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Productivity and Green Transition in Finland

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Abstract

This report discusses the shortcomings of conventional productivity measures that overlook the environmental efforts of firms aiming to reduce greenhouse gas emissions. It highlights the importance of utilizing green productivity metrics, such as carbon productivity and green total factor productivity, for a more comprehensive assessment of productivity within the context of sustainable development.

Key findings from recent empirical research conducted in Finland reveal a positive correlation between carbon and labor productivity, demonstrating that environmentally friendly practices can enhance both sustainability and efficiency in energy-intensive sectors. Energy efficiency also positively affects firm productivity, emphasizing the potential advantages of environmental regulations in driving economic growth, while simultaneously maintaining ecological well-being. Furthermore, carbon productivity exhibits a procyclical pattern, with financially stronger firms seeking more environmentally conscious workers (i.e., offering green jobs) during periods of economic growth.

The report also recognizes the challenge of overcoming technological path dependence and suggests strategies such as public funding for clean technology R&D and leveraging EU-level green investment programs, particularly for smaller nations like Finland.

Tiivistelmä

Tuottavuus ja vihreä siirtymä Suomessa

Tässä raportissa tarkastellaan vakiintuneiden tuottavuusmittareiden puutteita. Ne eivät ota huomioon yritysten pyrkimyksiä kasvihuonekaasupäästöjen vähentämiseen. Niin kutsuttujen vihreiden tuottavuusmittareiden – kuten hiilituottavuuden ja vihreän kokonaistuottavuuden – hyödyntäminen on kestävän kehityksen näkökulmasta tärkeää, koska niiden avulla tuottavuutta voidaan arvioida kattavammin kestävän kehityksen kontekstissa.

Viimeaikaisessa suomalaisessa tutkimuksessa on havaittu positiivinen yhteys hiilituottavuuden ja työn tuottavuuden välillä. Tämä osoittaa, että ympäristöystävälliset käytännöt voivat edistää sekä kestävää kehitystä että tehokkuutta energiaintensiivisillä aloilla. Energiatehokkuus myös lisää yritysten tuottavuutta, joten ympäristönsuojelulliset rajoitukset voivat samanaikaisesti lisätä talouskasvua ja pitää yllä ekologista hyvinvointia. Lisäksi hiilituottavuus vaihtelee myötäsyklisesti, ja talouskasvun ollessa positiivista yritykset rekrytoivat ympäristötietoisempia työntekijöitä (luovat nk. vihreitä töitä).

Tässä raportissa tarkastellaan myös haasteita, jotka liittyvät teknologiariippuvuuden poistamiseen. Ehdottamiamme toimintatapoja ovat julkisen rahoituksen lisääminen puhtaan teknologian t&k-toiminnalle ja EU-tason vihreiden investointiohjelmien hyödyntäminen erityisesti Suomen kaltaisissa pienemmissä maissa.

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Kiitokset: Tämä raportti on laadittu Suomen tuottavuuslautakunnalle yhteenvetona vihreän tuottavuuden keskeisistä havainnoista Suomessa.

Keywords: Carbon productivity, Green jobs, Green total factor productivity, Green transition, Energy efficiency

Avainsanat: Energiatehokkuus, Hiilituottavuus, Vihreä kokonaistuottavuus, Vihreä siirtymä, Vihreät ammatit

JEL: D24, O44, Q55, Q56

Contents

1 Introduction

Productivity growth in developed countries has slowed down since the financial crisis in 2008, with Finland experiencing particularly weak growth. The year 2007 marked the end of Finland's long period of catching up with the "productivity frontier" (OECD, 2018), referring to the countries with the highest labor productivity (LP) in the world. This has led to a widening productivity gap between Finland and other leading industrialized nations. In 1980, LP in Finland's business sector was approximately 58% of that in the United States, but it rose to approximately 86% by 2007 (Finnish Productivity Board, 2021; cf. Inklaar and Timmer, 2008). Currently, using the same method of comparison, the productivity of Finland's business sector in 2022 was only approximately 68% of that in the United States.

The Finnish Productivity Board (2022) identifies several key factors contributing to the slowdown in Finland's productivity growth: the negative productivity shock experienced by Finland's electronics industry, weakened cost competitiveness, and poor resource allocation. Notably, the report emphasizes that the slowdown in productivity growth does not seem to have been caused by a lack of competition or insufficient business dynamism. This suggests that Finland's current weak productivity growth is not due to structural problems.

Given Finland's abundant resources for renewable energy production, a transition towards a green economy could offer a potential avenue for narrowing this productivity gap. However, protectionist industrial policies implemented by larger nations, such as the US Inflation Reduction Act (2022) and the "France 2030" investment plan, may pose a challenge to Finland's ability to benefit from the green transition. As a small economy, Finland faces challenges in competing for foreign investments in net-zero technologies, particularly when these technologies are heavily subsidized by large nations. Hence, the emergence of national-level subsidies within the EU and elsewhere weakens Finland's competitive advantage during the green transition. On the other hand, union-level instruments such as the InvestEU Programme, launched as part of the NextGenerationEU recovery plan in 2021, might prove more beneficial for small EU countries like Finland.

The remainder of this report is organized as follows: Section 2 discusses the potential pathways by which green transition can affect the productivity of firms and industries. Section 3 discusses green productivity measures, such as Carbon Productivity and Green Total Factor Productivity. Section 4 summarizes empirical evidence on green productivity in Finland, based on an analysis of firm-level greenhouse gas (GHG) emission data. Section 5 analyzes the green transition through the lens of "directed technical change". Section 6 summarizes the key findings of the report.

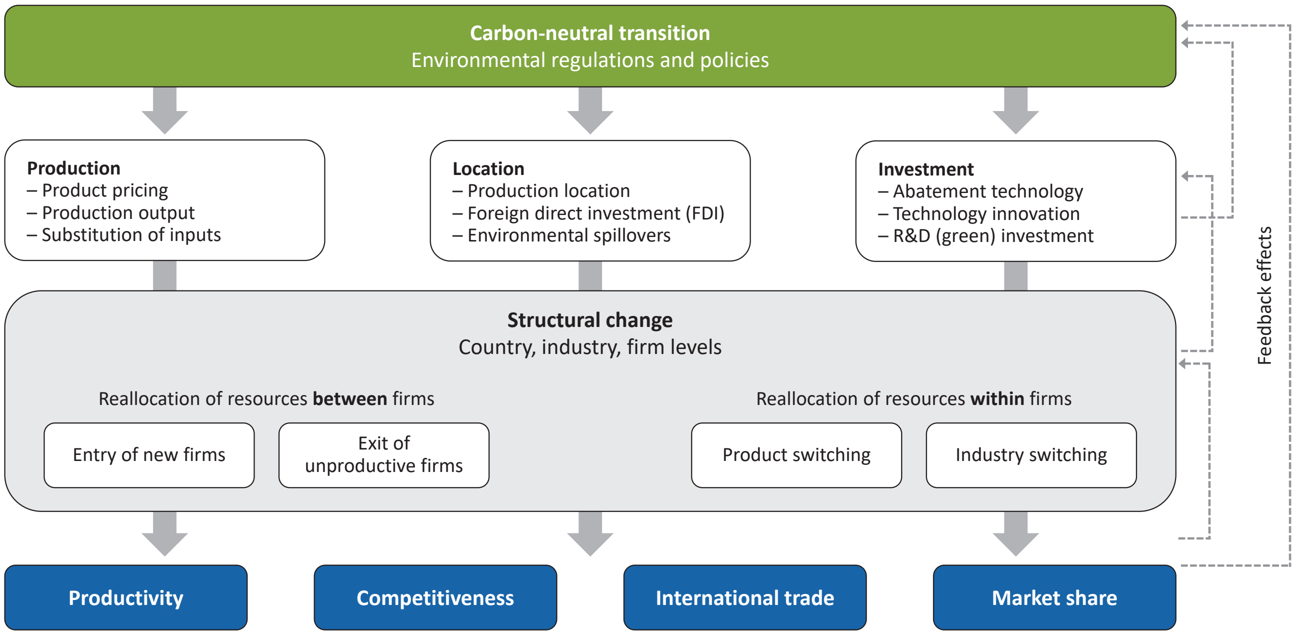
2 Green transition and structural change

The green transition[1], driven by climate policies, triggers major structural changes in production, distribution, and consumption. These policies, which include a range of regulations aimed at reducing the carbon footprint and promoting sustainability, serve as primary drivers for this shift towards a greener economy. As firms adapt to these regulations, their competitive landscape and productivity may change. The channels through which this transition can affect firm productivity and competitiveness are illustrated in Figure 1 (see Kuosmanen et al., 2023). Firms respond to these regulations by adjusting their production, location, and investment strategies. This includes decisions on product offerings, pricing, input usage, and potentially relocating production facilities or investing in new technologies to comply with environmental standards.

Each of these responses may influence resource allocation within and between firms. In particular, the structural changes caused by environmental regulations can manifest as increased creative destruction – where new firms that are better suited to the changed regulatory environment enter the market, while less productive older firms exit. Such structural changes affect productivity and competitiveness, as well as international trade and the market share of relevant firms. In turn, these factors will influence the future evolution of environmental regulations and policies.

As Kuosmanen et al. (2023) point out, GHG reduction regulations may have both positive and negative effects on

Figure 1 Indirect impacts of carbon-neutral transition on economic growth



Source: Kuosmanen et al. (2023).

green transition. Negative effects might emerge through changes in production locations: since regulations differ across the countries, the introduction of stricter regulations in one country might shift production to "pollution havens" where abatement costs are lower (Li and Zhou, 2017), indirectly increasing GHG emissions. However, regulations also have dynamic effects on firm behavior. The costs of complying with regulations can increase incentives to innovate, particularly innovations that lower compliance costs (Porter and van der Linde, 1995). For example, according to Levinson and Taylor (2008) and Levinson (2009), the shift to importing polluting goods (instead of producing them within the US) explains only a small part of the observed reduction in pollution emissions in the United States, while most of the reduction is explained by a shift to less-polluting technologies.

The effects of environmental regulation on market structure can be quite complex. Both rising production costs under constant technology and incentives to create improved technologies via R&D can affect the number and size of firms in the market. In addition, Millimet et al. (2009) distinguish two mechanisms through which environmental regulation can affect market structure. First, regulations may alter economies of scale, with the literature presenting mixed findings on whether they increase or decrease the optimal scale of production. Second, increased regulation might lead to new types of rent-seeking behavior, where firms introduce new abatement technologies in anticipation of future regulation, putting other firms at a competitive disadvantage.

3 Green productivity measures

Productivity stagnation is a challenge not only for Finland but for most Western countries. Economic literature offers various explanations, including weakened market dynamism, increased market power, resource misallocation, and a slowdown in technological advancement (Decker et al., 2016; Grossman et al., 2017; De Loecker et al., 2020; Hsieh and Klenow, 2009; Restuccia and Rogerson, 2017; Kuosmanen, 2022; Gordon, 2012; Bloom et al., 2020). The challenges of measuring productivity further complicate this issue (Brynjolfsson et al., 2021). Recent research suggests that neglecting GHG reduction efforts may explain productivity stagnation (Dai et al., 2023).

Traditional measures of productivity, such as Labor Productivity (LP) and Total Factor Productivity (TFP), fail to capture how well firms cope with the challenges posed by the green transition. These measures focus solely on economic output relative to conventional production factors such as labor and capital, overlooking the crucial aspect of modern economies: their environmental impact. Specifically, traditional metrics neglect GHG emissions, which are key factors influencing the sustainability of economic growth. GHG reduction necessitates substantial expenditure on R&D as well as capital expenditure. These labor and capital inputs are generally considered when determining traditional productivity figures used in national and corporate accounting. However, this poses a challenge. The implementation of significant emission reduction measures may distort traditional productivity measures, as production inputs may appear to generate less value added than before. This is because these measures do not consider the environmental benefits of reducing emissions.

Green productivity measures have been developed to address this shortcoming. These measures integrate environmental considerations with economic performance, offering a holistic view of sustainability and efficiency in production processes. Two key metrics are often used to quantify green productivity: Carbon Productivity (CP) and Green Total Factor Productivity (Green TFP). Traditional measures may show a decline in productivity when a firm implements emission reduction strategies, even though the firm is becoming more environmentally efficient.

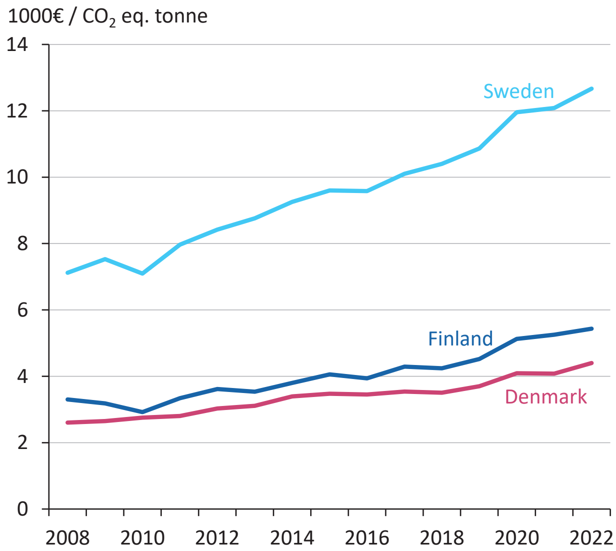
3.1 Carbon productivity

CP measures the economic output per unit of emissions (e.g., CO_2 or GHG in CO_2 eq.), indicating the efficiency of an economy, industry, or firm in producing economic output relative to its carbon footprint. An increase in CP indicates a reduction in emissions for the same level of output or an increase in output with stable emissions.

While similar in concept to partial productivity measures such as LP, CP focuses specifically on the relationship between economic output and GHG emissions. Partial productivity measures such as CP offer several advantages. They are relatively easy to calculate and interpret, allowing for clear comparisons between firms and industries. Additionally, focusing on a specific input-output relationship, such as CP's emphasis on GHG emissions, can provide valuable insights for targeted improvement strategies. However, partial productivity measures have certain limitations because they only consider a single aspect of production. Thus, they can potentially overlook the trade-offs between different inputs or environmental factors. For example, a focus on GHG emissions may inadvertently neglect other environmental impacts or resource-use efficiencies. Therefore, although CP offers valuable insights into the relationship between economic output and GHG emissions, it is important to complement this metric with broader indicators to ensure a more comprehensive assessment.

Figure 2 illustrates the CP levels for Finland, Sweden, and Denmark for the period 2008–2022, calculated based on data from Eurostat. In these three countries, CP has increased over time; however, Sweden's CP level is notably higher than those of Finland and Denmark. This difference could be attributed to various factors, including variations in environmental policies, industrial composition, investment in clean technologies, energy mix, and efficiency measures across the three countries.

Figure 2 Carbon productivity (level), measured as the ratio of GDP (2015 prices) to GHG emissions of all NACE activities (CO_2 eq.) in 1000€ per tonne of CO_2 eq.



Source: Authors' calculations based on Eurostat data.

Figure 3 illustrates the evolution of CP and LP in Finland's economy from 2008 to 2021. Notably, while LP demonstrated minimal growth, CP experienced a significant increase, highlighting contrasting trends in productivity. This divergence underscores the evolving dynamics of Finland's productivity landscape, with implications for both its economic performance and sustainability. The gap between these measures emphasizes the importance of integrating environmental considerations into productivity analysis.

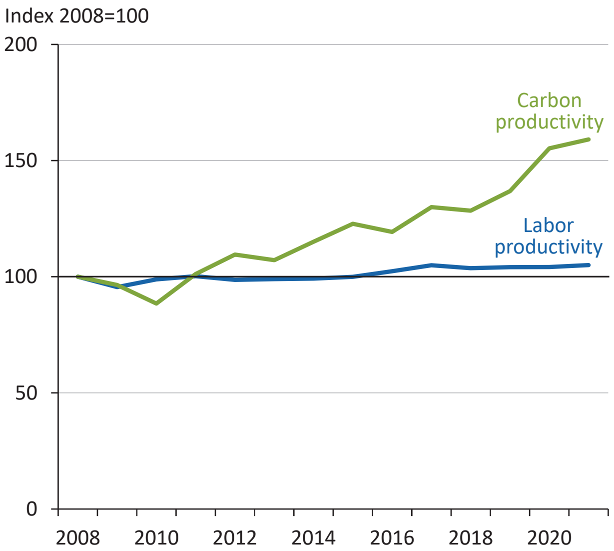
To gain a deeper understanding of the factors driving CP growth in Finland, several recent research projects have applied productivity decomposition analysis to Finland's most energy-intensive sectors and investigated the contribution of various factors. Section 5 highlights the results from these projects, including which factors were the most significant contributors to CP growth and how they differed across sectors.

3.2 Green total factor productivity

Green TFP offers a more comprehensive measure of productivity by incorporating environmental impacts, including GHG emissions, alongside traditional inputs, such as labor and capital. This approach captures the interplay between economic output, environmental sustainability, and resource efficiency, providing a nuanced understanding of productivity in the context of sustainable development. Green TFP assesses how efficiently an economy, industry, or firm transforms various inputs into outputs while accounting for the environmental impact of these inputs. This essentially reveals whether economic growth aligns with reductions in environmental pressure, highlighting the sustainability and resource efficiency of production processes. While Green TFP offers a more comprehensive picture compared to partial measures such as CP, it can be more challenging to estimate. This complexity arises from the need to aggregate the various inputs, outputs, and environmental factors into a single metric. Measurement methods for Green TFP include growth accounting, econometric approaches, and linear programming. Several alternative productivity measures also exist, such as the OECD's Environmentally Adjusted Multifactor Productivity (Cárdenas Rodríguez et al., 2023).

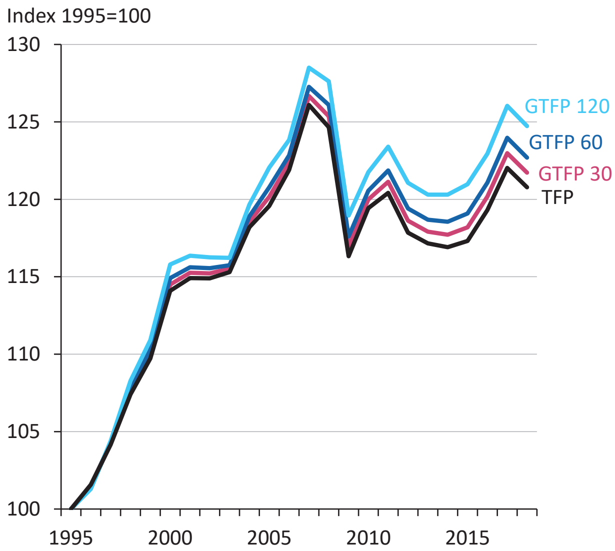
Figure 4 illustrates the changes in Finland's TFP (readily available from EUKLEMS datasets) and Green TFP (indicated in Figure 3 as GTFP), calculated by adjusting EUKLEMS's TFP indices for GHG emissions reduction, for the period 1995–2019. Green TFP is calculated for carbon prices of 30, 60, and 120 euros per tonne of

Figure 3 Carbon and labor productivity indices relative to the base year 2008



Source: Authors' calculations based on Statistics Finland data.

Figure 4 TFP and Green TFP change in Finland in 1995–2019



Source: Kuosmanen et al. (2023).

CO_2, based on OECD carbon pricing benchmarks (OECD, 2021). As evident from the figure, there is a gap between TFP and Green TFP change, suggesting a divergence between conventional TFP and Green TFP measures. This gap is also observed in many other OECD countries (see Dai et al., 2023), and is particularly large in those countries that put the most efforts into reducing GHG emissions.

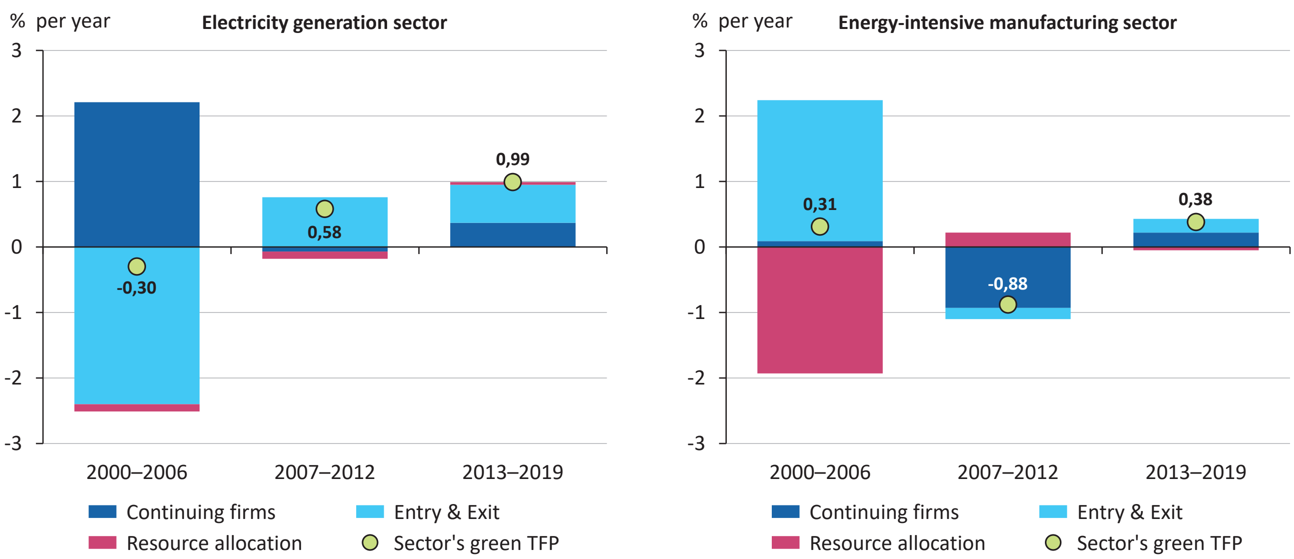
4 Empirical findings

4.1 Green productivity and structural change

Several recent studies have explored the role of structural change in green productivity growth. By applying the productivity decomposition of Kuosmanen and Kuosmanen (2021) to Statistics Finland's firm-level GHG emissions data merged with other register-based data, these studies examined the contributions of firm entry and exit, resource allocation, and industry switching to CP and Green TFP growth in energy-intensive sectors in Finland. The first study (Kuosmanen, 2022), conducted for the Prime Minister's Office, examined the contribution of structural change to CP growth in Finland's electricity generation industry. The second study (Kuosmanen and Maczulskij, 2024) identified the contribution of structural change to both CP and Green TFP growth in Finland's energy-intensive manufacturing sector. The third study, also conducted for the Prime Minister's Office, assessed Green TFP in energy-intensive sectors in the broader context of the green transition (Kuosmanen et al., 2023). Notably, these studies were among the first to quantify the contribution of structural change using firm-level data on GHG emissions in the literature.

As an example, Figure 5, based on the results from Kuosmanen et al. (2023), illustrates the decomposition results of Green TFP growth for Finland's electricity generation sector and energy-intensive manufacturing sector from 2000 to 2019, broken down into three sub-periods (2000–2006, 2007–2012, and 2013–2019). In both sectors, during the most recent period (2013–2019), firm entry and exit contributed positively to Green TFP growth. However, resource allocation requires improvement in the manufacturing sector.

Figure 5 Green TFP decomposition results for the electricity generation (left) and energy-intensive manufacturing (right) sectors



Source: Kuosmanen et al. (2023).

4.2 Links between labor productivity and green productivity

Another study commissioned by Finland's Prime Minister's Office investigated the relationship between the LP and CP in the country's carbon-intensive mining and quarrying, manufacturing, and electricity production sectors (Fornaro et al., 2023). The study found a positive relationship between CP and LP in these sectors, suggesting that advancements in eco-friendly practices and energy-intensive production can not only help reduce carbon emissions but also contribute to maintaining or even enhancing LP. On average, a 10% increase in CP is associated with a 1.5% increase in LP. By improving CP, firms can potentially optimize their production processes to achieve both environmental sustainability and economic efficiency. This highlights the potential for Finland's energy-intensive industries to develop environmentally friendly practices that mitigate climate change while sustaining economic well-being.

While the findings from this report provide descriptive evidence, another ongoing project financed by the Prime Minister's Office[2] further investigates the causal effect of energy efficiency (EE), measured as the ratio of value added and energy use, on both LP and TFP. The study employs two alternative instrumental variable approaches to identify the effects of energy efficiency: first, using EU ETS prices, and second, employing a shift-share instrument focusing on firm-specific energy source prices. The findings suggest that firms with higher energy efficiency demonstrate stronger productivity, emphasizing the positive impact of sustainable practices on productivity while simultaneously maintaining ecological well-being (Maczulskij and Kuosmanen, 2024).

4.3 Carbon productivity over the business cycle

The past project commissioned by the TT-Foundation[3] examined the role of structural changes in CP, as well as the cyclicality of CP. The findings demonstrate that CP is procyclical in nature. The analysis revealed a positive causal relationship between industrial output growth and CP in Finnish manufacturing firms. This positive association is primarily explained by firms' ability to reduce emissions during upturns, which is the main mechanism underlying the findings. Additionally, the study found that financially stronger firms show an increased demand for technologically proficient (STEM) and environmentally conscious workers, particularly at the top management level. This suggests that firms are better able to implement eco-friendly technologies during periods of economic expansion (Maczulskij and Fornaro, 2024).

5 Green transition as directed technical change

Available technologies influence the prices of production inputs, which in turn affect the new technologies that firms choose to develop (Acemoglu, 2002). For example, R&D activities within the energy sector might focus on non-renewable energy sources because their production costs are lower compared to renewable energy, due to earlier R&D investments. As a result, new methods for producing renewable energy might remain unprofitable for extended periods if firms lack incentives to develop them (Acemoglu et al., 2012). This path dependence underscores the need for public funding for R&D in renewable energy.

Firm-specific factors also contribute to path dependence. For instance, an incumbent firm specializing in gasoline cars, with a history of high-quality R&D related to their production, may lack the competence to produce electric vehicles and conduct relevant R&D. This could incentivice the firm to continue focusing on gasoline cars (Aghion et al., 2021). Additionally, previous investments can influence future R&D directions: a firm that has invested heavily on gasoline car production might find a shift to electric vehicles less profitable, given its existing investments. In contrast, new entering firms are not constrained by these considerations.

Beyond direct effects on GHG emissions, environmental taxes and subsidies can also redirect R&D towards cleaner production inputs and methods. Such redirection can be pursued through public funding or private R&D. For example, the EU Horizon Europe research and innovation program, which addresses climate change as one of its missions while leaving specific promotional methods to member partnerships, could be an effective tool for directing R&D towards cleaner energy production. However, detailed "orchestration" of R&D efforts can be harmful because of the unpredictable nature of innovation activities and the difficulty in measuring their results (cf. Takalo and Toivanen, 2018).

In addition to taxes, subsidies, and R&D funding, competition and trade policies play a role in the green transition. The relationship between competition policy and current green transition policies in the EU and the US is complex. The US Inflation Reduction Act of August 2022 includes protectionist tax credits for green investment, prompting the EU to respond with its own protectionist measures. These include the Green Deal Industrial Plan, which modifies EU restrictions to state subsidies for "net zero technology" fields, i.e., areas with maximally zero net GHG emissions (European Commission, 2023).

The new geopolitics and the re-emergence of distinct economic blocks can have direct positive effects on the green transition if state-subsidized investments in net zero technologies become part of protectionist policies. However, as noted by Deschryvere and Rouvinen (2024), new geopolitical dynamics also have several indirect negative effects on the green transition. For example, economic block decoupling slows down economic growth, and if the natural environment is considered a "luxury good" that receives more attention as living standards rise, could impede the green transition. In addition, the emergence of new blocks reduces the chances of arriving at new international agreements that are essential for green transition.

The impact of new protectionist policies on the Finnish economy largely depends on whether these policies are implemented at the national or EU level. As a small country, Finland may struggle to compete for green investments if larger EU member states offer them substantial national-level subsidies. However, Finland could benefit from union-level programs that provide financial support for green investments.

6 Conclusions

This report highlights the limitations of traditional productivity measures in capturing the environmental impacts of economic activity, which can lead to a misrepresentation of productivity gains achieved through emission reduction efforts. It highlights the need to utilize green productivity measures for a more comprehensive evaluation of productivity growth within the context of sustainable development and provides an overview of recent research on this topic in Finland.

The transition toward a green economy, driven by climate policies, initiates significant structural changes across industries and sectors. These changes influence firms' strategies, affecting their production methods, location choices, and investment decisions. While these adjustments may foster creative destruction - facilitating the entry of environmentally compliant firms and the exit of less productive ones - they also promote innovation and enhance productivity and competitiveness. Recent empirical research conducted in Finland has demonstrated the role of structural change in green productivity growth, particularly in energy-intensive sectors. This research highlights the positive contributions of firm entry and exit to green TFP growth and identifies opportunities for optimizing resource allocation. Additionally, recent studies suggest a positive relationship between carbon productivity (CP) and labor productivity (LP), indicating that eco-friendly practices can simultaneously enhance environmental sustainability and economic efficiency in Finland's energy-intensive sectors. Ongoing research underscores the positive impact of energy efficiency (EE) on productivity and ecological well-being, emphasizing the potential benefits of more strict environmental policies in driving productivity. Furthermore, findings indicate that CP is procyclical, with economically stronger firms showing increased demand for environmentally conscious workers, particularly during periods of economic expansion.

Addressing technological path dependence poses a significant challenge. This can be mitigated through public funding for R&D in clean technologies, alongside environmental taxes and subsidies, which redirect innovation from established, potentially polluting technologies towards cleaner alternatives, as illustrated by the EU's Horizon Europe program. However, given the unpredictable nature of innovation, excessive control over R&D efforts should be avoided. Additionally, while new protectionist policies may stimulate investment in green technologies, they also risk hindering international collaboration, impeding economic growth, and complicating global climate agreements. For Finland, navigating these complexities involves leveraging EU-level green investment programs to effectively compete and foster international cooperation, thereby advancing the transition to sustainability and overcoming path dependence.

Endnotes

1 While "green transition" broadly refers to the shift towards sustainable practices, and "carbon-neutral transition" specifically targets net-zero carbon emissions, in this report we use the term "green transition" to encompass both, including carbon neutrality as a key component.

2 For more information on the project, visit: https://www.etla.fi/tutkimukset/geopolitiikka-muuttaa-toimintaymparistoa-mita-tekee-suomi-etlatieto/

3 For more information on the project, see: https://www.etla.fi/tutkimukset/teollisuus-ja-ilmastonmuutoksen-hillitseminen/

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