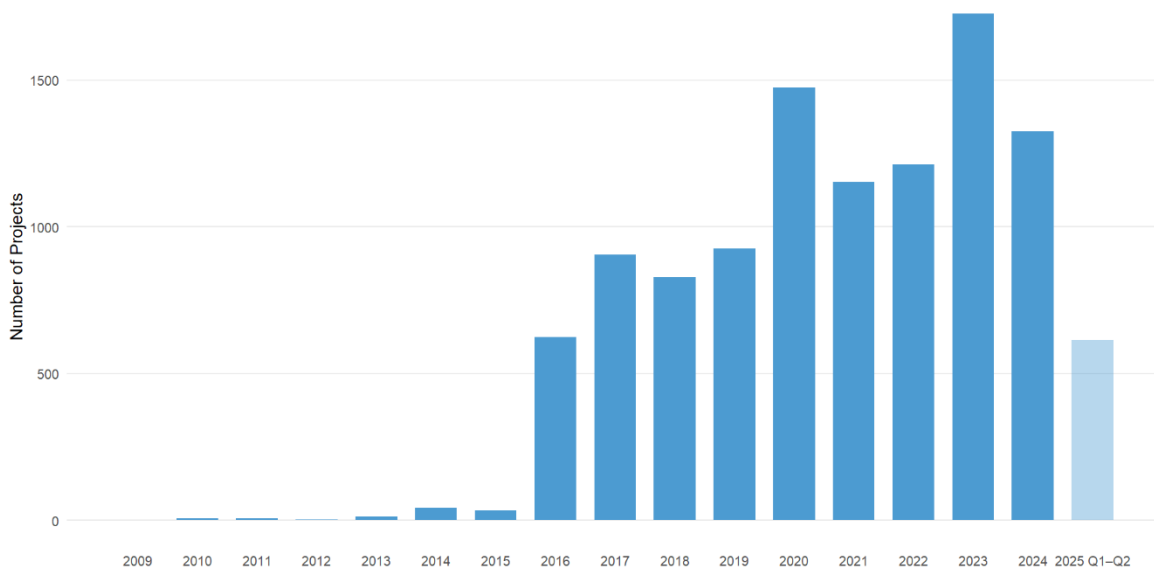


Figure 6: Number of Projects Related to Climate Change and the Green Transition

A similar trend is observable in the total funding data presented in Figure 7. Funding allocated to projects related to the theme appears to have started declining after 2022. At the same time, the number of projects has been more volatile than the funding amounts. This discrepancy is

understandable, as the total funding available each year is predetermined through government budget decisions. At the same time, the number of funded projects can vary depending on the size and scope of individual applications.

The post-2022 decline should therefore be interpreted with caution. It is unclear whether this represents an absolute reduction in green transition investment or a return to a more stable baseline following an exceptional funding peak. In this context, year-to-year volatility in project counts and funding volumes may reflect instrument use, timing, and political prioritization fluctuations, rather than a structural weakening of climate-oriented innovation policy.

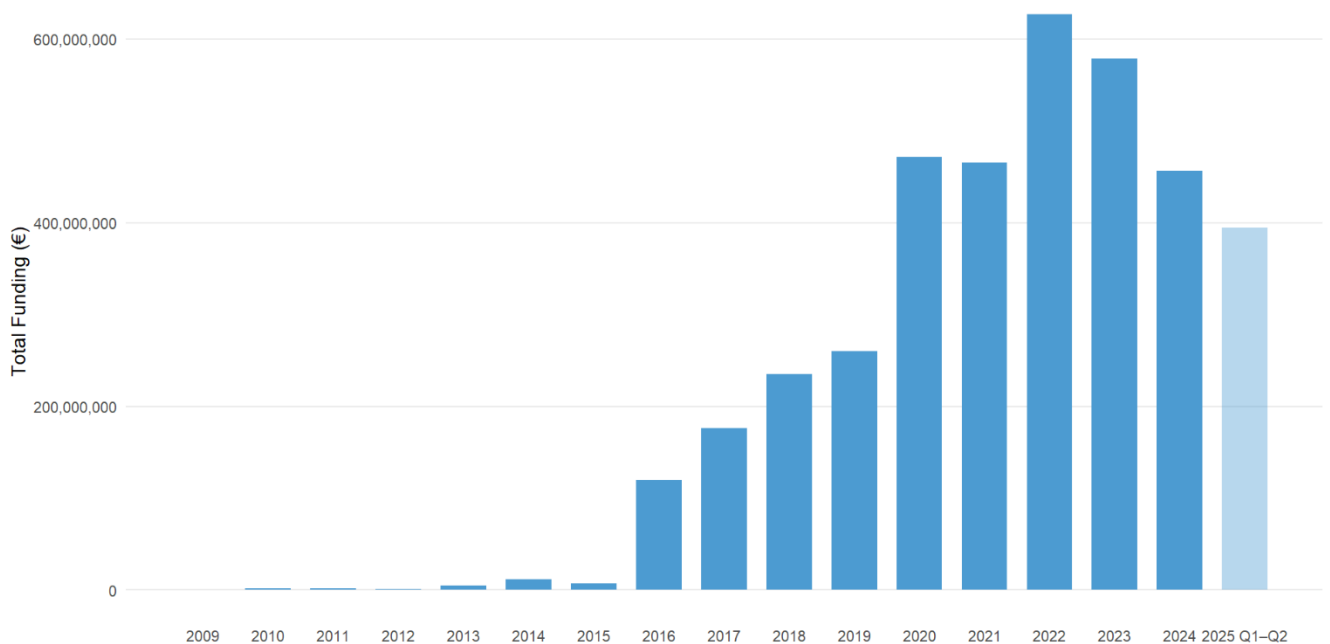


Figure 7: Total Funding Allocated to Climate Change and Green Transition Initiatives

Figure 8 illustrates the share of Business Finland’s total funding allocated to climate change and green transition–related projects. Since overall funding volumes have varied over time, the relative share offers a clearer picture of how thematic investment priorities have evolved.

Until 2015, the share remained consistently low probably due to missing project level funding data. However, from 2016 onward, a strong and sustained upward trajectory emerges: the share climbs to 28.1% in 2016, surpasses 50% by 2020. Between 2022 and 2024, the proportion stabilizes between 75% and 80%, suggesting that climate and transition-oriented projects have become a central focus of Business Finland’s RDI funding.

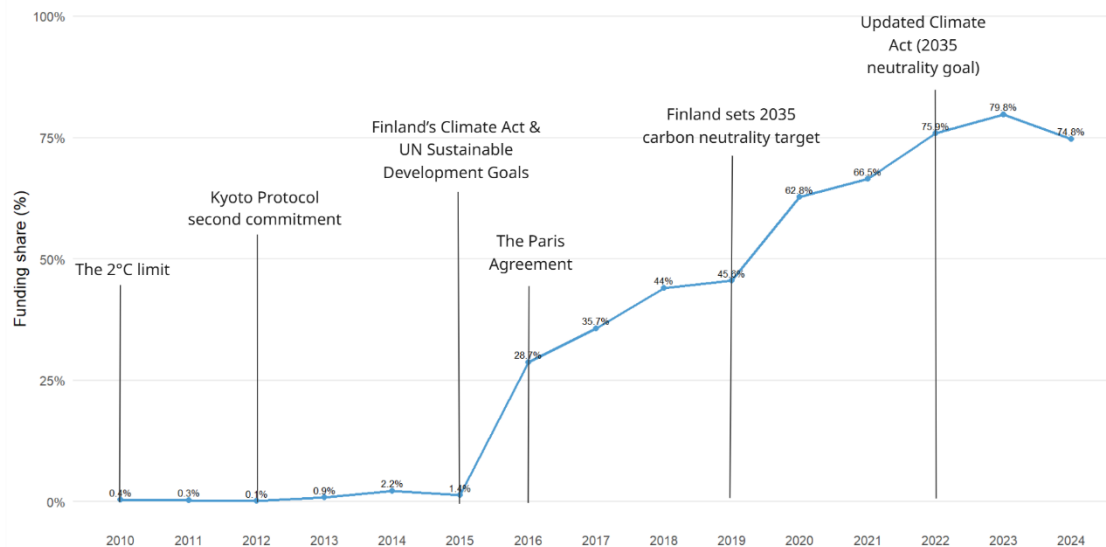


Figure 8: Development of the Funding Share (%) in Relation to Key Climate Policy Events

The observed growth in green transition funding aligns with major climate policy milestones, such as the revision of Finland's Climate Act and the 2035 carbon neutrality target. Since 2016, this shift appears consistent with the goals of mission-oriented innovation policy, which seeks to align public R&D funding with long-term societal challenges (Kattel & Mazzucato, 2018; Schot & Steinmueller, 2018). However, it remains unclear to what extent this development reflects a systematic policy effort rather than a natural response by firms to evolving market, regulatory, and societal expectations. The relatively modest increase in the projects formally linked to thematic programs suggests that strategic coordination has not fully kept pace with the shift in funding priorities.

The available funding data poses certain limitations, particularly for the early years of the review period. Project-level funding information was not available in the systems before 2010, and between 2010 and 2015, data were available for only a limited subset of projects. This is despite program-level records showing that hundreds of relevant projects were likely implemented during that time. The gap raises questions about the completeness and consistency of early funding records.

However, from 2016 onwards, the dataset can be considered relatively comprehensive and reliable. This corresponds with internal practices at Business Finland and publicly available information, which confirms that detailed project-level funding data is systematically recorded only from 2016 onwards. As a result, the in-depth analysis of funding distribution focuses on the period starting in 2016.

5.3 Funding Allocation by Firm Characteristics, Sector, Instrument, and Region

This section examines how green transition funding is distributed across different types of recipients and structural dimensions. By analyzing firm size, industry sector, funding instruments, and geographical location, the section offers a more nuanced view of who benefits most from public innovation funding. The results highlight dominant actors and trends while uncovering disparities that raise important questions about inclusivity and regional equity in innovation policy.

5.3.1 Firm Size Distribution

Figure 9 presents the distribution of green transition projects by firm size during 2016–2025. Large firms have carried out the highest number of projects throughout the period. Micro-sized firms also display relatively high project volumes, exceeding small and medium-sized firms. Notably, medium-sized firms have completed only about 100 projects annually, which has remained remarkably stable. In contrast, large and micro firms exhibit greater fluctuation and higher overall activity levels, with project numbers peaking in 2020 and 2023 across most size categories.

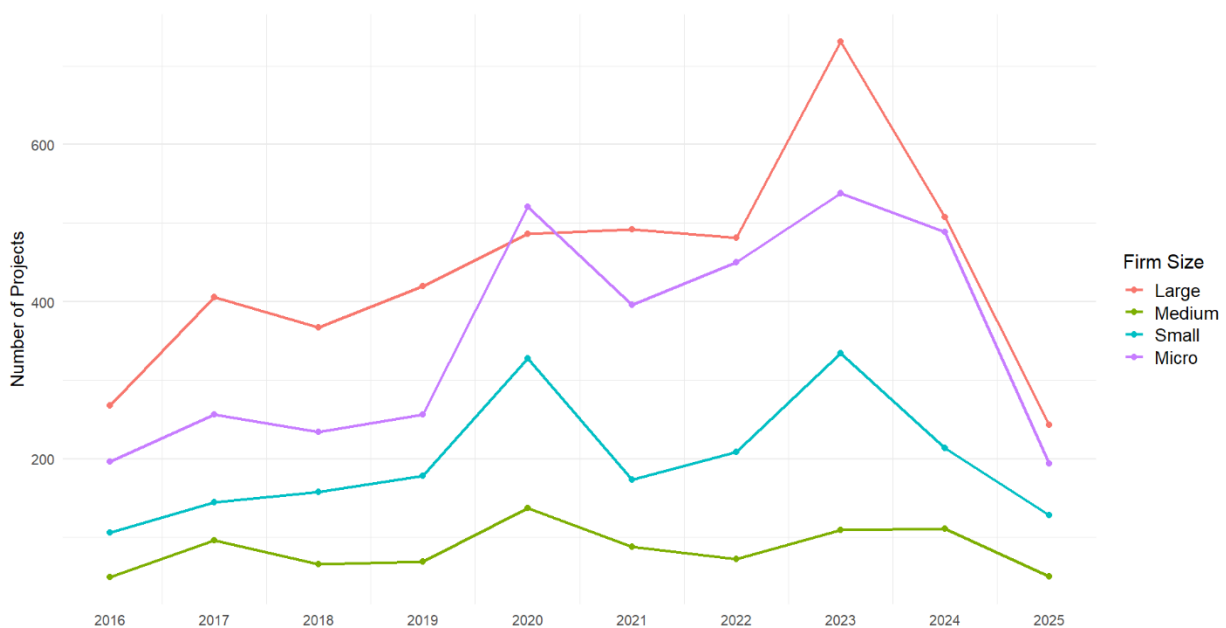


Figure 9: Number of Projects by Firm Size, 2016–2025

Figure 10 shows that large firms have also received most of the total funding. The overall increase in funding since 2016 is primarily driven by this group, which has consistently secured €200–300 million more per year than other firm sizes. This trend may reflect a situation where established firms invest in innovation to maintain competitive advantage, consistent with Aghion and Howitt's (1992, 2023) theory of endogenous innovation under competitive pressure. It also aligns with

Hogan et al. (2022), who argue that dominant firms often use public R&D funding to defend their market leadership.

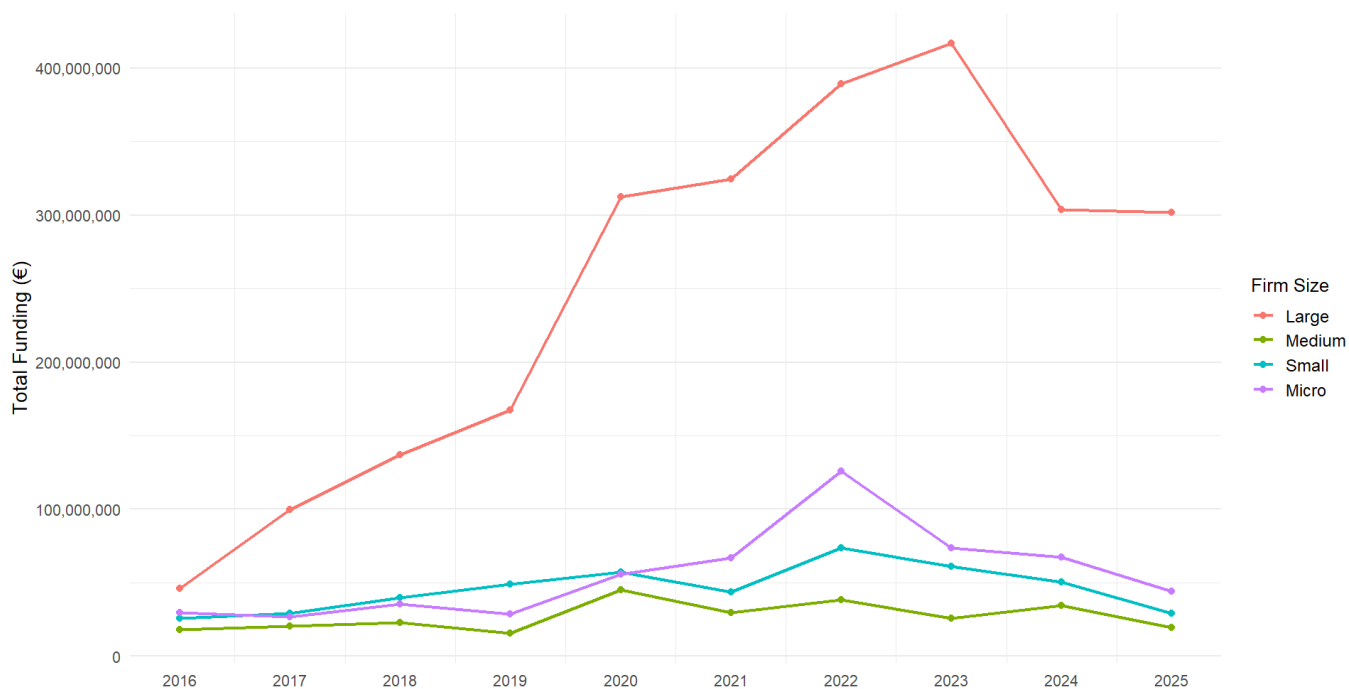


Figure 10: Total Funding by Firm Size, 2016–2025

In contrast, medium-sized firms receive disproportionately little support and remain the least funded group across the period. Micro and small firms have secured larger funding volumes. Micro firms, many are likely startups, play an active role in green transition projects, indicating early-stage innovation potential in emerging green technologies. Their involvement supports the notion that a share of the funding is directed toward radical, pre-commercial innovations, rather than incremental improvements (Dewar & Dutton, 1986). However, their modest funding share may reflect smaller project scopes or limited access to larger instruments, highlighting a possible need for more tailored support for early-stage innovators.

The observed distribution reflects the general pattern of Business Finland's enterprise funding. Nevertheless, within the green transition context, the dominance of large firms appears even more pronounced, particularly during the peak years of 2020–2022. Meanwhile, medium-sized firms remain underrepresented despite their potential for scalable innovation. This imbalance raises important questions about the inclusiveness of current funding instruments and whether they adequately support a broader and more diverse range of innovation actors.

5.3.2 Sectoral Funding Distribution

When examining the sectoral distribution based on TOL 2008 classifications, no single sector dominates in terms of funding granted. This suggests that green transition–related innovation and development activities are broadly distributed across multiple industries. Figure 11 shows the annual funding share (%) of the five most prominent sectors involved in such projects.

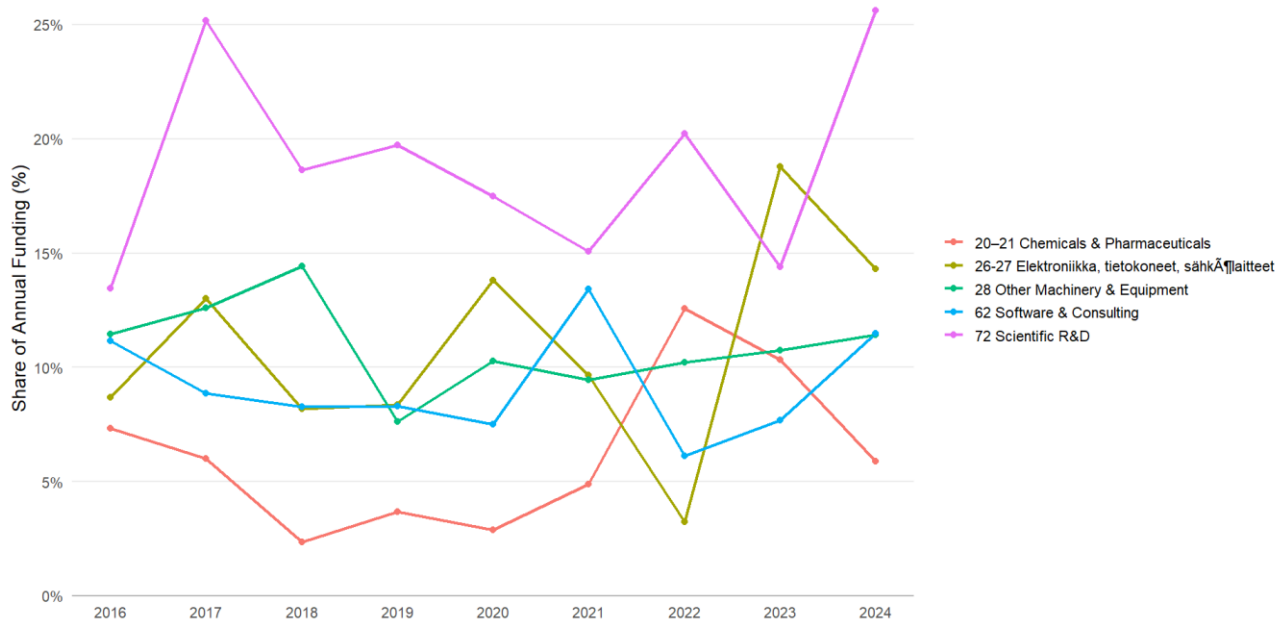


Figure 11: Trends in Annual Funding Share by Industry Sector

The five largest TOL categories account for approximately 45% of all projects, indicating that specific sectors play a more significant role while the activity is dispersed. The leading sector is Scientific R&D (TOL 72), which has received up to 25% of the annual funding at its peak. This underscores the central role of research-driven innovation in addressing green transition challenges and may also reflect the early-stage and experimental nature of many climate-related technologies that are not yet commercially viable.

Other notable sectors, each receiving around 10% of funding, include Software and Consulting (TOL 62), Other Machinery and Equipment (TOL 28), and Electronics, Computers, and Electrical Equipment (TOL 26–27). These sectors contribute to the green transition through technological advances that enhance energy efficiency, enable emissions monitoring, and support renewable energy solutions via software, automation, and electronics.

5.3.3 Funding by Instrument Type

Business Finland’s funding instruments offer a helpful lens through which to examine the types of projects that have received support. Figure 12 presents the number of funded projects by key instruments between 2016 and 2024. Five instruments account for 90% of all projects: De Minimis Grant, Energy Support, Research (EVET), and Research & Development.

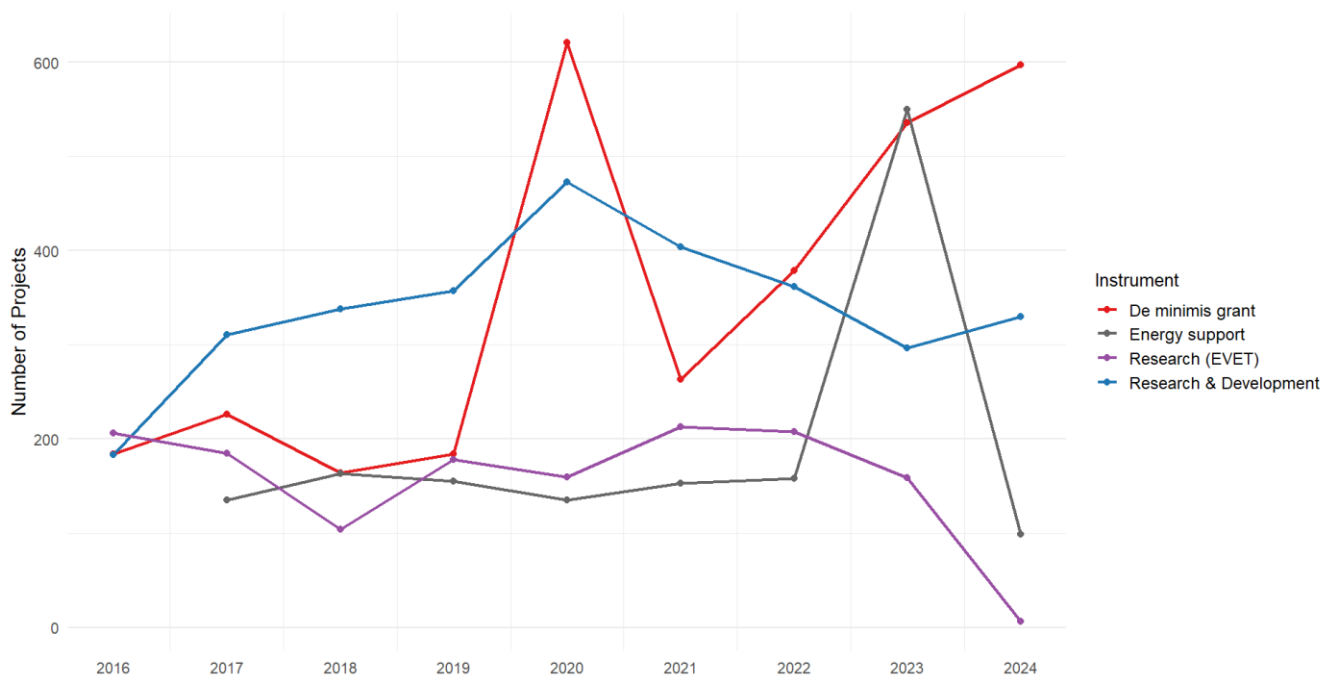


Figure 12: Number of Projects by Instrument Type, 2016–2024

The De Minimis Grant is the most frequently used instrument, although its annual usage has varied. This dominance is understandable, as several of Business Finland’s most accessible services operate under the de minimis regulation, including Tempo, Talent, Market Explorer, Innovation Voucher, and various preparatory and accelerator programs. These tools are attractive to SMEs and startups due to lighter administrative requirements, low thresholds for eligibility, and operational flexibility. As such, de minimis support is an important gateway to early-stage innovation and internationalization. While individual grants are modest, many projects highlight the instrument’s broad reach and policy relevance.

Traditional corporate R&D funding, primarily targeted at firms, has also played a significant role. This funding typically supports innovation, product development, and technology adoption, often through grants or loans for research-intensive activities aiming to boost competitiveness and export performance. Energy Support maintained a steady volume of 150–200 projects annually until 2023, when the number spiked to over 550. This surge likely reflects revisions to energy aid regulations,

which expanded eligible technologies and placed greater emphasis on commercialization, including energy storage and flexibility solutions.

Research (EVET) projects, coordinated by research organizations in collaboration with industry, have remained a consistently strong component of Business Finland’s portfolio. Their stable presence highlights the strategic importance of fostering innovation ecosystems and promoting knowledge exchange between academia and firms. These projects embody the principles of Chesbrough’s (2003) open innovation model, in which cross-sectoral collaboration and knowledge flows are essential for sustainable innovation. Public support for such cooperative R&D aligns with system-of-innovation perspectives emphasizing spillovers, diffusion, and joint problem-solving as key mechanisms (Becker, 2015; Martin & Scott, 2000).

A different pattern emerges when funding is analyzed in terms of volume rather than project count. Figure 13 shows that the largest share of total funding has consistently been corporate R&D, followed by collaborative research through EVET Research. Although De Minimis Grants account for the most significant number of projects, they represent only a small fraction of total funding.

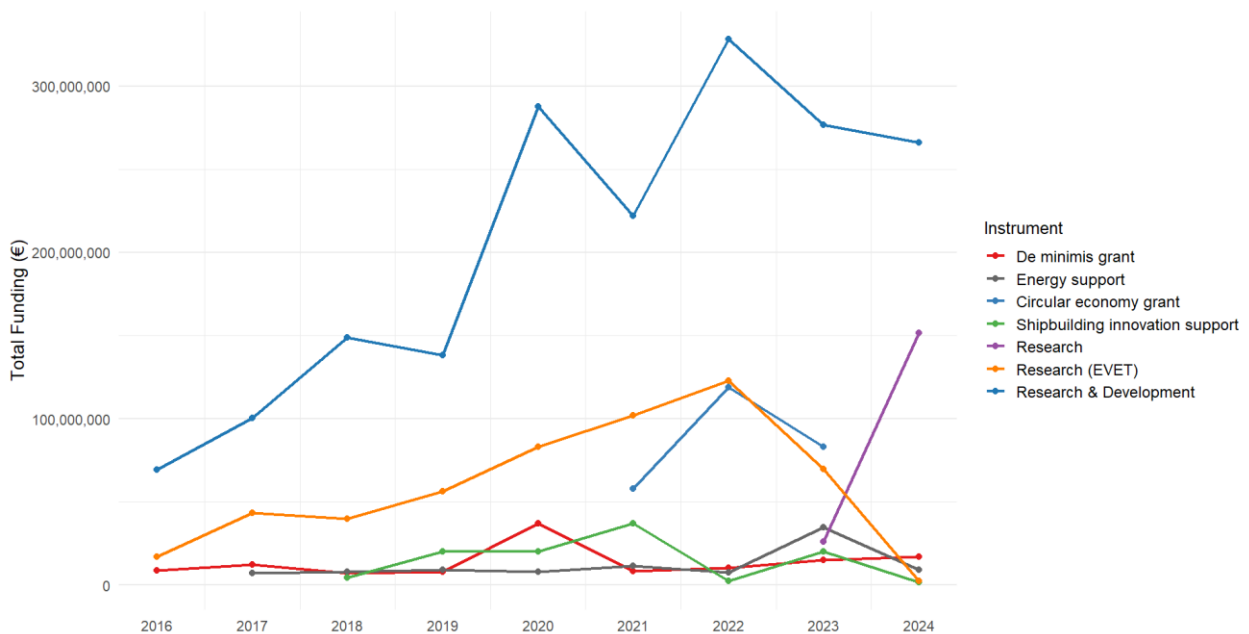


Figure 13: Total Funding by Instrument Type, 2016–2024

New instruments such as the Circular Economy Grant and Shipbuilding Innovation Support reflect evolving policy priorities within the green transition. The Circular Economy Grant was a time-limited instrument available between 2021 and 2023 as part of Finland’s Sustainable Growth Programme, co-funded by the EU’s Recovery and Resilience Facility (RRF). It aimed to accelerate

the green transition by supporting projects focused on circular economy solutions, particularly waste reduction, material efficiency, and product lifecycle innovation. While such targeted efforts may generate short-term momentum in specific domains, their limited duration raises policy continuity and long-term impact concerns. Addressing climate change requires sustained and strategic investments. Short-lived instruments, however well-designed, may struggle to deliver lasting structural change unless embedded within a broader and coherent policy framework.

By contrast, the Shipbuilding Innovation Support instrument has been in place since 2015 and represents a more enduring funding mechanism. It supports technologically advanced and high-risk development projects in the maritime industry, including innovations related to smart vessels, sustainable propulsion, and autonomous or Arctic-capable ship design. The growing funding volumes observed in recent years may reflect both the strategic importance of shipbuilding in Finland's innovation ecosystem and the sector's potential contribution to decarbonizing heavy transport. Rather than a short-term policy response, this instrument exemplifies a long-term, targeted investment stream within the green transition agenda.

5.3.4 Regional Concentration of Innovation Funding

Innovation funding in Finland is heavily concentrated in a few key urban centers. Figure 14 illustrates the distribution of total green transition funding among the ten most funded cities. Helsinki alone accounts for 42.4% of the total, underscoring its dominant role as Finland's capital and primary hub for innovation and business. Tampere (13.8%), Turku (7.2%), and Oulu (5%) follow, each combining a strong academic presence with robust industrial ecosystems.

All cities receiving over 2% of total funding are among Finland's 20 largest by population, primarily university cities. This reflects the importance of academic infrastructure and urban scale in attracting innovation investment. One partial exception is Porvoo, which lacks a university but likely benefits from prominent industrial actors like Neste.

The location of corporate headquarters and industrial clusters further shapes the geographical distribution of funding. Cities like Helsinki, Tampere, and Turku have the largest firms, reinforcing their status as innovation hotspots. In contrast, some larger cities without significant corporate anchors receive comparatively little funding, despite having a sizable population or university presence. This pattern raises questions about regional balance and the extent to which public innovation funding supports the development of more diverse and geographically inclusive innovation ecosystems.

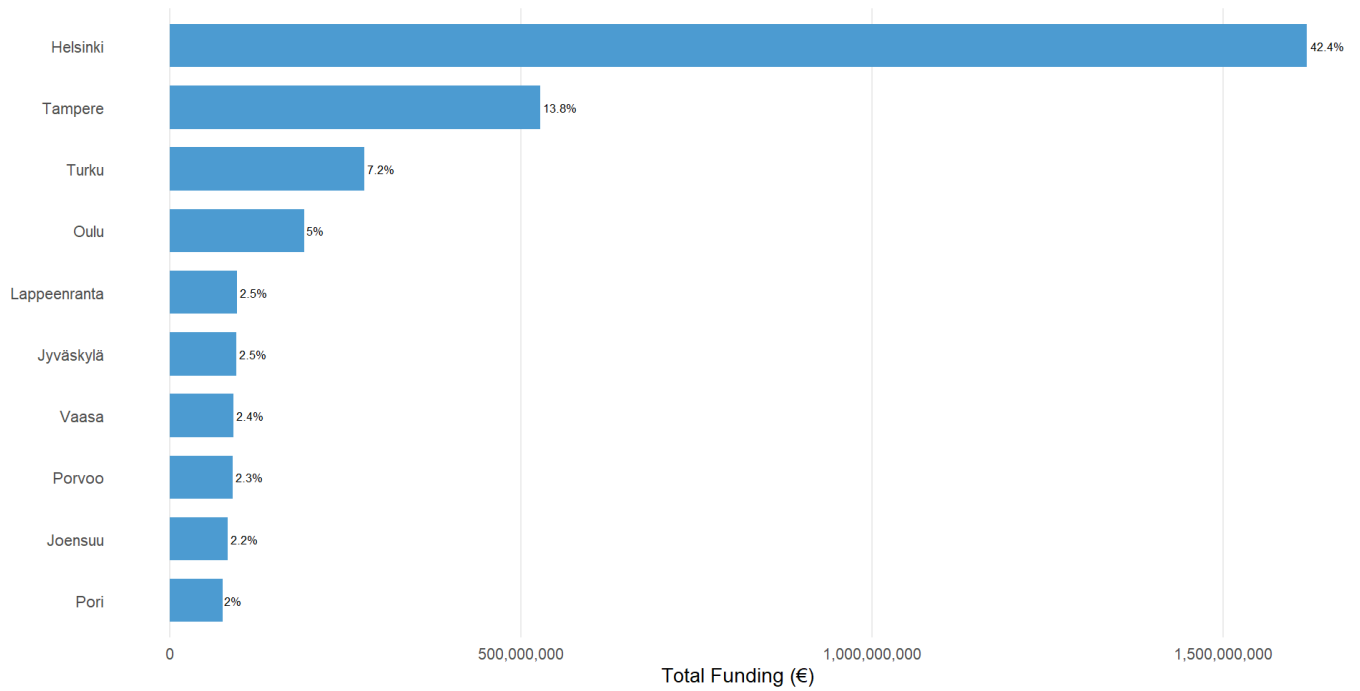


Figure 14: Share of Total Funding (€) Across the Top 10 Finnish Cities

However, it is important to note that Business Finland is not Finland's only public body funding innovation activities. In particular, the Centres for Economic Development, Transport and the Environment (ELY Centres) provide funding and advisory services mainly targeted at small and medium-sized enterprises (SMEs). This division of institutional responsibility may partly explain the low share of SME-targeted climate funding in Business Finland's data and the observed concentration of funding in large companies located in major urban centers.

6 Conclusions

This study examined how Business Finland's innovation funding has supported the green transition in Finland between 2000 and 2025. The analysis focused on funded projects' volume, structure, and thematic orientation, using a validated keyword-based methodology grounded in climate and sustainability discourses.

The findings show that climate-related themes have become increasingly central to Business Finland's funding portfolio, particularly after 2019. From that point onward, the number of green transition-related projects and their share of total funding increased markedly, reaching over 75% by 2022–2024. This shift has occurred alongside important advancements in climate policy, including the Climate Act and Finland's carbon neutrality goal by 2035.

However, whether this change signifies a consistent, long-term strategic direction remains uncertain. Notably, the proportion of projects linked to Business Finland's programs has not significantly increased. This suggests that the growth in climate-related funding may reflect top-down guidance and bottom-up responses by firms adapting to evolving market conditions and societal pressures. In this sense, the findings support Schot and Steinmueller's (2018) view of governments as facilitators of innovation ecosystems.

The analysis shows imbalances in how green transition funding is distributed. Large firms dominate the number of projects and total funding. Micro firms are active, but the amounts they receive remain small. Medium-sized firms, which often have strong growth potential, are particularly overlooked. This raises questions about how well current funding instruments serve different types of innovation actors and whether they leave out important contributors.

When looking at sectors, the green transition reaches across a broad range of industries. Most of the funding has gone to scientific research and development, which indicates that public support is still directed mainly toward early-phase projects led by research organizations. Other notable sectors include software, electronics, and manufacturing, where firms are developing likely technologies that respond to climate-related challenges. The instrument-level breakdown shows that traditional R&D projects and so-called EVET initiatives, research projects conducted by research organizations in collaboration with industry, account for most of the funding volume. At the same time, *de minimis* instruments serve as accessible entry points for smaller firms despite their limited financial scale.

Some newer funding instruments, like the Circular Economy Grant and support for shipbuilding innovation, show that policy priorities are shifting. At the same time, their use also points to a bigger issue: short-term tools can create quick momentum but rarely lead to lasting change unless they are part of a broader, long-term strategy. By contrast, the shipbuilding support instrument exemplifies a more sustained and sector-specific approach to mission-oriented funding.

Geographically, funding remains heavily concentrated in key urban centers, especially Helsinki, which accounts for over 40% of green transition funding. This spatial centralization raises questions about regional equity and the diffusion of innovation capacity beyond metropolitan areas.

Methodologically, the study employed a multi-layered validation process to identify climate-related projects from a large administrative dataset. The analysis relied on aggregated information because project-level funding data was unavailable before 2016, and confidentiality rules limited access to project details. Even so, the method appears to capture broader funding patterns, and occasional misclassifications are reliably unlikely to affect the overall results meaningfully.

Business Finland has moved toward a more mission-oriented innovation policy; however, significant structural and strategic challenges remain. Alignment with climate objectives is evident in funding priorities but less in programmatic coordination, regional inclusiveness, and support for early-stage or medium-sized innovation actors. Part of this urban concentration may also reflect that regional ELY Centres primarily serve SMEs and are not included in Business Finland's funding data.

While this study offers a comprehensive view of aggregate funding patterns, future research should examine whether the funded projects have genuinely advanced the goals of the green transition. A more detailed analysis of project content and implementation would help assess the extent to which supported initiatives contribute to systemic sustainability objectives or whether environmental themes function primarily as rhetorical framing.

Such an inquiry would allow researchers to evaluate the authenticity and depth of climate alignment at the project level and distinguish between transformative innovation and instances of greenwashing. For example, do projects meaningfully address emissions reductions, resource efficiency, and climate resilience, or are sustainability references merely superficial?

Finally, the findings invite reflection on the relationship between innovation funding, green transition goals, and productivity development in Finland. Although substantial investments have been directed toward climate-related R&D, much of this funding targets early-stage research rather

than commercially scalable innovation. These results might clarify the reasons behind Finland's slow productivity growth. Since much of the funding is directed toward early-stage research, it is unlikely that the economic benefits will appear right away. Future studies could explore whether and under what conditions mission-driven innovation policies, especially those focused on sustainability, eventually lead to improvements in productivity. Understanding this link better is key to shaping an innovation policy that balances environmental goals with long-term economic performance.

In addition, further study could be conducted:

- how collaboration across actors (e.g., firms and research organizations) supports ecosystem-level development and
- whether Business Finland's instruments differ in their effectiveness at promoting radical versus incremental innovation.

Finally, combining administrative funding data with project outcomes, performance metrics, and environmental indicators could clarify how well Finland's public innovation funding translates into real-world progress on climate and sustainability goals. While Business Finland has conducted evaluations focusing on individual instruments and specific programs, broader assessments of funding impact at the thematic level have not been prioritized. Such cross-cutting evaluations could reveal whether public RDI investments contribute to cumulative, systemic change or remain fragmented across isolated initiatives.

References

- Abdelfattah, F. – Salah, M. – Dahleez, K. – Darwazeh, R. – & Halbasi, H. A. (2025). Public policy and sustainability: How green core competence, government trust, and policy satisfaction influence green R&D investments in the private sector—sustainable *Futures*, Vol.9, 100461-
- Aghion, Philippe – Bergeaud, Antonin – Boppart, Timo – Klenow, Peter J. – Li, Huiyu (2019) A Theory of Falling Growth and Rising Rents. *The Review of Economic Studies*, Vol. 90 (6), p. 2675-2702.
- Aghion, Philippe – Blundell, Richard – Griffith, Rachel – Howitt, Peter – Prantl, Susanne (2009) The entry effects on incumbent innovation and productivity. *The Review of Economics and Statistics*, Vol. 91 (1), p. 20-32.
- Aghion, Philippe – Dechezleprêtre, Antoine – Hémous, David – Martin, Ralf – Van Reenen, John (2016) Carbon Taxes, Path Dependency, and Directed Technical Change: Evidence from the Auto Industry. *The Journal of Political Economy*, Vol. 124 (1), p. 1-51.
- Aghion, Philippe – Howitt, Peter (1992) A Model of Growth Through Creative Destruction. *Econometrica*, Vol. 60 (2), p. 323-351.
- Aghion, Philippe. – Howitt, Peter (2023) The Creative Destruction Approach to Growth Economics. *European Review*, Vol. 31 (4), p. 312–325.
- Akcigit, Ufuk – Ates, Tina S. (2021) Ten Facts on Declining Business Dynamism and Lessons from Endogenous Growth Theory. *American Economic Journal. Macroeconomics*, Vol. 13 (1) p. 257-298.
- Akcigit, Ufuk – Baslandze, Salomé – Lotti, Francesca (2023) Connecting to Power: Political Connections, Innovation, and Firm Dynamics. *Econometrica*, Vol. 91 (2), p. 529-564.
- Akcigit, Ufuk – Kerr, William R (2018) Growth through Heterogeneous Innovations. *The Journal of Political Economy*, Vol. 126 (4), p.1374-1443.
- Autor, David – Dorn, David – Katz, Lawrence F. – Patterson, Christina – Reenen, John Van (2020) The fall of labor share and the rise of superstar firms. *The Quarterly Journal of Economics*, Vol. 135 (2), p. 645-709.
- Bambi, Prince Dorian R. – Pea-Assounga, Jean B. B. (2025) Unraveling the interplay of research investment, educational attainment, human capital development, and economic advancement in technological innovation: A panel VAR approach. *Education and information technologies*, Vol.30 (3), p.3309-3341
- Becker, Bettina (2015) Public R&D policies and private R&D investment: a survey of the empirical evidence. *Journal of economic surveys*, Vol.29 (5), p. 917-942.

- Blundell, Richard – Griffith, Rachel – Van Reenen, John (1995) Dynamic Count Data Models of Technological Innovation. *The Economic Journal (London)*, Vol. 105 (429), p. 333-344.
- Blundell, Richard – Griffith, Rachel – Van Reenen, John (1999) Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms. *The Review of Economic Studies*, Vol. 66 (3), p. 529-554.
- Bloch, C., Sørensen, M. P., Graversen, E. K., et al. (2014) Developing a methodology to assess the impact of research grant funding: A mixed methods approach. *Evaluation and Program Planning*, 43, 105–117.
- Bower, Joseph L. – Christensen, Clayton M (1995) Disruptive Technologies: Catching the Wave. *Harvard Business Review*, Vol. 73 (1), p. 43–53.
- Braga, J. P., & Ernst, E. (2023). Financing the green transition: The role of macro-economic policies in ensuring a just transition. *Frontiers in Climate*, 5, Article 1192706.
- Business Finland (n.d.) *Rahoitustiedot*. <https://www.businessfinland.fi/suomalaisille-asiakkaille/tietoa-meista/rahoitustiedot> Accessed on March 19, 2025.
- Business Finland (n.d. -a). *Funding for research and development*. Retrieved from <https://www.businessfinland.fi/en/for-finnish-customers/services/funding/research-and-development> Accessed on May 19, 2025.
- Business Finland (n.d. -b). *Sustainable Growth Program for Finland*. Retrieved from <https://www.businessfinland.fi/en/for-finnish-customers/services/programs/sustainable-growth-program-for-finland> Accessed on May 19, 2025.
- Business Finland (n.d. -c) *Mitä ohjelmat ovat?* Retrieved from <https://www.businessfinland.fi/suomalaisille-asiakkaille/palvelut/ohjelmat> Accessed on June 1, 2025.
- Business Finland (2024) *Business Finlandin pääomasijoitustoiminta integroituu osaksi Tesia*. <https://www.businessfinland.fi/ajankohtaista/uutiset/2024/business-finland-venture-capital-integroituu-osaksi-tesia>. Accessed on March 3, 2025.
- Business Finland (2024a) *Budjettiriihi-päätöksiä: T&K-rahoituksen myöntövaltuus kasvaa*. <https://www.businessfinland.fi/ajankohtaista/uutiset/tiedotteet/2024/budjettiriihi-paatoksia-tk-rahoituksen-myontovaltuus-kasvaa> Accessed on March 20, 2025.
- Business Finland (2024b) *Evaluation of Business Finland's ecosystem financing instruments and partnership model*. Business Finland. <https://www.businessfinland.fi/globalassets/finnish-customers/tutkimus-ja-kehitys/vaikuttavuus/vaikuttavuusraportit/evaluation-ecosystem-financing-2024.pdf>

- Business Finland (2023) *Innovaatioista kilpailukykyä ja kestävää kasvua – Vaikuttavuusraportti 2023*. Business Finland.
<https://www.businessfinland.fi/globalassets/julkaisut/vaikuttavuusraportit/vaikuttavuusraportti-2023.pdf>
- Business Finland (2022) *Business Finland and sustainable growth programme for Finland – Design Evaluation*. Business Finland.
<https://www.businessfinland.fi/4ae76d/globalassets/julkaisut/business-finland-and-sustainable-growth-designevaluation.pdf>
- Busom, I. (2000). An Empirical Evaluation of The Effects of R&D Subsidies. *Economics of Innovation and New Technology*, Vol . 9 (2), 111–148.
- Cass, David (1965) Optimum Growth in an Aggregative Model of Capital Accumulation. *The Review of Economic Studies*, Vol 32 (3), p. 233–240.
- Chesbrough, HW (2003) The era of open innovation. *MIT Sloan management review*, Vol.44 (3), p.35-41
- Chesbrough, HW (2003a) *The open innovation: The New Imperative for Creating and Profiting from Technology*. Boston, MA: Harvard Business School Press.
- Christensen, Clayton (1997) *The innovator’s dilemma: When new technologies cause great firms to fail*. Boston, MA: Harvard Business School Press.
- Commerçon, Francis A. – Goldberg, Matthew H. – Lacroix, Karine – Carman, Jennifer P. – Rosenthal, Seth A. – Leiserowitz, Anthony (2023) Evaluating the Terms Americans Use to Refer to “Carbon Emissions”.
- Danneels, Erwin (2004) Disruptive Technology Reconsidered: A critique and Research Agenda. *The journal of product innovation management*, Vol 21 (4), p. 246-258.
- Delios, A., Clemente, E. G., Wu, T., et al. (2022). Examining the generalizability of research findings from archival data. *PNAS*, 119(30), e2120377119.
- Dewar, Robert D. – Dutton, Jane E. (1986) The Adoption of Radical and Incremental Innovations: An Empirical Analysis. *Management Science*, Vol 32 (11), p. 1422-1433.
- Dimos, C., Pugh, G., Hisarciklilar, M., Talam, E., & Jackson, I. (2022). The relative effectiveness of R&D tax credits and R&D subsidies: A comparative meta-regression analysis. *Technovation*, 115, 102450-
- Eckert, Eva – Kovalevska, Oleksandra (2021) Sustainability in the European Union: Analyzing the Discourse of the European Green Deal. *Journal of Risk and Financial Management*, Vol. 14 (2), p. 1-22, Article 80.

- Finnish Government (2025) *Final report of the Room for Growth project – Summary*. Room for Growth Working Group.
- Freeman, C. (1987). *Technology policy and economic performance: Lessons from Japan*. Pinter Publishers.
- Foray, D. – Mowery, D. C. – Nelson, R. R. (2012) Public R&D and social challenges: What lessons from mission R&D programs? *Research policy*, Vol.41 (10), p. 1697-1702.
- Ge, Ran – Xia, Yu – Ge, Liquan – Li, Fei (2025) Knowledge graph analysis in climate action. *Sustainability*, Vol. 17 (1).
- Georgiadis, N., Iliopoulou, D., Manthou, V., & Koutsouris, D. (2012). Qualitative and quantitative methodological approach for evaluating public R&D funding. *International Journal of Management Science and Information Technology*, (6), 1–27.
- Glavič, Peter – Lukman, Rebeka (2007) Review of sustainability terms and their definitions. *Journal of cleaner production*, Vol.15 (18), p.1875-1885
- Gjesdal, Anje M. – Andersen, Gisle (2023) Changing concepts of greenhouse gas expressions: Discursive specialization in parliamentary discourses on climate change.
- Goeschl, Timo – Perino, Grischa (2017) The Climate Policy Hold-Up: Green Technologies, Intellectual Property Rights, and the Abatement Incentives of International Agreements. *The Scandinavian journal of economics*, Vol.119 (3), p.709-732.
- Grundmann, R. – Krihsnamurthy, R. (2010) The Discourse of Climate Change: A Corpus-Based Approach. *Critical Approaches to Discourse Analysis Across Disciplines*, Vol. 4 (2), 125–146.
- Guardian (2024) *OP29 jargon buster: Key terms for this year’s climate conference in Azerbaijan*. Retrieved March 14, 2025 from <https://www.theguardian.com/environment/2024/nov/11/cop29-jargon-buster-key-terms-for-this-years-climate-conference-in-azerbaijan>.
- Halme, Kimmo – Salminen, Vesa – Kettinen, Juha – Lahtinen, Henri – Smolander, Arto – Ljungman, Jan – Holmberg, Daniel – Vingre Anete – Beckers, Dominik – Khalaf, Gabriel (2021) *Business Finlandin arviointi: Innovaatioita, kasvua ja kansainvälistymistä*. Työ- ja elinkeinoministeriö.
- Halme, Kimmo – Kotiranta, Annu – Pajarinen, Mika – Piirainen, Kalle A. – Rouvinen, Petri – Salminen, Vesa – Ylhäinen, Ilkka (2018) *Efforts of Finnvera, Finpro and Tekes in Promoting Internationally Oriented SMEs: Impact Study*, Business Finland Report 3/2018.

- Hogan, Teresa – Humphery-Jenner, Mark – Huong, Tran T.L. – Powell, Ronan (2022) Market dominance, R&D grant funding, and innovation outcomes. *R&D management*, Vol. 52 (4), p. 768-796.
- Hottenrott, Hanna – Lopes-Bento, Cindy (2014) (International) R&D collaboration and SMEs: The effectiveness of targeted public R&D support schemes. *Research policy*, Vol.43 (6), p. 1055-1066.
- Howell, Sabrina T. (2017) Financing Innovation: Evidence from R&D Grants. *The American economic review*, Vol.107 (4), p. 1136-1164.
- Intergovernmental Panel on Climate Change (2023) *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. IPCC. <https://doi.org/10.59327/IPCC/AR6-9789291691647.002>
- Intergovernmental Panel on Climate Change (2023a) *Annex I: Glossary & Annex II: Acronyms, Chemical Symbols and Scientific Units*. In *Climate Change 2023: Synthesis Report*. IPCC. <https://doi.org/10.59327/IPCC/AR6-9789291691647.003>
- Iversen, E., Raknerud, A., Klemetsen, M., & Bye, B. (2025). Innovation outcomes of public R&D support: A new approach to identifying output additionality. *Discussion Papers*.
- Johnstone, Phil – Rogge, Karoline S. – Kivimaa, Paula – Fratini, Chiara F. – Primmer, Eeva – Stirling, Andy (2020) Waves of disruption in clean energy transitions: Sociotechnical dimensions of system disruption in Germany and the United Kingdom. *Energy research & social science*, Vol.50.
- Kattel, Rainer – Mazzucato, Mariana (2018) Mission-oriented innovation policy and dynamic capabilities in the public sector. *Industrial and corporate change*, Vol.27 (5), p. 787-801.
- Khojasteh, Danial – Haghani, Milad – Shamsipour, Abbas – Zwack, Clara C. – Glamore, William – Nicholls, Robert J. – England, Matthew H. (2024) Climate change science is evolving toward adaptation and mitigation solutions. *Wiley Interdisciplinary Reviews. Climate Change*, 15(4), e884-n/a.
- Kim, Yoomi (2021) Technological Innovation, the Kyoto Protocol, and Open Innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, Vol.7 (3), p. 1-17, 198.
- Koljonen, Tiina – Soimakalio, Sampo – Asikainen, Antti – Lanki, Timo – Anttila, Perttu – Hildén, Mikael – Honkatukia, Juha – Karvosenoja, Niko – Lehtilä, Antti – Lehtonen, Heikki – Lindroos, Tomi J. – Regina, Kristiina – Salminen, Olli – Savolahti, Mikko – Siljander, Riikka – Tiittanen, Pekka (2017) Energia- ja ilmastostrategian vaikutusarviot: Yhteenvetoraportti. *Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja*, 21/2017.

- Kukkonen, Anna – Ylä-Anttila, Tuomas (2020) The Science–Policy Interface as a Discourse Network: Finland’s Climate Change Policy 2002–2015. *Politics and Governance*, Vol. 8 (2), p. 200–214
- Kuosmanen, T. (Toim.) (2022) Misallocation of labor and capital in Finland, Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 2022:44. <https://urn.fi/URN:ISBN:978-952-383-212-1>
- König, Michael D. – Liu, Xiaodong – Zenou, Yves (2019) R&D networks: theory, empirics, and policy implications. *The review of economics and statistics*, Vol. 101 (3), p. 476–491.
- Larrue, Philippe (2021) The design and implementation of mission-oriented innovation policies: A new systemic policy approach to address societal challenges. *IDEAS Working Paper Series from RePEc*, (100). <https://doi.org/10.1787/3f6c76a4-en>
- Leipold, Sina – Feindt, Peter H. – Winkel, Georg – Keller, Reiner (2019) Discourse analysis of environmental policy revisited: traditions, trends, perspectives. *Journal of the Environmental policy & planning*, Vol. 21 (5), p. 445-463.
- Lepore, Jill (2014) The disruption machine. *The New Yorker*, 90, 30–36.
- Leung, T. Y. – Sharma, Piyush (2021) Differences in the impact of R&D intensity and R&D internationalization on firm performance – Mediating role of innovation performance. *Journal of business research*, Vol.131, p. 81–91.
- Lim, W. M. (2024). What is quantitative research? An overview and guidelines. *Australasian Marketing Journal*, 33(2), 199–229.
- Lovio, Raimio (2009) Näkökulmia innovaatio toiminnan ja -politiikan muutokseen 2000-luvulla. helsingin Kauppakorkeakoulu, Working paper W-466.
- Luoma, P., Larvus, L., Hjelt, M., Vanhanen, J., Päällysaho, M., Heikinheimo, E., Kara, M., Simola, K., & Harder, S. (2017). *Innovation for sustainable growth: Evaluation of the results and impacts of selected Tekes cleantech programmes (Tekes Report 1/2017)*. Tekes – the Finnish Funding Agency for Innovation.
- Mahoney, J., & Goertz, G. (2006). A tale of two cultures: Contrasting quantitative and qualitative research. *Political Analysis*, 14(3), 227–249.
- Marino, Marianna – Lhuillery, Stephane – Parrotta, Pierpaolo – Sala, Davide (2016) Additionality or crowding-out? An overall evaluation of public R&D subsidy on private R&D expenditure. *Research Policy*, Vol. 45 (9), p. 1715-1730.
- Markides, Constantinos (2006) Disruptive Innovation: In Need of Better Theory. *The Journal of product innovation management*, Vol.23 (1), p. 19-25.

- Marques, Carla – Monteiro-Barata Jose (2006) Determinants of the Innovation Process: An Empirical Test for the Portuguese Manufacturing Industry. *Management research*, Vol. 4 (2), p.113-126
- Martin, Stephen – Scott, John T. (2000) The nature of innovation market failure and the design of public support for private innovation. *Research policy*, Vol. 29 (4), p. 437-447.
- Mazzucato, Mariana (2018) Mission-oriented innovation policies: challenges and opportunities. *Industrial and Corporate Change*, Vol.27 (5), p. 803–815.
- Mazzucato, M. – Semieniuk, G. (2017) Public financing of innovation: new questions. *Oxford Review of Economic Policy*, Vol.33, 24-48.
- McDowall, Will (2018) Disruptive innovation and energy transitions: Is Christensen’s theory helpful? *Energy research & social science*, Vol.37, p.243-246
- Ministry of Finance (2023) *Working group on financing the green transition: Final report* (Publications of the Finnish Government 2023:5). Finnish Government.
<https://urn.fi/URN:ISBN:978-952-383-847-5>
- Moore, Brendan – Verfuert, Caroline – Minas, Angela Mae – Tipping, Christianne – Mander, Sarah – Lorenzoni, Irene – Hoolohan, Claire – Jordan, Andrew J. – Whitmarsh, Lorraine (2021) Transformations for climate change mitigation: A systematic review of terminology, concepts, and characteristics. Wiley interdisciplinary reviews. *Climate change*, Vol.12 (6), p.e738-n/a
- MOT Kielipalvelu (n.d.) *MOT Kielipalvelu*. Sanakirja.fi. <https://www.sanakirja.fi/>
- Nelson, Richard R. – Rosenberg, Nathan (1993) Technical Innovation and National Systems. In: *National Innovation Systems: A Comparative Analysis*, ed. by Richard R. Nelson, p. 3–21.
- OECD (2024) *OECD Main Science and Technology Indicators: Highlights from the March 2024 edition*.
- OECD (2023) *OECD R&D Tax Incentives Database, 2022 edition*.
 DSTI/STP/NESTI(2023)2/FINAL. Available at: <https://www.oecd.org/sti/rd-tax-stats-bindex-notes.pdf>
- OECD/Eurostat (2018) *Oslo Manual: Guidelines for Collecting, Reporting and Using Data on Innovation, 4th Edition*, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris, <https://doi.org/10.1787/9789264304604-en>.
- OECD (2017), *OECD Reviews of Innovation Policy: Finland 2017*, OECD Publishing, Paris.
<http://dx.doi.org/10.1787/9789264276369-en>

- Papanastassiou, Marina – Pearce, Robert – Zanfei, Antonello (2020) Changing perspectives on the internationalization of R&D and innovation by multinational enterprises: A review of the literature. *Journal of international business studies*, Vol. 51 (4), p. 623-664.
- Prins, Gwyn – Galiana, Isabel – Green, Christopher – Grundmann, Reiner – Korhola, Atte – Laird, Frank – Nordhaus, Ted – Pielke Jnr, Roger – Rayner, Steve – Sarewitz, Daniel – Shellenberger, Michael – Stehr, Nico – Tezuko, Hiroyuki (2010) *The Hartwell Paper: A new direction for climate policy after the crash of 2009*. London School of Economics & Oxford Institute for Science, Innovation & Society.
- Pyo, J., Lee, W., Choi, E. Y., et al. (2023). Qualitative research in healthcare: Necessity and characteristics. *Journal of Preventive Medicine and Public Health*, 56(1), 12–20.
- Ramsey, F. P. (1928) A Mathematical Theory of Saving. *The Economic Journal*, Vol. 38 (152), p. 543–559.
- Resutek, Robert J. (2022) Is R&D Really That Special? A Fixed-Cost Explanation for the Empirical Patterns of R&D Firms. *Contemporary accounting research*, Vol.39 (1), p. 721-749
- Roberts, Edward B. (1988). What We've Learned: Managing Invention and Innovation. *Research technology management*, Vol. 31 (1), p. 11–29.
- Scarse, Ivan I. – Ockwell, David G. (2010) The role of discourse and linguistic framing effects in sustaining high carbon energy policy—An accessible introduction. *Energy Policy*, Vol.38 (5), p. 2225–2233.
- Schmidt, Tobias – Rammer, Christian (2007) Non-technological and technological innovation: Strange Bedfellows? *ZEW, Centre for European Economic Research*, Discussion Paper No. 07-052.
- Schot, Johan – Steinmueller, W. Edward (2018), Three Frames for Innovation Policy: R&D, Systems of Innovation and Transformative Change. *Research Policy* 47(9), 1554–1567
- Schumpeter, Joseph A. (1942) *Capitalism, Socialism and Democracy*. Harper & Brothers.
- Solow, Robert (1956) A contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, Vol 70, p. 65–94.
- Stecula, Dominik A. – Merkley, Eric (2019) Framing Climate Change: Economics, Ideology, and Uncertainty in American News Media Content from 1988 to 2014. *Frontiers in communication*, Vol.4, Article 6.
- Suomen Akatemia (2024) Tieteen tila -tilastot 2024: Tutkimuksen rahoitus, henkilöstö ja julkaisutoiminta.
- Suomen Yrittäjät – Finnvera Oyj – Työ- ja elinkeinoministeriö (2024) *Pk-yritysbarometri – syksy 2024*. Suomen Yrittäjät.

- Swan, Trevor W. (1956) Economic Growth and Capital Accumulation. *Economic Record*, Vol 32 (2), p. 334–361.
- Takalo, Tuomas – Tanayama, Tanja – Toivanen, Otto (2013) Market failures and the additionality effects of public support to private R&D: Theory and empirical implications. *International Journal of Industrial Organization*, Vol.31, p. 634-642.
- Takalo, Tuomas – Tanayama, Tanja – Toivanen, Otto (2013a) Estimating benefits of targeted R&D subsidies. *The review of economics and statistics*, Vol. 95 (1), p. 255-272.
- Team Finland (2025) <https://www.team-finland.fi/> Accessed on March 3, 2025.
- Team Finland (2019) Team Finland -verkosto. Strategia 2019. https://www.team-finland.fi/4aaf24/siteassets/team-finland-subsite/documentation/team_finland_strategia_2019.pdf
- Tellis, Gerard J. (2006) Disruptive Technology or Visionary Leadership? *The journal of product innovation management*, Vol.23 (1), p. 34-38).
- Tilastokeskus (2023) *Tutkimus- ja kehittämistoiminnan menot* [Online publication]. <https://stat.fi/julkaisu/clmyhpabwjb5h0aunugh0htp5> Retrieved February 21, 2025.
- Tiede ja tutkimus (n.d.) *Research and innovation system*. Retrieved March 5, 2025, from <https://tiedejatutkimus.fi/fi/science-innovation-policy/research-innovation-system>
- Utterback, James M. – Abernathy, William J. (1975) A dynamic model of process and product innovation. *Omega (Oxford)*, Vol. 3 (6), p. 639–656.
- Valtiovarainministeriö (2024) *Suomen keskipitkän aikavälin suunnitelma 2025–2028: Kansallinen keskipitkän aikavälin finanssipoliittis-rakenteellinen suunnitelma*. Valtiovarainministeriön julkaisuja 2024:54. <https://urn.fi/URN:ISBN:978-952-367-864-4>
- Valtiovarainministeriö (2024) Tuottavuuden kasvu uudessa ympäristössä - Miten vihreä siirtymä ja geopolitiikka vaikuttavat tuottavuuteen?, Valtiovarainministeriön julkaisuja 2024:47. <https://urn.fi/URN:ISBN:978-952-367-836-1>
- Valtiovarainministeriö (n.d.) Kestävä kasvu. From <https://vm.fi/kestava-kasvu> Accessed on March 20, 2025.
- Valtiovarainministeriö (2022) Uudistuva ja kestävä Suomi: Valtiovarainministeriön virkamiespuheenvuoro 2022 (Valtiovarainministeriön julkaisuja 2022:77). <http://urn.fi/URN:ISBN:978-952-367-205-5>
- Vela Almeida, Diana – Kolinjivadi, Vijay – Ferrando, Tomaso – Roy, Brototi – Herrera, Héctor – Vecchione Gonçalves, Marcela – Van Hecken, Gert (2023) The “Greening” of Empire: The European Green Deal as the EU first agenda. *Political geography*, Vol.105, Article 102925.

- Weeks, Michael R. (2015) Is disruption theory wearing new clothes or just naked? Analyzing recent critiques of disruptive innovation theory. *Innovation*, Vol. 17 (4), 417-428.
- Wickham, H., & Grolemund, G. (2017). *R for Data Science: Import, tidy, transform, visualize, and model data*. O'Reilly Media. <https://r4ds.had.co.nz/strings.html>
- Wu, Jinsong – Strezov, Vladimir (2023) Green Technologies and sustainability: A new trend. *Green Technologies and Sustainability*, Vol.1 (1), p.100008, Article 100008.
- Xie, Xuemei – Huo, Jiage – Zou, Hailiang (2019) Green process innovation, green product innovation, and corporate financial performance: A content analysis method. *Journal of Business Research*, Vol. 101, p. 697-706.

Appendices

Appendix 1: Keyword List Based on Academic Papers and IPCC Reports

	Keyword EN	Keyword FI	Source(s)
1	afforest(ation)	metsittää, metsittäminen, metsänistutus	IPCC (2023a)
3	biodiversity	biodiversiteetti, luonnon monimuotoisuus	Eckert & Kovalevska (2021); Leipold et al. (2019); IPCC (2023a)
4	bioeconomy	biotalous	Leipold et al. (2019)
5	bioenergy	bioenergia	IPCC (2023a)
6	biofuel	biopolttoaine	Wu & Strezov (2023)
7	biomass	biomassa	Wu & Strezov (2023)
8	blue infrastructure	-	IPCC (2023a)
9	carbon	hiili, hiilen	Gjesdal & Andersen (2023); Ge et al. (2025); Scrase & Ockwell (2010); Commerçon et al. (2023); Khojasteh et al. (2024); Wu & Strezov (2023); IPCC (2024a)
10	circular economy	kiertotalous	Eckert & Kovalevska (2021); Leipold et al. (2019)
11	clean energy, (MOT: clean power)	puhdas energia	Eckert & Kovalevska (2021)
12	clean tech(nology)	puhdas teknologia	Eckert & Kovalevska (2021)
13	clean(er) production		Glavič & Lukman (2007)
14	climate	ilmasto	Eckert & Kovalevska (2021); Gjesdal & Andersen (2023); Ge et al. (2025); Stecula & Merkley (2019); Grundmann & Krishnamurthy (2010); Leipold et al. (2019); Scrase & Ockwell (2010); Commerçon et al. (2023); Khojasteh et al. (2024); IPCC (2024a)
15	CH4	-	IPCC (2023a); Khojasteh et al. (2024)
16	CO2	-	Gjesdal & Andersen (2023); IPCC (2023a)
17	de/reforestation	metsäkato / metsien hävittäminen / metsien tuhoutuminen / uudelleenmetsitys / metsitys /	IPCC (2023a)

		metsittäminen / metsänistutus	
18	decarbonization	hiilen poistaminen	Khojasteh et al. (2024); IPCC (2024a)
19	eco-efficiency	ekotehokkuus	Glavič & Lukman (2007)
20	eco-friendly	ympäristöystävällinen, ympäristöä säästävä	Wu & Strezov (2023)
21	ecodesign	ekologinen suunnittelu, ekomuotoilu	Glavič & Lukman (2007)
22	ecology/ecological	ekologia / ekologinen, ympäristönsuojelu	Eckert & Kovalevska (2021); Leipold et al. (2019); IPCC (2023a)
23	electric vehicle	sähköajoneuvo, sähköauto	Wu & Strezov (2023)
24	emission(s)	(saaste)päästö(t)	Eckert & Kovalevska (2021); Ge et al. (2025); Commerçon et al. (2023); IPCC (2023a)
25	energy efficiency	energiätehokkuus, energian hyötysuhde	Scrase & Ockwell (2010); Wu & Strezov (2023)
26	energy storage	energian varastointi	Wu & Strezov (2023)
27	energy-efficient	energiätehokas, energiaa säästävä, energiataloudellinen	Wu & Strezov (2023)
28	environment(al/ally)	luonnonsuojelu, ympäristöystävällinen, ympäristönsuojelu	Eckert & Kovalevska (2021); Glavič & Lukman (2007); Leipold et al. (2019); Scrase & Ockwell (2010); Wu & Strezov (2023)
29	food loss	ruokahävikki	IPCC (2023a)
30	food security	ruokaturva, ruokahuollon toimivuus	Khojasteh et al. (2024); IPCC (2023a)
31	food waste	ruokahävikki, hävikkiruoka, elintarvikejäte	IPCC (2023a)
32	fossil fuel	fossiilinen polttoaine	Scrase & Ockwell (2010)
33	GHG	-	IPCC (2023a)
34	global warming	maapallon ilmaston lämpeneminen, globaali lämpeneminen, maapallon lämpeneminen	Grundmann & Krishnamurthy (2010); Khojasteh et al. (2024); IPCC (2023a)
35	green (/greenhouse ...)	vihreä / kasvihuone-	Eckert & Kovalevska (2021); Gjesdal & Andersen (2023); Ge et al. (2025); Grundmann & Krishnamurthy (2010);

			Scrase & Ockwell (2010); Commerçon et al. (2023); Khojasteh et al. (2024); Wu & Strezov (2023); IPCC (2024a)
36	hydrogen-powered vehicle	vetyajoneuvo, vetykäyttöinen	Wu & Strezov (2023)
37	hydro power	vesivoima	Wu & Strezov (2023)
38	IPCC	-	Glavič & Lukman (2007)
39	just transition	-	Eckert & Kovalevska (2021); IPCC (2023a)
40	Kyoto Protocol	Kiotoon pöytäkirja	Khojasteh et al. (2024)
41	life cycle assessment	elinkaariarviointi, ekotasetutkimus	Glavič & Lukman (2007); Khojasteh et al. (2024); Wu & Strezov (2023)
42	low-carbon	vähähiilinen, vähähiilisyys	Gjesdal & Andersen (2023); Scrase & Ockwell (2010)
43	net zero	ilmastoneutraali, hiilineutraali	IPCC (2023a)
44	methane	metaani	IPCC (2023a); Khojasteh et al. (2024)
45	planetary health	-	IPCC (2023a)
46	pollution	saastuminen, saastutus, saaste	Glavič & Lukman (2007); Commerçon et al. (2023); Wu & Strezov (2023)
47	recover(y/ing) material, materials recovery	materiaalien talteenotto, uusiokäyttö	Eckert & Kovalevska (2021); Glavič & Lukman (2007)
48	recycling	kierrätys, kierrättäminen, uudelleen käyttö, hyötykäyttö, jätteiden hyväksikäyttö, jätteiden hyödyntäminen, kiertoon palautus, talteenotto	Eckert & Kovalevska (2021); Glavič & Lukman (2007); Wu & Strezov (2023)
49	renewable energy	uusiutuva energia, ekoenergia, uudistuva energianlähde	Ge et al. (2025); Stecula & Merkle (2019); Leipold et al. (2019); Scrase & Ockwell (2010); Wu & Strezov (2023)
50	renewable resources	uusiutuvat luonnonvarat, uudistuvat luonnonvarat	Glavič & Lukman (2007)
51	resource depletion	-	Wu & Strezov (2023)
52	resource efficiency	luonnonvarojen käytön tehokkuus, resurssitehokkuus	Wu & Strezov (2023)

53	reuse, re-use	käyttää uudelleen, kierrättää, uusiokäyttö, uudelleenkäyttö, kierrätys	Eckert & Kovalevska (2021); Glavič & Lukman (2007); Wu & Strezov (2023)
54	SDG	-	Wu & Strezov (2023); IPCC (2024a)
55	smart grid	älykäs sähköverkko, älykäs verkko	Wu & Strezov (2023)
56	solar power	aurinkoenergia	Wu & Strezov (2023)
57	sustainab(le/ly/ility)	kestävä, ympäristöä säästävä, kestävyys, ekologisuus	Eckert & Kovalevska (2021); Ge et al. (2025); Glavič & Lukman (2007); Leipold et al. (2019); Scrase & Ockwell (2010); Khojasteh et al. (2024); Wu & Strezov (2023)
58	waste management	jätehuolto	Wu & Strezov (2023)
59	waste minimization	jätteiden vähentäminen	Glavič & Lukman (2007)
60	wastewater treatment	jätevedenkäsittely, jäteveden puhdistus	Wu & Strezov (2023)
61	water resources	vesivarat, vesivoimavarat	Khojasteh et al. (2024)
62	water security	vesiturvallisuus	IPCC (2023a)
63	wind power	tuulivoima, tuulienergia	Wu & Strezov (2023)
64	zero waste	nollahukka, jätteenhävitys	Glavič & Lukman (2007)

Appendix 2: Final Keyword List with Regex

	EN	FI
1	bio[-]?based.*	aurinkoenerg.*
2	bio[-]?fuel.*	bioöljy.*
3	bio[-]?gas.*	biohiil.*
4	bio[-]?mass.*	biojalost.*
5	bio[-]?material.*	biokaasu.*
6	bioeconom.*	biokomposiit.*
7	bioenergy.*	biopohjai.*
8	carbon.*capture.*	biopolttoaine.*
9	carbon.*dioxide.*	biotalou.*
10	carbon.*footprint.*	ekologi.*

11	carbon.*neutral.*	ekotehok.*
12	circular.*econom.*	energian varastoin.*
13	clean.*energ.*	energiatehok.*
14	clean.*product.*	fuusioenergi.*
15	clean.*tech.*	hiilidioksid.*
16	climate.*	hiilijalanjäl.*
17	CO2	hiilineutraal.*
18	decarboni[sz].*	hiilitase.*
19	eco.*efficien.*	ilmasto.*
20	eco.*friend.*	jätehuol.*
21	ecolog.*	jäteveden puhdist.*
22	electric vehicle.*	käyttää.*uudelleen
23	emission.*	kasvihuone.*
24	energy efficien.*	kestävä.*
25	energy storage.*	kierrät.*
26	energy[-]?efficient.*	kiertotalou.*
27	environmental.* data.*	materiaalitehok.*
28	environmental.* footprint.*	metaan.*
29	environmental.* friend.*	päästö.*
30	environmental.* impact.*	resurssitehok.*
31	environmental.* issue.*	sähköajoneuv.*
32	environmental.* monitoring.*	sähköaut.*
33	environmental.* regulation.*	saast.*
34	fossil fuel.*	talteenotto.*
35	GHG	tuulienergi.*
36	green transition.*	tuulivoim.*
37	greenhouse gas.*	uudelleen.*käytt.*
38	life.*cycle.*assessment.*	uusiokäyttö.*
39	low[-]?carbon.*	uusiutuva.* energ.*
40	methane.*	vesivoim.*
41	re[-]?use.*	vihre.* energi.*
42	recycl.*	vihre.* kasvu.*
43	renewable energ.*	vihre.* kehity.*
44	resource efficien.*	vihre.* ratkais.*
45	smart.*grid.*	vihre.* siirtymä.*
46	solar power.*	vihre.* talou.*
47	sustainab.*	vihre.* teknologi.*

48	waste management.*	ympäristön?[-]?kuorm.*
49	wastewater treatment.*	ympäristönsuojel.*
50	wind power.*	ympäristöystäväll.*