UNIVERSITY OF LJUBLJANA
SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

# MANAGEMENT PRACTICES, GREEN TRANSITION, AND FIRM PERFORMANCE AT THE MANUFACTURING FIRMS IN CENTRAL AND EASTERN EUROPEAN COUNTRIES

Ljubljana, September 2025

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## ABSTRACT

This thesis examines the relationship between selected management practices, green transition efforts, and firm performance in the manufacturing sector across Central and Eastern European (CEE) countries, drawing on data from the EBRD-EIB-WBG Enterprise Survey. The empirical findings indicate that product innovation, labour training, and workforce growth are positively associated with firm economic performance. In contrast, reliance on external financing demonstrates a negative impact on profitability. Furthermore, the adoption of environmental management practices showed positive link to the likelihood of setting environmental targets and strengthening sustainability commitments, however, no clear association was found with profitability. Notably, firms implementing energy management practices experienced a short-term decline in profitability, suggesting a longer payback horizon. Overall, the results highlight the strategic importance of aligning sustainability with operational strategies to enhance both economic resilience and environmental responsibility within the region's industrial landscape.

**KEY WORDS:** innovation, labour, external financing, green management practices, firm performance, CEE region, manufacturing sector, environmental performance

**SUSTAINABLE DEVELOPMENT GOALS**


## POVZETEK

Ta magistrska naloga preučuje povezavo med izbranimi vodstvenimi praksami, prizadevanji za zeleni prehod in uspešnostjo podjetij v proizvodnem sektorju držav Srednje in Vzhodne Evrope (CEE) ter temelji na podatkih iz ankete podjetij EBRD-EIB-WBG. Empirične ugotovitve kažejo, da produktne inovacije, usposabljanje zaposlenih in rast delovne sile pozitivno vplivajo na ekonomsko uspešnost podjetij. Nasprotno pa zanašanje na zunanje financiranje negativno vpliva na dobičkonosnost. Uvedba praks okoljskega upravljanja je povezana s povečano verjetnostjo postavljanja okoljskih ciljev in krepitve trajnostnih zavez, vendar analiza ne razkriva jasne povezave z dobičkonosnostjo. Podjetja, ki uvajajo energetske prakse upravljanja, kratkoročno beležijo upad dobičkonosnosti, kar nakazuje na daljšo dobo povračila naložb. Rezultati poudarjajo strateški pomen usklajevanja trajnostnih prizadevanj z operativnimi strategijami za krepitev tako ekonomske odpornosti kot okoljske odgovornosti v industrijskem okolju regije.

**KLJUČNE BESEDE:** inovacije, delovna sila, zunanje financiranje, zelene upravljavske prakse, uspešnost podjetij, regija Srednje in Vzhodne Evrope, proizvodni sektor, okoljska uspešnost

**CILJI TRAJNOSTNEGA RAZVOJA**

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sl. – Slovene

**CDP** – (sl. Projekt razkrivanja ogljika) Carbon Disclosure Project
**CEDEFOP** – (sl. Evropski center za razvoj poklicnega usposabljanja) European Centre for the Development of Vocational Training
**CEE** –(sl. Srednja in vzhodna Evropa) Central and Eastern Europe
**EBRD** – (sl. Evropska banka za obnovo in razvoj) European Bank for Reconstruction and Development
**EEA** – (sl. Evropska agencija za okolje) European Environment Agency
**EIB** – (sl. Evropska investicijska banka) European Investment Bank
**EMS** – (sl. Sistem upravljanja z energijo) Energy Management System
**ESG** – (sl. Okoljski, družbeni in upravljavski dejavniki) Environmental, Social, and Governance
**EU** – (sl. Evropska unija) European Union
**GHG** – (sl. Toplegreditni plini) Greenhouse Gas
**GRI** – (sl. Globalna pobuda za poročanje) Global Reporting Initiative
**HRS** –(sl. Sistem za rekuperacijo toplote) Heat Recovery System
**ILO** – (sl. Mednarodna organizacija dela) International Labour Organization
**ISO** – (sl. Mednarodna organizacija za standardizacijo) International Organization for Standardization
**IQR** – (sl. Interkvartilni razpon) Interquartile Range
**LCA** –(sl. Ocena življenjskega cikla) Life Cycle Assessment
**OECD** – (sl. Organizacija za gospodarsko sodelovanje in razvoj) Organization for Economic Co-operation and Development
**SASB** – (sl. Odbor za standarde trajnostnega računovodstva) Sustainability Accounting Standards Board
**SME** – (sl. Malo in srednje veliko podjetje) Small and Medium-sized Enterprise
**WBG** – (sl. Skupina Svetovne banke) World Bank Group

# 1 INTRODUCTION

The manufacturing sector in Central and Eastern Europe (CEE) has undergone significant transformation over recent decades, evolving from centrally planned systems into competitive, market-oriented economies integrated within the European Union (EU). Amidst these transitions, firms in the region continue to face increasing pressures to sustain economic performance while simultaneously responding to global trends such as operational improvements, sustainable production, and intensified market competition (OECD, 2021b; European Commission, 2022a).

In particular, the ability of firms to strategically manage innovation, workforce development, financing decisions, and environmental responsibilities has become increasingly crucial for long-term competitiveness and resilience. However, despite growing recognition of these internal factors, empirical evidence on how such management practices influence firm performance in the CEE context remains limited and fragmented.

Therefore, the purpose of this thesis is to address this research gap by examining the relationship between selected internal management practices and firm performance in the CEE manufacturing sector. Specifically, the study investigates how innovation, labour-related strategies, external financing, and environmental practices affect both firms' economic and environmental outcomes. Economic performance is assessed using indicators such as sales growth rate, sales per employee, and profit margin, while environmental performance is measured by the adoption of formal environmental targets. By doing so, this thesis aims to contribute to a more comprehensive understanding of how CEE manufacturing firms navigate competitiveness and sustainability challenges in an evolving economic landscape.

The central research question guiding this study focuses on identifying the main internal factors that influence firm performance in the CEE manufacturing sector. It provides the foundation for examining how internal management practices shape firm-level outcomes in this regional context. Recognizing that firm performance encompasses both economic and environmental dimensions, the question supports a multidimensional analysis and provides the basis for investigating specific drivers such as innovation, labour management, financing, and environmental practices.

To further structure the research, two sub-questions have been developed. The first sub-question explores the mechanisms within management practices that drive higher firm economic performance among manufacturing firms in the CEE region. Based on the reviewed literature, the following hypotheses are proposed:

H1: Innovation management practices — product and process innovation — positively impact firm economic performance, measured by sales growth rate, in the manufacturing sector.

H2a: Labour training positively impacts firm economic performance, measured by sales per employee, in the manufacturing sector.

H2b: An increase in the number of permanent employees positively impacts firm economic performance, measured by sales growth rate, in the manufacturing sector.

H3: External financing — line of credit or loan — positively impacts firm economic performance, measured by profit margin, in the manufacturing sector.

Given the increasing importance of sustainability in business strategy, the second sub-question addresses the environmental dimension of firm performance. It investigates the dual role of environmental practices in enhancing both environmental responsibility and economic competitiveness in the CEE manufacturing context. In response, the following hypotheses are formulated based on the reviewed literature:

H4a: The adoption of environmental management practices — energy management, waste management, water management, air pollution control measures, and machinery upgrades — leads to improved firm environmental performance, indicated by the adoption of environmental targets, in the manufacturing sector.

H4b: The adoption of environmental management practices — energy management, waste management, machinery upgrades, and heating and cooling improvements — positively impacts firm economic performance, measured by profit margin, particularly over longer investment horizons, given the potential delayed return on such investments, in the manufacturing sector.

To answer these research questions, the thesis adopts a twofold approach consisting of an extensive literature review and an empirical analysis. The theoretical section draws upon secondary data from academic literature, institutional reports, and prior empirical studies to establish a conceptual framework. The synthesis of existing insights on innovation, labour management, financing, and environmental sustainability provided the foundation for formulating relevant hypotheses which were subsequently tested through empirical analysis.

The empirical analysis is based on cross-sectional data from the 2018 EBRD-EIB-WBG Enterprise Survey, focusing exclusively on manufacturing firms across five CEE countries: Czech Republic, Hungary, Poland, Slovakia, and Slovenia. The dataset encompasses essential information on firm characteristics, management practices, and performance indicators relevant to the research questions. The data was analysed using the statistical software R, applying appropriate statistical analyses.

The structure of this thesis is as follows: the second and third chapter present the theoretical background and literature review covering management practices, environmental commitments and firm performance with specific considerations for the CEE manufacturing sector. The fourth chapter outlines the research design and employed methodology, including the sample selection and variable construction. The fifth chapter presents the descriptive analysis, empirical findings with a discussion of the results in relation to prior research, and addresses the limitations of the study and opportunities for future research. Finally, the sixth chapter concludes the thesis by summarizing the key insights and offering practical recommendations for policymakers and business leaders.

Ultimately, this thesis aims to provide actionable insights into how manufacturing firms in post-transition economies can strengthen both competitiveness and sustainability, which can be achieved by effectively managing innovation, human capital, financial resources, and environmental practices in an increasingly complex global environment.

# 2 MANAGEMENT PRACTICES AND FIRM PERFORMANCE

Management practices play a fundamental role in shaping firm performance across sectors and economies. Bloom and Van Reenen (2006), in their seminal cross-country study of manufacturing firms, provide robust empirical evidence that well-structured management practices are strongly associated with improved productivity, profitability, sales growth, and firm survival. Their research highlights that firms with stronger managerial capabilities are better positioned to adopt innovations, develop workforce competencies, and allocate resources efficiently, thereby securing sustained competitive advantage. Moreover, they reveal substantial variation in management quality across countries and industries, indicating that targeted improvements in management practices offer significant performance gains, particularly in emerging regions such as CEE (Bloom & Van Reenen, 2006).

Building on these insights, both academic research and institutional analyses have emphasised that manufacturing firms, given their operational complexity and global competition, are especially sensitive to the quality of their management decisions. Effective management enables firms to navigate volatile markets, respond to technological shifts, and optimize production processes, all of which are essential for sustaining competitiveness and growth (Bloom et al., 2019; OECD, 2021b; World Bank, 2020). Firm performance is a multidimensional concept that encompasses a range of financial and operational outcomes. Common indicators include sales growth, profitability metrics such as profit margin or investment return, and productivity improvements, frequently measured by sales per employee (Bloom & Van Reenen, 2006; Syverson, 2011). In the manufacturing sector specifically, firm performance additionally reflects operational efficiency, innovation capability, and resilience to external shocks (Ketokivi & Schroeder, 2004). These interconnected dimensions collectively capture a firm’s ability to create value, sustain competitiveness, and support long-term growth trajectories (OECD, 2019b). Within the broad landscape of management practices, this study focuses on three key areas particularly relevant to manufacturing performance: innovation activities, labour management, and access to external financing.

First, innovation — both in products and processes — is widely recognised as a principal driver of firm competitiveness. Firms that engage in continuous innovation are better able to respond to evolving customer needs, improve production efficiency, and open new market opportunities (Tavassoli & Karlsson, 2016; OECD, 2021b). Empirical evidence confirms that innovation-active firms tend to outperform their peers, particularly when innovation is embedded within broader organisational strategies (Rosenbusch et al., 2011; European Commission, 2022c).

Second, labour management practices, including workforce training and the expansion of permanent employment, are critical enablers of firm performance. Skilled and stable workforces contribute not only to higher productivity but also to the successful implementation of innovation and process improvements (Combs et al., 2006; Dearden et al., 2006; World Bank, 2019b). This is especially pertinent in manufacturing environments, where cumulative expertise and operational continuity are vital for maintaining efficiency and product quality (Toner, 2011; OECD, 2019a).

Third, access to external financing, particularly through credit lines and loans, provides manufacturing firms with the liquidity required to fund investments in capacity expansion, workforce development, and innovation (Beck & Demirguc-Kunt, 2006; Rahaman, 2011; OECD, 2020; EIB, 2023). Firms with greater financial flexibility are better equipped to seize growth opportunities, buffer against market volatility, and sustain long-term competitiveness (OECD, 2021a).

In addition to traditional management practices, growing attention has been given to environmental management, emerging as a vital dimension of firm performance. In the manufacturing sector, green practices—such as energy efficiency, waste reduction, and pollution control—not only support regulatory compliance but also help reduce environmental impact, enhance operational efficiency, and strengthen long-term competitiveness. In the CEE context, where policy frameworks increasingly promote sustainability transitions, environmental management has become a key pillar of performance, complementing innovation, labour, and financial strategies, and contributing to both environmental goals and economic resilience (Ambec & Lanoie, 2008; Green et al., 2012; Horbatch et al., 2012).

By focusing on these interrelated areas — innovation, labour management, external financing, and environmental management — this study aims to build a comprehensive understanding of the management practices that shape firm performance in the manufacturing sector. These practices operate through distinct yet often interconnected mechanisms, enabling firms to adapt, grow, and remain competitive. This is particularly relevant for CEE economies, where strengthening such practices holds significant potential for boosting resilience, improving productivity, and maintaining competitiveness in a rapidly evolving global industrial landscape.

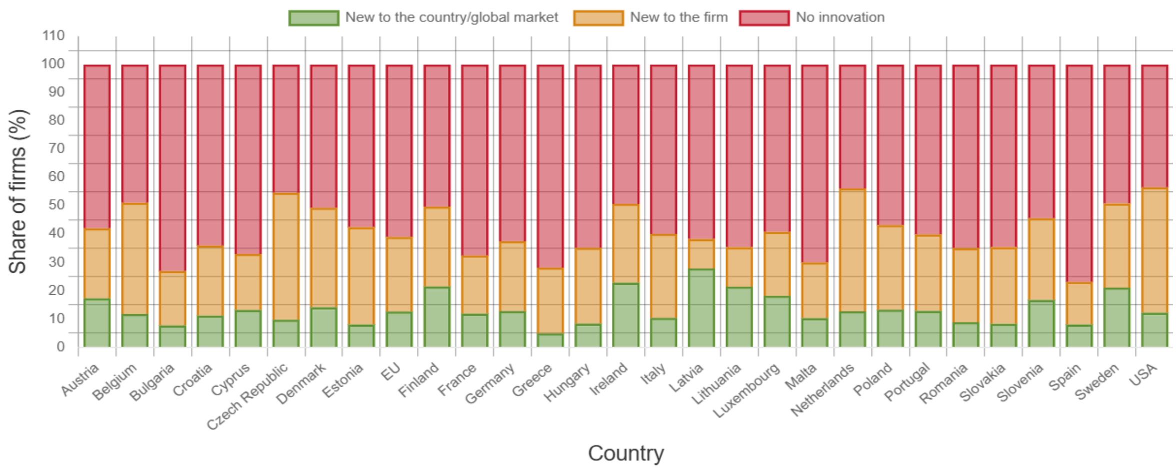
## 2.1 Innovation

Innovation plays a pivotal role in driving firm performance, particularly in the manufacturing sector, where advancements in technology and processes are crucial for maintaining firm competitiveness and improving operational efficiency. The Oslo Manual, a widely recognized international standard for measuring innovation, defines innovation as the implementation of a new or significantly improved product (good or service), process, marketing approach, or organizational practice. Innovation enables firms to adapt to evolving market demands, enhance productivity, and sustain long-term growth (OECD & Eurostat, 2018).

The World Bank (2020) highlights that innovation is particularly critical for firms in post-transition economies, where upgrading technologies and adopting innovative practices are essential for competitiveness in both domestic and international markets. Furthermore, it highlights that product innovation is particularly vital for firms in emerging markets, including CEE countries, where it supports industrial upgrading and entry into higher value-added segments of global value chains. Firms in CEE region face unique innovation challenges stemming from historical underinvestment in research and development, and slower diffusion of new technologies (OECD, 2019b).

The European Investment Bank (EIB, 2023) also emphasizes significant disparities in innovation activity across EU Member States, with advanced economies outpacing those in CEE. Nevertheless, firms in CEE countries are increasingly engaging in innovation, introducing new products and processes both within their operations and to the wider market (Figure 1). Recognizing the diverse forms and impacts of innovation, this study focuses on two specific types of innovation — product innovation and process innovation — which are particularly relevant in the manufacturing context and are examined as distinct factors influencing firm performance in this research.

*Figure 1: Innovation activity by country*




*Source: EIB (2023).*

### 2.1.1 Product innovation

Product innovation refers to the development of new or significantly improved goods or services in terms of technical specifications, components and materials, user-friendliness, or other functional characteristics (OECD & Eurostat, 2018). In the manufacturing industry, product innovation is often a primary driver of growth, often linked to increased sales, customer satisfaction, and market share. In the manufacturing sector, product innovation plays a central role in driving firm growth and competitiveness by meeting evolving customer demands and differentiating from competitors (World Bank, 2020).

Empirical evidence demonstrates that product innovation contributes to building competitive advantages by helping firms safeguard against competition and market risks (Camison & Lopez, 2010). Similarly, Artz et al. (2010), through a longitudinal study across U.S. and Canadian industries, found that product innovation has a significant positive effect on firm performance across industries, including manufacturing, notably in terms of revenue growth and market expansion.

A cross-country analysis by Na and Kang (2019), using World Bank Enterprise Survey data, confirms a positive association between product innovation and sales growth in Southeast Asia’s manufacturing sector, with parallel insights applicable to CEE economies. Similarly, Atalay et al. (2013), emphasize that product innovation significantly contributes to higher market share and profitability in manufacturing firms through a study on the Turkish manufacturing sector, reinforcing its role as a critical element of firm performance.

Furthermore, European Commission (2024a) reports that product innovation accounts for a substantial share of total turnover in European manufacturing firms, underlying its role as a critical lever for financial performance. According to the Organisation for Economic Co-operation and Development (OECD, 2021b), European manufacturing firms that engage in continuous product innovation outperform their peers in both domestic and export markets, benefiting from enhanced brand value and customer loyalty.

The Community Innovation Survey (2022) reported that more than 50% of the enterprises in the EU engaged in innovation activities between 2020 and 2022, with higher shares in technologically advanced industries (European Commission, 2024a). This is especially relevant for CEE countries seeking to enhance their competitiveness in advanced manufacturing sectors such as machinery, automotive, and chemicals (European Commission, 2022c).

Product innovation not only enhances market presence but also strengthens firms' ability to respond to external shocks, such as demand fluctuations or supply chain disruptions. This resilience is crucial for manufacturing firms operating in volatile environments, a reality faced by many firms in CEE. However, despite the benefits of product innovation, it is important to note that it often requires substantial investment in research and development, and there's no guarantee of market acceptance, which can pose financial risks (OECD, 2021b). In line with these findings, this study hypothesizes a positive relationship between product innovation and firm performance in the CEE manufacturing sector, particularly in terms of sales growth and market positioning.

### 2.1.2 Process innovation

Process innovation involves implementing new or significantly improved production or delivery methods. This can include changes in techniques, equipment, or software to improve efficiency, reduce costs, and improve product quality (OECD & Eurostat, 2018). While product innovation typically drives market expansion, process innovation enhances a firm's internal operations—production efficiency, increasing flexibility, and enhancing responsiveness to customer demand (Doran & Ryan, 2014; Reichstein & Salter, 2006).

Research consistently demonstrates that process innovation contributes to firm performance through multiple channels. Reichstein and Salter (2006) emphasize that process improvements targeting supply chains and production methods significantly boost operational efficiency and productivity. Tavassoli and Karlsson (2015), in their study of Swedish firms, found that combining process innovations with broader organizational changes yielded superior outcomes, including market performance gains. Doran and Ryan (2014) similarly argue that process eco-innovations enhance firms' ability to deliver quality products and drive profitability gains in manufacturing firms.

Importantly, while process innovation is often associated with cost efficiency, its contribution to sales growth stems from enhanced production capacity, increased labour productivity, and improved consistency in output—factors that enable firms to scale operations, respond to shifting market demands, and more effectively capitalize on commercial opportunities. Moreover, process innovation is increasingly recognized as a key enabler for meeting environmental standards and improving energy efficiency, aligning with broader sustainability objectives. These dynamics are especially relevant in manufacturing sectors characterized by high competition and supply chain complexity, where operational agility and process reliability are crucial for maintaining or expanding market share (OECD, 2021b; EIB, 2023).

In the context of CEE manufacturing sector, process innovation is increasingly prioritized as firms seek to modernize operations and enhance competitiveness. According to the EIB Investment Survey (2023), manufacturers in the region are investing in process optimization as a strategic response to market volatility, rising energy costs, and evolving customer expectations. Process innovation is thus anticipated to contribute to sales growth not only through internal efficiency gains, but also by strengthening firms' ability to deliver value in dynamic and demanding environments.

While product and process innovations each contribute to firm performance through different mechanisms, research suggests that they are most effective when pursued together.

Tidd and Bessant (2018) emphasize that integrating product and process innovation enhances both revenue generation and cost efficiency, creating a virtuous cycle of competitiveness. Firms that simultaneously develop new products and improve their production processes can achieve higher quality, lower costs, and faster time-to-market — all crucial advantages in manufacturing sectors.

Furthermore, European Commission (2024a) and OECD (2021b) advocate for integrated innovation strategies, highlighting that firms in the manufacturing sector must balance investments in new product development with improvements in production methods to remain competitive in global markets and meet increasing sustainability requirements. However, balancing product and process innovations can be complex. Firms may face resource constraints that limit their ability to invest equally in both areas, and misalignment between product development and process capabilities can lead to inefficiencies or suboptimal performance. In light of this, the following analysis investigates the distinct and complementary effects of product and process innovations on firm performance, offering insights into how CEE manufacturing firms can leverage both forms of innovation to achieve sustainable growth and competitive advantage.

## 2.2 Human capital management

Following the importance of innovation, human capital management practices also play a vital role in shaping firm performance, particularly in the manufacturing sector, where skilled human capital is critical for competitiveness. Therefore, investments in human capital through employee training and workforce expansion have been widely recognized as key drivers of productivity and operational efficiency, ultimately supporting firms' success and growth (OECD, 2019a; World Bank, 2019b).

### 2.2.1 Employee training

Employee training is a fundamental mechanism for building firm-specific human capital. Firms that invest in structured training initiatives equip their workforce with the technical and operational skills necessary to adapt to changing technologies and market demands (OECD, 2019a). According to Eurostat (2022b), enterprises that implement continuous training programs report higher productivity levels, especially in industries undergoing technological transitions, such as manufacturing.

Empirical studies confirm that investments in employee development contribute not only to individual skill enhancement but also to broader organizational benefits. Sung and Choi (2014) demonstrated that firms engaging in employee development experience higher levels of innovation output, which supports superior financial performance. Similarly, research by Pedro Martins (2021) on Portuguese firms funded by the European Social Fund revealed that companies receiving grants for employee training experienced productivity growth of approximately 5% and notable improvements in firm profitability and value added.

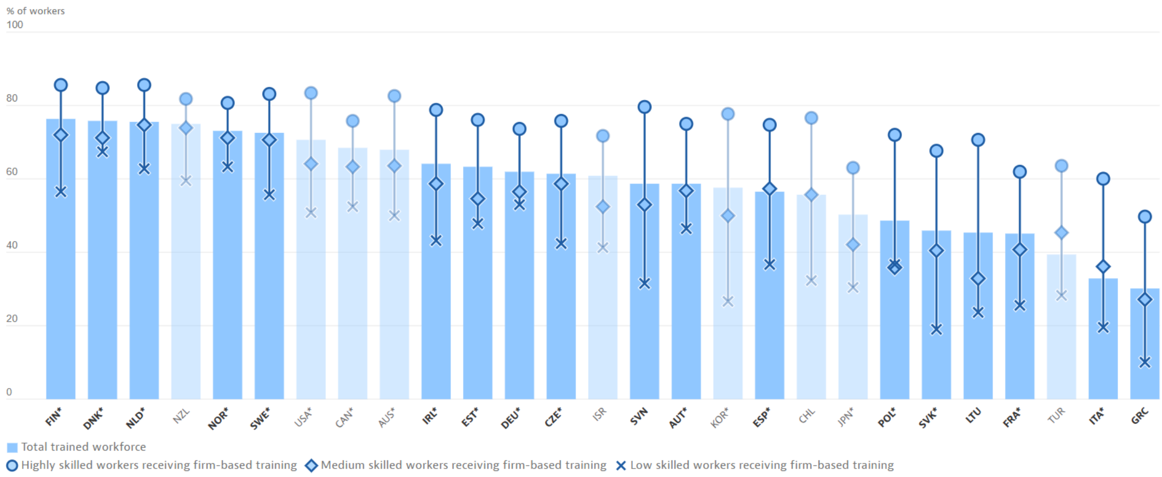
Furthermore, Aragón et al. (2003) found that sustained investment in human capital enhances productivity and reduces employee turnover, with long-term positive impacts on profitability. Supporting this, Zwick (2006) examined the relationship between training intensity and productivity in the German manufacturing sector, finding that firms investing more in training see significant productivity improvements, particularly in high-tech manufacturing industries. Zwick's study emphasised the importance of the quality and relevance of training programmes for realising these productivity gains. These findings align with the OECD (2019a), which highlights that training in emerging European economies is crucial for improving productivity and fostering sustainable growth. Nonetheless, there is a risk that employees, once upskilled, may become more attractive to other employers, leading to increased turnover, especially if retention strategies are lacking. This may result in firms bearing the costs of training without reaping the long-term benefits (Kumari, 2022).

Evidence from research applicable to the manufacturing sector supports these conclusions. Combs et al. (2006) and Toner (2011) found that technical skills training contributes significantly to firm performance by enhancing labour productivity and, in the case of manufacturing industries, improving product quality. Both studies emphasise that sustained and continuous training initiatives, as opposed to isolated or one-off sessions, have the greatest impact on operational efficiency and overall firm performance. In the context of CEE, institutional research consistently emphasises the pivotal role of employee training in enhancing firm competitiveness and productivity, especially in manufacturing sectors facing evolving technological demands.

According to the OECD (2021c), while employer-sponsored training is a recognised driver of labour productivity growth, many CEE countries lag behind Western Europe in participation rates for adult learning and on-the-job training. This gap presents a significant barrier to firms' ability to adopt advanced manufacturing processes and digital technologies. The OECD further emphasizes that firms investing in continuous training programmes are better positioned to foster innovation and adapt to fast-changing market requirements, particularly in high-tech and export-oriented industries.

As shown in Figure 2, participation in employment-based training varies significantly across countries, with CEE economies generally reporting lower rates compared to advanced economies. The data, originating from 2015, illustrates a persistent training gap, highlighting the need for increased investment in workforce development to enhance firm competitiveness in the region (OECD, n.d.).

*Figure 2: Share of workers receiving employment-based training, by skill level and country (data from 2015)*

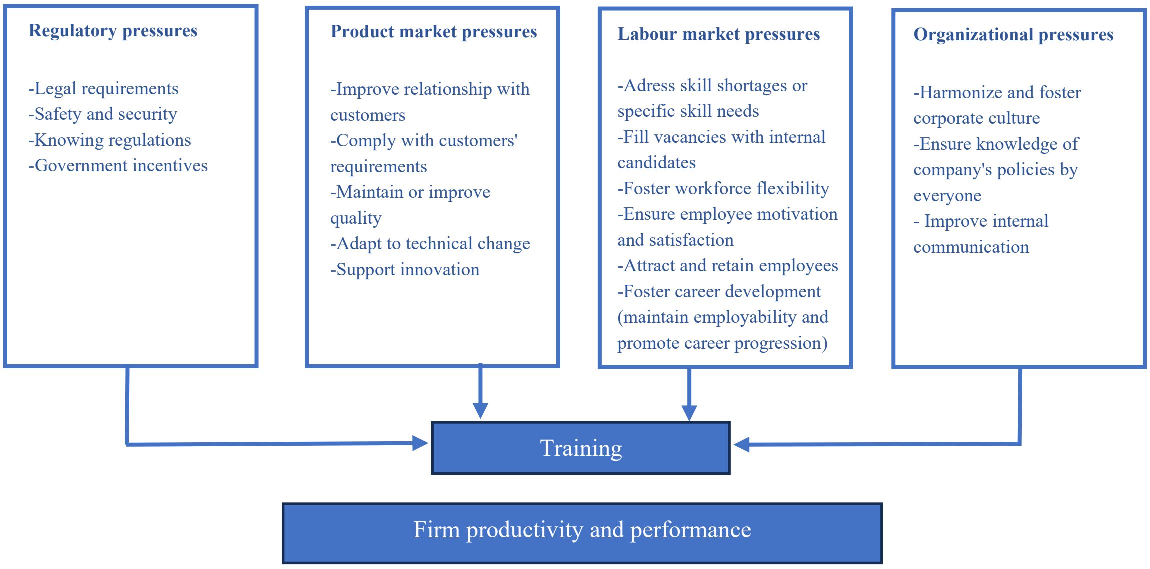



*Source: OECD (n.d.).*

Similarly, the World Bank (2019b) highlights that upskilling initiatives are instrumental in helping firms within the CEE region close critical skills gaps and integrate more effectively into global value chains. Their findings suggest that firms engaging in structured employee development programmes not only improve operational efficiency but also accelerate the diffusion of innovation and technological adoption. This is particularly important for small and medium-sized enterprises (SMEs) in the region, which often face greater constraints in accessing skilled labour. However, it's crucial to ensure that training programs are tailored to the specific needs of the firm and its employees. Generic or poorly targeted training can lead to ineffective outcomes, wasting resources and failing to address the actual skill gaps present within the organization (OECD, 2021c). Eurostat (2022b) reinforces this perspective, reporting that manufacturing firms in countries such as Poland, the Czech Republic, and Hungary that implement continuous vocational training observe measurable improvements in both process efficiency and product quality.

Furthermore, the European Centre for the Development of Vocational Training (CEDEFOP) emphasizes the strategic importance of embedding training within firms' long-term planning, noting that continuous human capital development initiatives enhance resilience, workforce adaptability, and overall firm performance (CEDEFOP, 2022). Moreover, beyond immediate productivity gains, robust training systems foster stronger employee engagement and retention, thereby reducing turnover and supporting sustained growth. To better understand the underlying motivations for enterprise-level training provision, Figure 3 presents the main drivers identified by firms, ranging from regulatory compliance and labour market pressures to internal organisational needs. These motivations align with the broader findings of institutional studies, which emphasize the strategic importance of workforce training for improving firm productivity and competitiveness (OECD, 2021c).

*Figure 3: Reasons for training provision in enterprises*




*Source: Adapted from OECD (2021c).*

Collectively, these insights strongly support the argument that firm-level investments in training are not merely beneficial but essential for sustaining competitive advantage and driving growth in the CEE manufacturing sector. These findings align with broader empirical research, reinforcing that structured employee development remains a cornerstone of firm success in the dynamic industrial landscape of the region, which will be further explored in this study.

### 2.2.2 Permanent workforce growth

The expansion of a firm's permanent workforce is widely recognised as a key indicator of sustainable growth, strategic investment in human capital, and long-term operational stability. Unlike temporary or non-standard forms of employment, permanent roles enable firms to cultivate organisational knowledge, strengthen employee engagement, and develop firm-specific skills that are essential for maintaining competitive advantage. This is particularly crucial in manufacturing sectors, where complex production processes and high-quality standards depend heavily on the expertise and stability of the workforce. By maintaining a stable and growing base of permanent employees, firms are better positioned to ensure consistent production quality, enhance process efficiency, and support sustained firm growth (Lim & Mali, 2022).

The OECD (2021c) emphasizes that stable employment relationships promote stronger organisational commitment and foster effective collaboration among employees, both of which are essential for implementing continuous improvement initiatives and sustaining high operational standards. Moreover, workforce stability contributes to long-term productivity gains by supporting the accumulation of firm-specific human capital. Eurofound (2020) similarly highlights that firms fostering employment stability benefit from stronger organisational commitment, operational efficiency, and enhanced capability to implement continuous improvements — all of which are essential for sustained firm performance.

Employment stability, particularly through the growth of permanent employees, is closely linked to improved firm performance. According to the International Labour Organization (ILO) permanent employment supports better talent retention, lowers turnover costs, and encourages firms to invest more in employee training, enhancing productivity over time. These effects are especially relevant in manufacturing sectors, where stable employment fosters the accumulation of firm-specific skills and knowledge. In contrast, reliance on temporary or part-time contracts can increase operational risks due to higher turnover and lower workforce engagement. Therefore, promoting permanent employment and workforce stability not only strengthens job quality but also supports sustainable firm growth (ILO, 2020).

Empirical research further supports the positive relationship between permanent employment and firm performance. The findings of Han et al. (2025) demonstrate that firms with higher employment stability — characterised by lower turnover rates and a stronger reliance on permanent workforce structures — achieve superior firm performance over time. This supports the argument that cultivating a stable, long-term workforce contributes to sustained productivity gains and operational efficiency, which are critical for manufacturing firms seeking competitive advantage.

Complementary findings from Lim and Mali (2022) reinforce this view, as their study on Korean manufacturing firms from 2010 to 2015 demonstrated that firms increasing their permanent workforce base outperformed those dependent on temporary labour — not only in productivity but also in firm growth and financial outcomes. The World Bank (2019b) further highlights that workforce stability plays a crucial role in building firms' resilience against external shocks, a particularly relevant factor for manufacturing firms in the CEE region. Stable employment enables firms to maintain operational continuity during market disruptions and supports their efforts to move into higher value-added production activities (World Bank, 2019b).

Moreover, OECD (2021c) points out that in the face of demographic challenges and labour market tightness in CEE, firms expanding their permanent employment base are better positioned to mitigate skills shortages and enhance operational continuity. Stable employment relationships foster stronger organisational commitment and collaboration, which are critical for implementing process improvements and maintaining production quality standards (OECD, 2021a).

Eurostat (2022a), through its labour market analyses, indicates that firms increasing their number of permanent employees tend to report better outcomes in both operational efficiency and responsiveness to market demands. Notably, firms with an expanding permanent workforce structure exhibit greater capability to engage in innovation activities and pursue continuous improvement initiatives (Eurostat, 2022a).

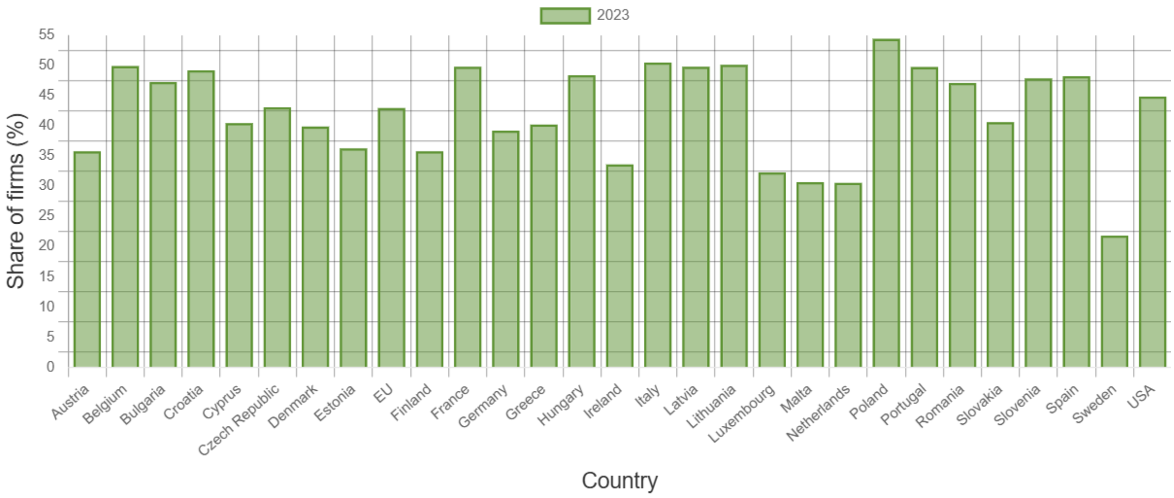
Overall, the findings emphasise that expanding the permanent workforce is not merely a cost factor, but a strategic choice that strengthens firm resilience, drives productivity, and supports sustained growth. Manufacturing firms which invest in stable employment are equipped to better adapt to market demands and sustain performance improvements. Building on these insights, this study empirically examines the link between permanent workforce growth and firm performance in the CEE manufacturing sector.

### 2.3 Financing sources

Access to finance is another critical enabler of firm growth, competitiveness, and resilience, particularly in capital-intensive sectors such as manufacturing. Firms require sufficient liquidity not only to fund daily operations but also to invest in productivity-enhancing initiatives and seize growth opportunities. Typically, firms rely on two primary financing sources: internal funds, generated from retained earnings or operating profits, and external funds, sourced from financial institutions or capital markets. While internal financing allows firms to maintain autonomy and avoid debt obligations, it is often insufficient to support larger investments in innovation, expansion, or modernisation (OECD, 2020). Consequently, many firms turn to external financing to supplement internal resources and sustain their growth trajectories.

As illustrated in Figure 4, external financing plays an essential role across European firms, with notable variations by country. In many CEE economies, firms increasingly rely on external finance to support their investment activities, highlighting its importance for driving firm growth and resilience in the region (EIB, 2023). Among external financing sources, debt instruments such as credit lines and loans are crucial tools for managing liquidity, funding working capital needs, and enabling strategic investments (Beck et al., 2008). Institutional evidence strongly supports the view that access to credit lines and loans substantially improves firms' ability to grow and remain competitive. The EIB highlights that firms with pre-approved credit lines were better positioned to withstand liquidity shocks during the COVID-19 crisis, maintaining operational continuity and safeguarding investment plans. Credit lines act as a form of precautionary liquidity insurance, enabling firms to respond flexibly to market disruptions and sustain long-term investment activities (EIB, 2021).

*Figure 4: Use of external finance by country*




*Source: EIB (2023).*

Similarly, EIB (2023) reports that easier access to financing is positively associated with firms' growth expectations, particularly in the CEE region, where credit constraints are especially pronounced. The OECD further emphasises that access to stable credit facilities allows firms to navigate periods of revenue volatility and capitalise on growth opportunities that might otherwise be constrained by limited internal funds (OECD, 2020). Lines of credit, in particular, are valued for their flexibility, providing firms with revolving capital that can be deployed as needed to finance short-term operational expenditures or bridge cash flow gaps (World Bank, 2019a).

Specifically in the CEE region, the OECD (2020) observes that persistent structural barriers to financing continue to hinder firm development. However, policy interventions such as credit guarantee schemes have played a positive role in strengthening SME resilience and enhancing investment capacity. Likewise, the World Bank (2019a) identifies access to external financing as one of the most significant enablers of SME growth, confirming that firms with adequate financing resources experience higher investment levels and faster growth trajectories. Nevertheless, excessive reliance on debt may erode profitability due to interest obligations, potential over-leverage, and reduced financial flexibility (OECD, 2020). This can be particularly problematic for SMEs or firms with volatile revenues, as fixed repayment schedules may constrain reinvestment capacity and increase exposure to financial distress.

Finally, the World Bank (2019a) highlights that credit constraints remain one of the most significant barriers to firm growth in emerging and developing economies. Firms that secure reliable access to credit facilities report higher profitability and greater investment in technology and workforce development—both critical for sustaining competitiveness in rapidly evolving industrial environments.

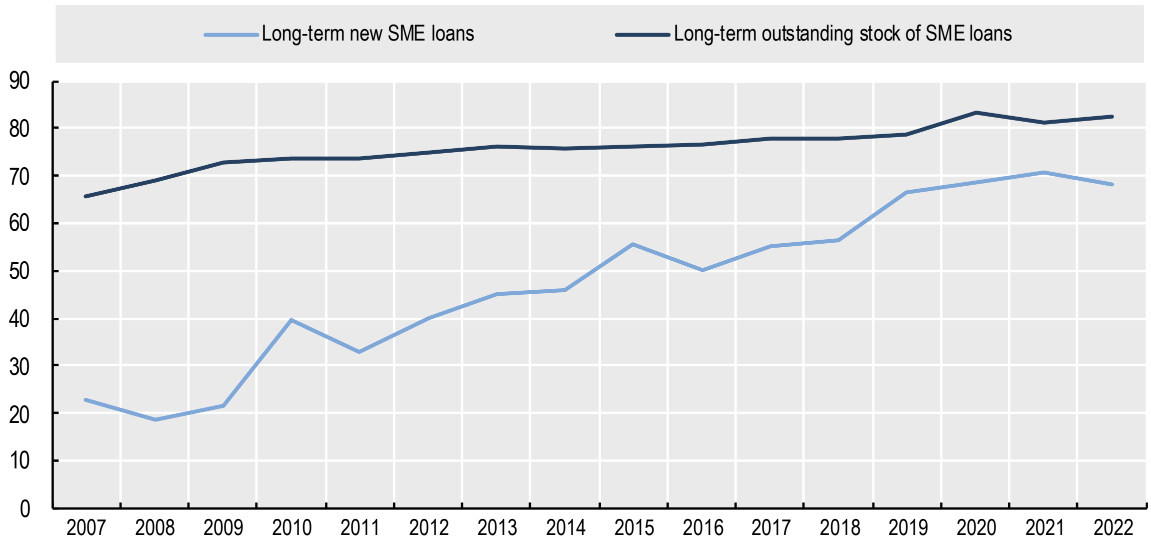
Complementing the institutional insights, empirical research provides robust evidence on the role of credit lines and bank loans in enhancing firm performance. Garcia-Teruel and Martinez-Solano (2007) demonstrate that firms leveraging short-term loans for working capital management benefit from improved liquidity and profitability, particularly in manufacturing sectors where cash flow stability is essential for operational continuity. In a similar vein, Love and Sánchez (2009) find that access to bank credit lines enables firms to relax liquidity constraints and increase their capacity to invest in productive fixed assets. Their results suggest that firms with access to external finance are better positioned to pursue investment opportunities that would otherwise be constrained by internal cash flow limitations. When it comes to financing long-term investments, Ayyagari et al. (2011) emphasise that structured bank loans allow manufacturing firms in emerging markets to invest in large-scale fixed assets without depleting operational cash flows.

Extending this argument to firm-level growth and innovation capacity, Rahaman (2011) demonstrates that firms with secure access to credit lines or bank loans are better positioned to pursue capacity expansion and innovation initiatives, thereby directly strengthening firm performance and competitiveness. Similarly, Beck and Demirguc-Kunt (2006) highlight that improved access to bank loans reduces SMEs' dependence on high-cost, short-term financing alternatives, supporting operational efficiency and sustainable growth. They further underline that limited access to external financing remains one of the primary constraints on SME growth, particularly in developing economies where smaller firms encounter disproportionate barriers compared to larger enterprises. However, Waked (2016), focusing on Saudi SMEs, finds that, while external financing is essential for SME growth, its effectiveness is often undermined by high interest rates, rigid collateral requirements, and inadequate financial infrastructure.

Harvie et al. (2013) provide complementary evidence from selected Asian economies, showing that while SMEs often rely on informal lending or trade credit due to restricted access to bank loans, those with broader access to formal external financing — including bank loans, government-backed loans and credit cooperatives — achieve significantly higher productivity and growth rates. Similarly, Altaf and Shah (2017), examining Indian manufacturing firms, find that companies utilising working capital financing such as short-term bank loans and customer advances outperform those relying solely on internal funds, highlighting the critical role of financial flexibility in enhancing firm performance. However, they also highlight that excessive reliance on short-term external financing may erode profitability, suggesting a threshold beyond which financial flexibility becomes detrimental.

As illustrated in Figure 5, it is visible that both the share of long-term new SME loans and the outstanding stock of SME loans have increased steadily over the past decade, highlighting the growing reliance of smaller firms on structured debt financing to support investments in fixed assets and productive capacity (OECD, 2024a). The data, adjusted for inflation using country-specific GDP deflators (base year 2007), are sourced from the OECD Scoreboard, which compiles information received directly from national sources. Building on the literature reviewed, this study examines the relationship between access to credit lines or loans and firm profitability in the manufacturing sector. By doing so, it aims to provide empirical evidence on the role of debt financing in enhancing firm-level financial performance, contributing to the wider body of research on capital structure dynamics and financial access in emerging markets.

*Figure 5: Share of long-term SME loans of total SME loans (median value), 2007–2022*




*Source: OECD (2024a).*

## 3 GREEN TRANSITION AND FIRM PERFORMANCE

Following the key management practices that influence firm performance —namely innovation, labour, and external financing — the green transition is another strategic dimension that emerges as a critical lever for long-term firm competitiveness and sustainability. It represents a fundamental shift from carbon-intensive production and consumption models to low-carbon, resource-efficient, and environmentally sustainable practices. In the manufacturing sector, this transition holds particular importance, as production processes are major contributors to greenhouse gas (GHG) emissions, energy consumption, resource depletion, and environmental degradation (EEA, 2021).

The term "green transition" gained prominence through global environmental agreements such as the Kyoto Protocol (1997) and the Paris Agreement (2015), which emphasized the need to reduce emissions and promote sustainable development. The term became a cornerstone of European policy with the introduction of the European Green Deal (2019), aiming for a climate-neutral Europe by 2050 (European Commission, 2019). The main objective is embedding sustainability into the core of economic policy and corporate strategy.

At its heart, the green transition seeks to reconcile environmental responsibility with firm-level competitiveness. For manufacturers, this involves adopting clear environmental objectives — including energy efficiency, $CO_2$ emissions reduction, waste minimisation, and pollution control — as well as operational strategies that deliver tangible improvements (European Commission, 2023). These environmental goals are not only regulatory requirements but also strategic levers that enhance firms' resilience to market shifts, resource price volatility, and tightening environmental standards. Firms that proactively embrace sustainability can improve operational efficiency, reduce costs, and access new market opportunities, particularly as global supply chains increasingly prioritise sustainable sourcing and production (European Commission, 2022a). However, OECD (2022) addresses the risk of long payback periods of green investments and how budget constraints or short planning horizons can discourage firms from pursuing such strategies.

Crucially, the relationship between the green transition and firm performance is dual-faceted, encompassing both environmental performance and economic performance. Environmental performance includes measurable progress in reducing GHG emissions, improving energy and water efficiency, reducing waste, and lowering pollutant outputs (EEA, 2024b). Economic performance, meanwhile, captures improvements in profitability, operational cost savings, productivity, and market competitiveness — benefits that often flow directly from sustainable operational improvements (Porter & van der Linde, 1995; Ambec & Lanoie, 2008).

Empirical studies consistently demonstrate that the adoption of structured environmental targets and green management practices drives this dual performance outcome. Firms that set and pursue environmental targets are more likely to improve internal accountability, reduce inefficiencies, and enhance their overall market positioning. Yet, achieving these benefits depends on the effective implementation of green management practices at the operational level (Porter & van der Linde, 1995; European Commission, 2023).

These operational measures not only enable firms to meet regulatory and internal environmental objectives but also yield immediate and long-term financial benefits as shown in empirical evidence. By optimising resource use and adopting energy-efficient technologies, manufacturing firms have reported substantial reductions in operational costs. Furthermore, firms implementing green innovations often achieve better market positioning and reduced exposure to regulatory risks and financial penalties, increasing their resilience to future shocks, such as resource scarcity or carbon pricing mechanisms (Horbatch et al., 2012).

For manufacturing firms in CEE, the green transition presents both a significant challenge and a valuable opportunity. Historically reliant on energy-intensive processes, CEE firms have faced structural barriers such as limited access to green financing and slower adoption of sustainable technologies. However, this landscape is rapidly evolving. Supported by EU policy incentives and increasing global market expectations, CEE manufacturers are accelerating the integration of environmental targets and green management practices (EIB, 2023). EIB Investment survey (2023) reports that energy intensity in CEE manufacturing has been steadily declining, reflecting efforts to modernize production and adopt cleaner technologies. Specifically for SMEs, the growing trend of target-setting for energy efficiency and emissions reduction, supported by EU structural funds and national incentives, has been linked to measurable declines in energy intensity and improved cost competitiveness (EIB, 2023; European Commission, 2022a). As these transformations deepen, firms in the region that effectively align policy commitments with operational improvements are poised to achieve superior environmental performance while capturing economic gains through cost efficiency and market differentiation.

### 3.1 Environmental policy frameworks and targets

The accelerating momentum of global climate action and European environmental policies has placed the manufacturing sector at the forefront of the green transition. Companies and industries, particularly manufacturing, are under growing scrutiny to adopt environmentally sustainable practices. In response, governments and international organizations have developed comprehensive policy frameworks with a clear mandate: manufacturing firms are expected not only to comply with regulatory obligations but also to proactively establish internal environmental targets that guide sustainable practices (European Commission, 2019; European Commission, 2023).

The adoption of environmental targets has become a critical component of corporate strategy, especially in sectors with high environmental footprints such as manufacturing. These targets refer to measurable, time-bound commitments aimed at reducing environmental impact — including cutting GHG emissions, improving energy efficiency, minimizing waste, and conserving resources. By setting such targets, firms can operationalize broader sustainability goals, align with regulatory expectations, and improve internal efficiency, competitiveness, and overall environmental performance (ISO, 2015; EIB, 2023; European Commission, 2023).

Defined as specific, quantifiable objectives related to areas such as energy consumption, $CO_2$ emissions, waste reduction, or pollution control, environmental targets serve as tangible expressions of broader policy ambitions and management practices. According to the European Commission (n.d.-a), the Corporate Sustainability Reporting Directive positions clear environmental targets as both internal benchmarks for performance and external signals of accountability to investors, customers, and regulatory authorities. Furthermore, it strengthens this approach by mandating the disclosure of environmental objectives and progress, thereby embedding target-setting into corporate reporting and risk management frameworks.

The European Green Deal, introduced by the European Commission in 2019, is a cornerstone policy aiming to transform the EU into a climate-neutral economy by 2050. With objectives such as achieving net-zero GHG emissions and decoupling economic growth from resource use, the Green Deal's interim goal of a 55% reduction in emissions by 2030 compels firms to integrate $CO_2$ reduction targets directly into their operational strategies (European Commission, 2019). Supporting this ambition, complementary frameworks like the EU Ecolabel encourage firms to publicly report on environmental objectives, promoting transparency and accountability (European Commission, n.d.-b). Similarly, regulations such as the Sustainable Finance Disclosure Regulation incentivize companies to adopt and disclose environmental targets, improving their access to green financing and investment incentives (European Commission, n.d.-c).

Voluntary frameworks also play a pivotal role. The Global Reporting Initiative (GRI) offers globally recognized standards for sustainability reporting, providing organizations with a structured approach to disclosing their environmental, social, and governance (ESG) impacts. Adherence to GRI standards embeds environmental targets for energy consumption, waste management, and GHG emissions into firms' internal monitoring systems and promotes continuous improvement in sustainability performance (GRI, n.d.; Hahn & Kühnen, 2013). Similarly, the Sustainability Accounting Standards Board (SASB) framework integrates sustainability considerations into financial reporting, which encompasses ESG factors that significantly influence a company's financial performance, operational success, and long-term value creation. Firms subject to mandatory sustainability reporting requirements tend to improve their sustainability management practices, including environmental monitoring, in alignment with investor expectations and regulatory developments (Ioannou & Serafeim, 2017).

ISO 14000 is another series of international standards, developed by the International Organization for Standardization (ISO) to provide a framework for effective environmental management systems (EMS). The most prominent standard within this series, ISO 14001 requires organizations to establish, implement, and maintain environmental objectives as part of their environmental management systems (EMS). This structured approach mandates continuous monitoring and improvement of environmental performance, with internal targets serving as a foundation for certification and external verification (ISO, 2015; Morrow & Rondinelli, 2002).

The Life Cycle Assessment (LCA) methodology, standardized under ISO 14040 and ISO 14044, complements these efforts by providing firms with a tool to evaluate environmental impacts across their entire value chain. By identifying inefficiencies and hotspots for emissions and resource use, LCA informs the setting of internal environmental objectives aimed at minimizing overall environmental footprint (Finnveden et al., 2009).

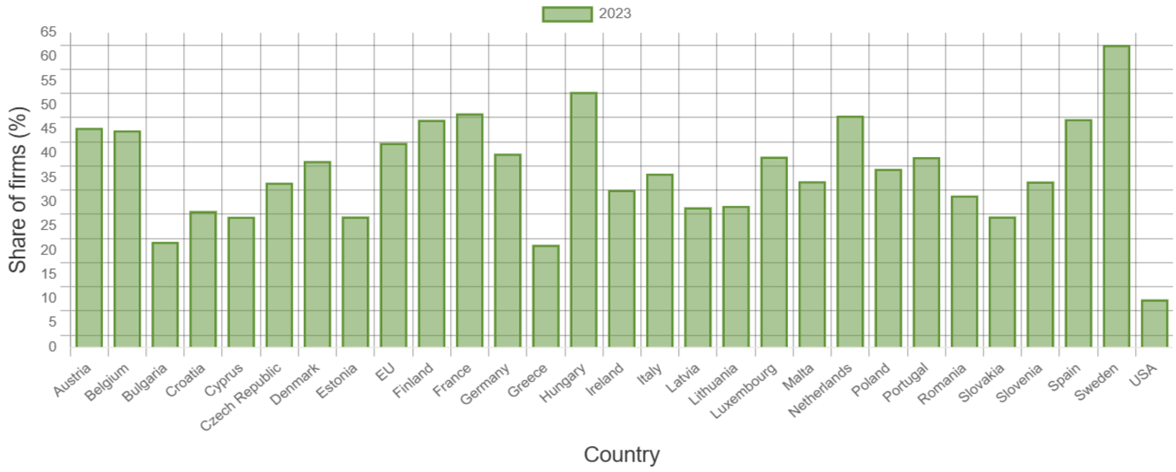
Voluntary disclosure initiatives, such as the Carbon Disclosure Project (CDP), play a pivotal role in enhancing internal target setting by encouraging firms to disclose emissions data, environmental strategies, and climate-related goals. CDP's standardized questionnaires and scoring system promote transparency and accountability, aiding companies in aligning with investor expectations and setting ambitious internal targets for emissions reduction and resource efficiency (CDP, n.d.). In addition, the Cradle to Cradle Certified® Product Standard promotes sustainable product design and circular economy principles. To meet certification criteria, firms must set clear targets related to material health, energy efficiency, and resource circularity, driving continuous improvements in environmental performance (McDonough & Braungart, 2002).

Beyond compliance and access to financing, environmental targets play a crucial role in driving operational improvements. Firms that set and pursue clear energy efficiency and emissions reduction targets often report reductions in energy consumption and operational costs, thereby strengthening their market competitiveness (EIB, 2023). Institutional research highlights that in CEE, there is growing momentum toward the adoption of formal environmental targets. Historically, CEE manufacturers faced challenges such as limited access to green financing and weaker regulatory incentives, but this gap is narrowing. According to the European Commission (2022a), EU-level policy incentives and funding mechanisms — including structural funds and green transition initiatives — are increasingly supporting firms in CEE to adopt energy and climate-related targets.

The EIB (2023) further observes that rising energy prices, policy support, and increasing pressures from global supply chains are motivating CEE firms to integrate environmental objectives into their operational strategies. Companies that proactively embrace target-setting are better positioned to access international markets and participate in sustainable procurement opportunities, aligning with the requirements of global buyers and investors (EIB, 2023).

Recent findings from the EIB Investment Survey (2023) demonstrate that several CEE economies are engaging in setting and monitoring internal targets for emissions reduction and energy consumption, reflecting the deepening integration of sustainability within corporate strategies (Figure 6). However, despite policy frameworks and disclosure standards providing the external impetus for firms to set environmental targets, it is often the implementation of specific environmental operational practices — energy management, pollution control, and resource efficiency measures — that enables firms to meet these targets and drive measurable improvements in their environmental and financial performance.

*Figure 6: Climate change targets by country*




*Source: EIB (2023).*

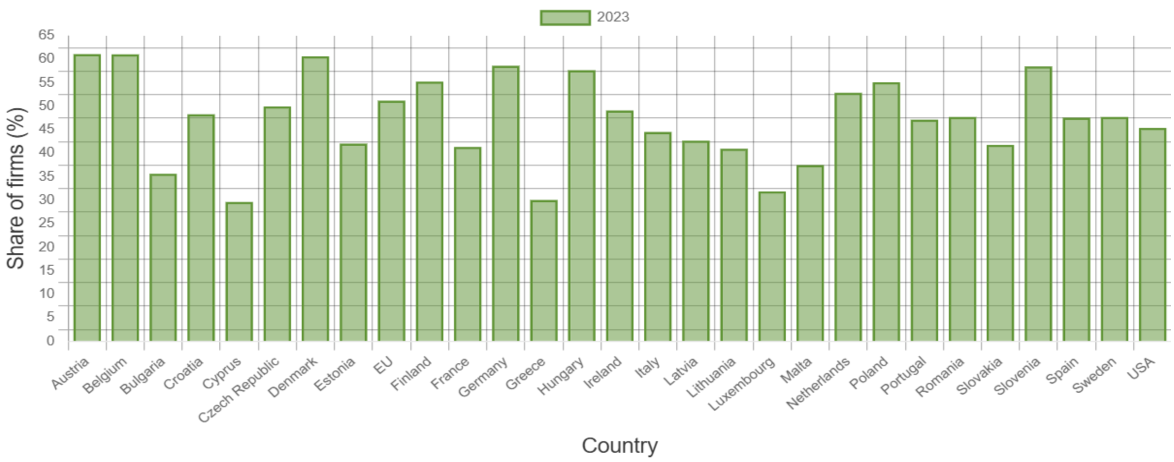
## 3.2 Green management practices

Green Management Practices (GMPs) encompass a wide range of environmentally sustainable strategies that companies, especially in the manufacturing sector, adopt to minimise their ecological footprint while enhancing overall environmental and economic performance. These practices are not only crucial for compliance with environmental regulations but also serve as a competitive advantage in an increasingly eco-conscious global market. They integrate environmental considerations into a company's operations, from production processes to supply chain management, to achieve resource efficiency, pollution prevention, green innovation, and sustainability. Firms adopting GMPs benefit from improved energy efficiency, waste reduction, lower operational costs, and a stronger reputation among consumers and stakeholders (Lun, 2011; Green et al., 2012). The following sections highlight key strategies and their contributions to both environmental and economic performance in manufacturing, supported by recent research.

Energy Management Systems (EMSs) are structured frameworks enabling firms to monitor, control, and optimize their energy consumption. According to the ISO, EMS involves creating and implementing an energy policy, establishing realistic energy use targets, and developing action plans to achieve these targets, in accordance with the international standard ISO 50001 (ISO, 2018). Empirical research suggests reduction in energy costs as a result of EMS adoption, significantly improving profit margins in the long-term. Knayer and Kryvinska (2023) analysed EMS implementation across 386 companies and concluded that compliance with ISO 50001 enhances energy efficiency, operational performance, and drives cost reductions. Halis and Halis (2021), studying Turkish industrial firms, demonstrated that EMS indirectly enhances firm performance by promoting pro-environmental energy consumption and improving energy management. Furthermore, Böttcher and Müller (2015) revealed that EMS implementation in German automotive suppliers significantly reduces carbon emissions while enhancing profitability. Collectively, these findings emphasize EMS as a pivotal driver of both energy efficiency and operational cost savings, while aligning with regulatory and environmental objectives. Despite these benefits, it is important to acknowledge that the reviewed studies caution about the high initial investment costs associated with energy management practices, which often entail longer payback periods.

Beyond traditional EMSs, firms are increasingly adopting advanced strategies such as machinery and equipment upgrades, alongside the integration of smart manufacturing technologies. The importance of energy efficiency investments is also evident in recent data from the EIB Investment Survey (2023), which shows that the share of firms investing in energy efficiency measures continues to grow across the EU, including in CEE countries (Figure 7). Notably, western European countries lead in such investments, while CEE countries including Hungary, Poland, and the Czech Republic are increasingly prioritizing energy efficiency within their investment strategies. Among EU firms, those in the manufacturing sector (60%) and large firms (63%) prioritized energy efficiency investments the most (EIB, 2023).

*Figure 7: Share of firms investing in measures to improve energy efficiency by country*




*Source: EIB (2023).*

Upgrading to energy-efficient machinery, while often requiring substantial upfront investment, has been shown to substantially reduce energy consumption. However, this financial barrier is frequently cited in the EIB Investment Survey (2023) as a key reason why firms delay or avoid energy-efficiency upgrades, particularly in cost-sensitive industries. El Abdelaoui et al. (2023) found that manufacturing plants investing in modern cutting tools and optimised motor systems experience significant reductions in energy consumption while maintaining or even enhancing productivity levels. Similarly, the UK Department for Business, Energy and Industrial Strategy (2021) reported that approximately 50% of manufacturing firms installed new equipment to improve energy efficiency. Moreover, firms implementing a combination of energy management practices — including energy monitoring, building efficiency improvements, industrial equipment upgrades, and the optimisation of heat supply systems — reported average reductions in energy usage of up to 25% compared to 2019 levels. Collectively, these technological upgrades, while associated with high upfront costs, enhance process efficiency, lower operational costs, and contribute directly to improved firm performance.

Heating and cooling system improvements play a crucial role in enhancing energy efficiency and operational cost savings in manufacturing environments. According to the International Energy Agency (2022), industrial heating and cooling processes account for nearly 50% of total final energy consumption in manufacturing, making them a significant target for efficiency upgrades. While these upgrades are also associated with high upfront investment costs and long payback periods, frequently cited by institutional sources as key barriers to implementation, they still represent a valuable tool in firms' broader environmental management strategies (EIB, 2023). A particularly effective strategy within heating and cooling improvements is the use of heat recovery systems (HRS). This is supported by the European Commission, which published the CORDIS results package on waste heat recovery, highlighting innovative clean technologies developed through Horizon 2020-funded projects. These initiatives focus on enhancing energy efficiency in industrial processes by capturing and utilizing waste heat (European Commission, 2022b). As reported by Oyedepo and Fakeye (2021), waste heat recovery technologies significantly enhance energy efficiency by repurposing waste heat from industrial processes. Their study highlights that, particularly in energy-intensive industries, these technologies offer considerable potential to reduce energy consumption and environmental impacts, contributing meaningfully to sustainable energy development.

Implementing waste reduction strategies, such as recycling and circular economy initiatives, offers significant financial and environmental benefits. Ghisellini et al. (2016) reported that recycling initiatives in manufacturing firms resulted in up to a 12% reduction in operational expenses while creating new income opportunities through the sale of recycled materials. Derhab and Elkhwesky (2023) found that micro, small, and medium-sized enterprises implementing structured waste management strategies significantly reduced waste generation while benefiting financially. Another empirical study emphasised that effective waste management not only mitigates environmental impacts but also generates revenue from recycled materials and supports regulatory compliance (Barca et al., 2024). Collectively, these strategies align with circular economy principles, delivering operational cost savings and advancing firms' sustainability objectives.

Water management is increasingly recognised as a critical component of sustainable manufacturing, particularly in the context of growing concerns over water scarcity and environmental compliance. The European Environment Agency (EEA) notes that improving wastewater treatment and adopting water recycling in industrial processes significantly contributes to reducing freshwater withdrawals and lowering pollutant discharges, thereby supporting broader water conservation objectives and regulatory compliance. It further highlights that industrial sectors with high water consumption, such as chemicals and energy supply, especially benefit from on-site treatment solutions that effectively reduce pollutant loads and protect water bodies (EEA, 2018). The OECD (2024b) similarly emphasises that integrated water management strategies — such as closed-loop recycling and advanced wastewater treatment — help reduce both water intensity and pollution loads, directly contributing to environmental sustainability goals. The European Commission (2024b) further highlights the role of water reuse and recycling in advancing circular economy principles, mitigating environmental impacts, and preserving natural water resources. Complementing these insights, recent research by Zhang and Tang (2019) demonstrates that the implementation of high-quality water management systems fosters greater self-discipline among firms, strengthening water risk management and leading to improvements in environmental performance over time.

Air pollution control measures are crucial for sustainable manufacturing, addressing both environmental and economic objectives by reducing harmful emissions such as $CO_2$, particulate matter, and sulphur oxides, which are prevalent in manufacturing processes. EEA (2024a) reported that industrial emissions decreased by 33% between 2012 and 2021, largely due to the enforcement of stricter regulations and the widespread adoption of cleaner technologies. Complementing these findings, EEA (2023) highlighted that firms participating in the EU Emissions Trading System have achieved significant emissions reductions, particularly in energy-intensive sectors. These improvements stem from investments in cleaner technologies and enhanced energy efficiency, which have simultaneously lowered compliance costs and generated operational savings for participating firms. Wang et al. (2024) further highlighted that nearly 70% of reviewed studies adopting pollution control strategies reported net economic gains, primarily through reduced healthcare costs and improved worker productivity. Beyond environmental and health benefits, air pollution control measures provide significant economic advantages. By investing in cleaner technologies, firms achieve regulatory compliance, avoid costly fines, and enhance environmental and economic performance.

Collectively, the evidence strongly supports that green management practices — including EMSs, machinery upgrades, HRSs, water management, waste management, and air pollution controls — contribute meaningfully to both financial and environmental performance in manufacturing firms. These strategies improve operational efficiency, reduce costs, and enable firms to meet increasingly stringent environmental targets related to energy efficiency, $CO_2$ emissions, and pollutants reduction, thereby establishing a strong rationale for the empirical analysis conducted in this study. While the economic benefits may materialize over longer investment horizons, the integration of green management practices remains a vital lever for firms seeking growth while advancing environmental responsibility.

In conclusion, Table 1 provides an integrated overview of the key management practices examined in this study — innovation, labour training, employment growth, external financing, and environmental management — and their theoretical linkages to firm performance. It highlights how the practices are expected to influence economic or environmental performance, based on the existing literature. While most practices are associated with positive effects, some, such as external financing and green practices, reveal more nuanced or delayed outcomes due to cost structures or contextual factors. This summary emphasizes the interdependent and strategic role of these practices in shaping firm-level outcomes, setting the stage for the empirical investigation that follows.

*Table 1: Summary of management practices and their theoretical linkages to firm performance*

| **Management practice** | **Theoretical finding** | **Performance dimension** | **Expected effect** |
|---|---|---|---|
| Product innovation | Drives revenue by enabling market expansion and demand responsiveness. | Economic (sales growth) | Positive |
| Process innovation | Enhances efficiency, operations, and adaptability, indirectly raising revenue. | Economic (sales growth) | Positive, indirect |
| Labour training | Increases employee productivity through skills development. | Economic (sales per employee) | Positive |
| Permanent workforce growth | Increases operational capacity, enabling sales expansion. | Economic (sales growth) | Positive |
| External financing | Supports investment and profitability, but may reflect financial stress or increase short-term costs. | Economic (profitability) | Positive, ambiguous in broader literature |
| Green management practices | Operational and sustainable improvements support environmental commitments. | Environmental (target adoption) | Positive |
| Green management practices | Drives operational and cost efficiency, increasing profitability, but may also involve high upfront costs that delay financial returns. | Economic (profitability) | Positive, short-term effects may be limited |

*Source: Own work.*

# 4 RESEARCH DESIGN FOR MANAGEMENT PRACTICES, GREEN TRANSITION AND FIRM PERFORMANCE

This chapter outlines the overall research design used to examine the relationship between management practices and firm performance in the CEE manufacturing sector. It begins by presenting the key hypotheses derived from the theoretical framework and literature review. The chapter then describes the employed methodology, including data description and sampling criteria. Together, these elements form the basis for testing the proposed hypotheses and addressing the research questions.

## 4.1 Research goals and hypotheses

Building on the theoretical framework and research questions, the following hypotheses are formulated to specify how selected management practices are expected to influence firm performance.

Numerous studies highlight that both product and process innovations are crucial for enhancing firm competitiveness and driving sales growth in manufacturing. Product innovation enables firms to respond to evolving customer demands, penetrate new markets, and differentiate from competitors, while process innovation improves production and operational efficiency, and enhances product quality, both contributing to revenue growth (OECD, 2021b; Camison & Lopez, 2010; Atalay et al., 2013; Tavassoli & Karlsson, 2015; Na & Kang, 2019). Particularly for CEE firms, where innovation adoption is increasingly supported by policy initiatives, these activities are strongly associated with improved firm performance (World Bank, 2020; EIB, 2023). Therefore, hypothesis H1 was developed.

H1: Innovation management practices — product and process innovation — positively impact firm economic performance, measured by sales growth rate, in the manufacturing sector.

Extensive research confirms that workforce training enhances firm-specific human capital, leading to increased productivity and operational efficiency (Martins, 2021; Toner, 2011; Zwick, 2006). Firms investing in continuous training programmes are better positioned to adopt advanced manufacturing processes and maintain competitiveness in dynamic markets, especially in the CEE region, where skill shortages and technological transitions require sustained human capital development (OECD, 2021c; CEDEFOP, 2022). Therefore, hypothesis H2a was developed.

H2a: Labour training positively impacts firm economic performance, measured by sales per employee, in the manufacturing sector.

Permanent employment fosters workforce stability, strengthens organisational knowledge, and supports sustained operational excellence. Research demonstrates that firms expanding their permanent workforce experience higher innovation output, better process efficiency, and stronger market responsiveness (Han et al., 2025; Lim & Mali, 2022; OECD, 2021a). In manufacturing sectors, stable employment structures contribute to productivity improvements and resilience against external shocks, thereby supporting long-term competitiveness (World Bank, 2019b; ILO, 2020). Thus, hypothesis H2b was developed.

H2b: An increase in the number of permanent employees positively impacts firm economic performance, measured by sales growth rate, in the manufacturing sector.

Access to external financing provides firms with critical liquidity to fund investments in innovation, capacity expansion, and workforce development (OECD, 2020; World Bank, 2019a). Empirical research indicates that firms with external financing, credit lines or loans, are better equipped to navigate market disruptions, finance growth initiatives, and improve profitability through enhanced financial flexibility (Beck & Demirguc-Kunt, 2006; Garcia-Teruel & Martinez-Solano, 2007). In the context of CEE manufacturing, where financing constraints remain a key challenge, credit availability plays a pivotal role in strengthening firm performance (EIB, 2023; OECD 2020b). Thus, hypothesis H3 was established.

H3: External financing — line of credit or loan — positively impacts firm economic performance, measured by profit margin, in the manufacturing sector.

Theoretical and empirical findings consistently underline that the implementation of multiple green management practices enables firms to meet environmental objectives and adopt formal environmental targets (European Commission, 2023). Practices such as energy management systems, waste and water management, air pollution controls, and machinery upgrades collectively contribute to reduced resource consumption, lower emissions, and improved regulatory compliance (ISO, 2018; Derhab & Elkhwesky, 2023; Horbatch et al., 2012; EEA, 2024b; El Abdelaoui et al., 2023). Firms adopting these integrated strategies signal stronger environmental commitment and align with evolving policy expectations. Thus, hypothesis H4a was developed.

H4a: The adoption of environmental management practices — energy management, waste management, water management, air pollution control measures, and machinery upgrades — leads to improved firm environmental performance, indicated by the adoption of environmental targets, in the manufacturing sector.

Empirical research demonstrates that adopting environmental management practices generates significant cost savings and operational efficiencies, which contribute to improved financial performance over time (Lun, 2011; Green et al., 2012). Measures such as energy management and machinery upgrades lower energy costs, waste management reduces disposal expenses, and heating and cooling improvements enhance overall energy efficiency (Knayer & Kryvinska, 2023; Oyedepo & Fakeye, 2021; Ghisellini et al., 2016; El Abdelaoui et al., 2023). Although the upfront investment required for implementing these practices may impact short-term profitability, the cumulative benefits typically emerge over a longer horizon—strengthening firms' cost structures, enhancing regulatory compliance, and supporting competitive positioning in sustainability-driven markets. Thus, hypothesis H4b was developed.

H4b: The adoption of environmental management practices — energy management, waste management, machinery upgrades, and heating and cooling improvements — positively impacts firm economic performance, measured by profit margin, particularly over longer investment horizons, given the potential delayed return on such investments, in the manufacturing sector.

## 4.2 Research methodology

To address the research questions and hypotheses, this study adopts a quantitative, cross-sectional research design, utilizing statistical analysis to examine the relationship between management practices and firm performance in the manufacturing sector of the CEE region. Rather than collecting primary data, this study is based on secondary data derived from the publicly available 2018 EBRD-EIB-WBG Enterprise Survey (Manufacturing Module), a reputable and comprehensive dataset widely used for firm-level research in emerging economies. The Enterprise Survey is a collaborative initiative by the World Bank Group (WBG), the European Bank for Reconstruction and Development (EBRD), and the European Investment Bank (EIB). It is designed to evaluate firm-level performance, management practices, and the broader business environment in emerging and transition economies (EBRD et al., 2022).

Although the survey is officially designated as the 2018 wave and data collection was predominantly conducted in 2018, in some countries the fieldwork extended into 2019 and early 2020. For consistency, this thesis refers to it as the 2018 survey wave, in accordance with institutional reporting practices. Regarding the timing of firm-level data, the last fiscal year reported varies slightly across respondents, predominantly covering 2018, with a smaller proportion of firms referring to either 2017 or 2019 as their most recent fiscal year. The survey covers data from over 18,000 firms across more than 40 countries, including the CEE region, making it a valuable source for analysing firm-level dynamics (EBRD et al., 2022)

To ensure data consistency and cross-country comparability, the Enterprise Survey follows a standardized data collection methodology. Data were gathered through structured, face-to-face interviews with business owners and top managers of the surveyed firms. Furthermore, the Manufacturing Module of the 2018 EBRD-EIB-WBG Enterprise Survey applies a stratified sampling approach to ensure the inclusion of firms of varying sizes — from SMEs to large firms — across multiple manufacturing sub-sectors and geographical locations (EBRD et al., 2018).

Specifically, the module focuses on manufacturing firms, providing granular, firm-level insights into management practices, including innovation activities, workforce training and composition, financing sources, environmental strategies, and key performance metrics. The dataset also includes detailed firm characteristics, such as firm size, firm age, and ownership structure. This breadth of information enables a comprehensive examination of how management practices influence both economic and environmental performance in the manufacturing sector, making it well-suited for testing the proposed hypotheses. The analysis is based on cross-sectional firm-level data from five selected CEE countries, chosen to align with the research objectives and ensure sufficient data representation across the region.

Before conducting the analysis, the dataset was cleaned, and necessary preparation steps were applied to ensure robustness. Following this step, descriptive statistics are provided to summarize key variables, while inferential statistics — primarily regression models — are used to test the research hypotheses. All statistical analyses were conducted using the R programming language, which was employed for data management, visualization, and econometric analysis. The structured and comprehensive nature of the Enterprise Survey dataset provides a solid foundation for rigorous empirical investigation, enabling the derivation of meaningful conclusions on how management practices influence both economic and environmental performance in the CEE manufacturing sector.

## 4.3 Data description

The dataset derived from the 2018 EBRD-EIB-WBG Enterprise Survey captures key information on management practices, firm performance (both economic and environmental), and firm-specific characteristics such as country, firm size, and firm age. To assess the impact of management practices on firm performance, the dataset includes three main groups of variables: dependent variables (performance indicators), independent variables (management practices), and control variables (country, firm size, and firm age), as shown in Table 2.

The analysis includes both binary and continuous variables to capture different dimensions of firm behaviour and performance. Binary variables indicate the presence or absence of specific management practices or outcomes, while continuous variables reflect performance metrics and operational changes over time. This approach allows the model to assess both structural characteristics and dynamic operational outcomes.

While capital is a common control variable in firm performance analysis, this study uses firm size category as a proxy due to data limitations. Firm size serves as a practical indicator of resource availability, scalability, and operational complexity, but does not capture capital intensity, asset quality, or investment structure — all of which may influence firm outcomes. This limitation may introduce omitted variable bias, which is acknowledged in the analysis.

*Table 2: Overview of variables used in the empirical analysis*

| | |
|---|---|
| **Dependent variables** | Sales growth rate (3-year) (%) |
| | Sales per employee (EUR) |
| | Profit margin (%) |
| | Environmental targets (Yes/No) |
| **Independent variables** | Product innovation (Yes/No) |
| | Process innovation (Yes/No) |
| | Labour training (Yes/No) |
| | Permanent employees' growth rate (3-year) (%) |
| | Line of credit/loan (Yes/No) |
| | Energy management (Yes/No) |
| | Waste management (Yes/No) |
| | Water management (Yes/No) |
| | Air pollution controls (Yes/No) |
| | Machinery upgrades (Yes/No) |
| | Heating and cooling improvements (Yes/No) |
| **Control variables** | Country (category) |
| | Firm size (category) |
| | Firm age (category) |

*Source: Own work.*

The empirical analysis in this thesis is inspired by the foundational work of Bloom and Van Reenen (2006), who systematically examined the relationship between management practices and firm performance using structured survey data and regression analysis. Their study, focused on the manufacturing sector, demonstrated how internal management quality—particularly in operations, performance monitoring, and incentives—can shape firm-level productivity and profitability. Building on their framework, this thesis extends the analysis to manufacturing firms in the CEE region and investigates how broader management dimensions—namely innovation, labour development, external financing, and environmental practices—affect broader dimensions of firm performance.

The following sections describe the variables selected for the empirical analysis, including their construction, measurement, and relevance to the research objectives. Survey questions are cited directly from the 2018 EBRD-EIB-WBG Enterprise Survey, which served as the basis for variable construction. The section concludes with a description of the sample and the applied sampling criteria.

### 4.3.1 Dependent variables – performance indicators

Performance indicators were selected based on established literature in firm performance research, particularly in the manufacturing sector. Each indicator reflects a different dimension of firm success, enabling a comprehensive assessment of economic and environmental outcomes. Three key indicators are used to capture firm-level economic performance and one indicator for environmental performance, as outlined below.

— Sales growth rate (3-year) (%) reflects a firm's ability to expand its market presence and increase revenue over time. This indicator is widely used as a proxy for firm growth and competitiveness, especially relevant in the context of the CEE manufacturing sector where economic dynamics are evolving rapidly (Coad & Rao, 2008). It is calculated as the percentage change in total annual sales over a three-year period, comparing the most recent fiscal year with three years prior.

— Sales per employee (EUR) serves as a measure of labour productivity, reflecting how efficiently firms utilize their workforce to generate revenue. Given the importance of productivity in manufacturing, this variable offers valuable insights into operational efficiency (Syverson, 2011). It is calculated by dividing total annual sales in the last fiscal year by the number of permanent full-time employees at the end of that fiscal year. Since the sales per employee metric was originally reported in local currency units, it was converted to euros (EUR) to enable cross-country comparability. The conversion used the average exchange rates from the European Central Bank for the year 2018, aligning with the timing of the survey implementation. Specifically, the following exchange rates were applied for countries outside the Eurozone: Poland (PLN 4.2615), Czech Republic (CZK 25.647), and Hungary (HUF 318.89) (ECB, 2019).

— Profit margin (%) measures firm's operational profitability, capturing the proportion of sales revenue that remains after covering the direct costs of production. A higher profit margin indicates efficient cost management and stronger financial performance, which is especially relevant for manufacturing operations, as it highlights their ability to manage production costs effectively while maintaining revenue streams (Bloom & Van Reenen, 2006). The profit margin is calculated using gross margin methodology based on data availability, as the difference between total annual sales and total annual cost of sales, divided by total annual sales, for last fiscal year.

— Adoption of environmental targets is used in this study as an indicator of commitment to sustainability and as a proxy for firms' environmental performance. Firms that set specific targets demonstrate their intent to actively manage and monitor their environmental impact, aligning their operations with broader sustainability frameworks and regulatory expectations. A composite binary variable was constructed based on firms reporting adoption of environmental targets in one or more key environmental areas: energy consumption, $CO_2$ emissions, and other pollution emissions. Firms that reported adopting at least one of these environmental targets were coded as "Yes," indicating proactive environmental management. The specific survey questions used to construct each dependent variable are summarized in Table 3.

*Table 3: Dependent variables derived from the 2018 EBRD-EIB-WBG Enterprise Survey questions*

| **Dependent variable** | **Survey questions used** |
|---|---|
| Sales growth rate (3-year) (%)<br>(Continuous variable) | *"D.2: In fiscal year [Insert last complete fiscal year], what were this establishment's total annual sales for all products and services?"*<br>*"N.3: Looking back to fiscal year [Insert last complete fiscal year minus two], what were total annual sales for this establishment?"* |
| Sales per employee (EUR)<br>(Continuous variable) | *"D.2: In fiscal year [Insert last complete fiscal year], what were this establishment's total annual sales for all products and services?"*<br>*"L.1: At the end of fiscal year [Insert last complete fiscal year], how many permanent, full-time individuals worked in this establishment?"* |
| Profit margin (%)<br>(Continuous variable) | *"D.2: In fiscal year [Insert last complete fiscal year], what were this establishment's total annual sales for all products and services?"*<br>*"N.2 From this establishment's Income Statement for fiscal year [Insert last complete fiscal year], please provide the following information: Total cost of sales"* |
| Environmental targets<br>(Binary variable: 1=Yes, 0=No) | *"BMGC.16: Over the last three years, did this establishment have targets for energy consumption?"*<br>*"BMGC.18: Over the last three years, did this establishment have targets for $CO_2$ emissions?"*<br>*"BMGC.20: Over the last three years, did this establishment have targets for pollution emissions other than $CO_2$?"* |

*Source: Own work based on EBRD, EIB, & WBG (2018).*

### 4.3.2 Independent variables – management practices

Management practices were identified and selected from the survey to align with the study's research objectives, capturing firms' approaches to innovation, labour development, external financing, and environmental management. These variables represent key drivers of firm performance, commonly emphasized in the literature of organizational competitiveness, productivity, and sustainable growth.

Innovation is widely recognized as a primary factor contributing to firm competitiveness and long-term performance, particularly in manufacturing industries. To capture firms' engagement in innovation, two binary variables were used: product innovation and process innovation, reflecting both market-oriented and operational aspects of innovative activities.

Human capital management practices are crucial for enhancing firm productivity, especially in manufacturing sectors that rely on skilled labour and process efficiency. Two variables (binary and continuous) were constructed to reflect firms' commitment to workforce development: labour training indicating implementation of formal training programs for permanent employees, and percentage growth in permanent full-time employment over a three-year period, reflecting the expansion of stable employment.

External financing is another determinant of firm performance, particularly influencing investment capacity and financial stability. This study includes a binary variable capturing whether firms maintain an active line of credit or loan from a financial institution, allowing for the assessment of the potential relationship between debt financing and firm profitability.

Environmental management reflects firms' efforts to align operations with sustainability goals, regulatory compliance, and corporate social responsibility. A composite set of relevant environmental practices was captured, focusing on multiple aspects of resource management and pollution control in order to assess their impact in the surveyed firms. The specific survey questions used to construct each independent variable are summarized in Table 4.

*Table 4: Independent variables derived from the 2018 EBRD-EIB-WBG Enterprise Survey questions*

| **Independent variable** | **Survey questions used** |
|---|---|
| Product innovation<br>(Binary variable: 1=Yes; 0=No) | *"H.1 During the last three years, has this establishment introduced new or improved products or services?"* |
| Process innovation<br>(Binary variable: 1=Yes; 0=No) | "*H.5 During the last three years, has this establishment introduced any new or improved process?"* |
| Labour training<br>(Binary variable: 1=Yes; 0=No) | "*L.10 Over fiscal year [Insert last complete fiscal year], did this establishment have formal training programs for its permanent, full-time employees?*" |
| Permanent employees' growth rate (%)<br>(Continuous variable) | *"L.1 At the end of fiscal year [Insert last complete fiscal year], how many permanent, full-time individuals worked in this establishment?"*<br>*"L.2 Looking back, at the end of fiscal year [Insert last complete fiscal year minus two], how many permanent, full-time individuals worked in this establishment?"* |
| Line of credit/loan<br>(Binary variable: 1=Yes; 0=No) | *"K.8: At this time, does this establishment have a line of credit or a loan from a financial institution?"* |
| Environmental management practices<br>(Binary variables: 1=Yes; 0=No):<br><br>-Energy management<br>-Waste management<br>-Water management<br>-Air pollution controls<br>-Machinery upgrades<br>-Heating and cooling improvements | *"BMGC.23: Over the last three years, did this establishment adopt any of the following measures?"*<br>*Energy management - BMGc23d*<br>*Waste minimization, recycling, and waste management - BMGc23e*<br>*Water management - BMGc23g*<br>*Air pollution control measures - BMGc23f*<br>*Machinery and equipment upgrades - BMGc23c*<br>*Heating and cooling improvements - BMGc23a* |

*Source: Own work based on EBRD, EIB, & WBG (2018).*

#### 4.3.3 Sampling criteria and description of sample

To ensure that the dataset aligns with the research objectives, specific sampling criteria were applied to construct a focused and relevant sub-sample. The aim was to include manufacturing firms with diverse characteristics across countries, sizes, and organizational types within the CEE region. Firms were retained if they were fully privately owned, belonged to the manufacturing sector, had independent financial reporting (i.e., not part of a multi-establishment firm with consolidated financial statements), and had complete responses for key performance variables. Observations with missing values in key variables were removed, and all variables were screened for outliers. In cases where outliers were likely to distort results, selected variables were transformed to reduce their impact. The sample includes firms from five countries — Czech Republic, Hungary, Poland, Slovakia, and Slovenia — selected to represent the CEE region due to their shared economic characteristics, industrial history, and significance as manufacturing hubs.

These post-transition economies provide a suitable context for examining how management practices influence firm performance in evolving market environments. The sample also captures variation in firm size (small, medium, and large enterprises) and age groups (young, mature, and old), based on international standards. Firm size was categorized as follows: small (5–19 employees), medium (20–99 employees), and large (100 or more employees), based on the EBRD-EIB-WBG Enterprise Survey (2018). Firm age was initially categorized as follows: young (0–5 years), mature (6–15 years), and old (16+ years), based on groupings adapted from the EBRD-EIB-WBG Enterprise Survey (2018) dataset.

Applying these criteria resulted in a filtered sample that captured sufficient variation across countries, firm sizes, and age groups, while ensuring consistency and relevance for the empirical analysis. Although the EBRD-EIB-WBG Enterprise Survey includes sampling weights to improve representativeness at the national level, the analysis in this study was conducted without applying weights, as the focus was on firm-level relationships within a cleaned and filtered sub-sample.

The initial sample consisted of 1,985 firms across the selected CEE countries. However, to maintain data reliability and completeness for hypothesis testing, firms with incomplete responses in the key dependent variables for performance metrics were excluded. The final samples are as follows:

— Baseline sample: A total of 1,283 firms were retained for the models analysing economic performance, measured by sales growth rate and sales per employee, as well as for environmental performance, measured by the adoption of environmental targets. This sample serves as the baseline for the study analysis. Specifically, the initial sample of 1,985 observations was cleaned to exclude firms with incomplete responses to the variables of total annual sales for the last fiscal year and total annual sales from three years prior, where responses were recorded as “Don’t know” or “Does not apply” (in case where the firm was not in operation three years prior). Although environmental performance is measured using a different indicator, the same baseline sample is retained to ensure consistency across models and maintain comparability of results.

— Reduced sample: The baseline sample of 1,283 observations was further reduced to 1,166 firms for the models analysing profit margin, due to additional incomplete responses in the variable for total cost of sales for the last fiscal year, where firms responded "Don't know".

The variation in both sample sizes reflects differences in data availability for each performance metric. Despite these differences, the sample sizes remain sufficiently large to support statistically meaningful analysis and representativeness is maintained, as demonstrated by the consistency in firm characteristics across both samples. Incomplete responses in the independent variables are addressed later in the descriptive statistics and hypotheses testing sections to ensure the robustness of the regression models. The following tables present the distribution of firm characteristics, defined by firms with complete data for the respective models.

Table 5 presents the distribution of firms across the five selected CEE countries. Within the baseline sample (1,283 firms), the largest share of firms is from Hungary (28.37%) and Poland (24.39%), followed by the Czech Republic (21.20%), Slovakia (14.50%), and Slovenia (11.53%). While some variation exists, this distribution reasonably reflects the economic size, industrial activity, and manufacturing presence in these countries, ensuring sufficient geographic diversity for robust analysis. In the reduced sample (1,166 firms), the distribution of firms across countries remains largely stable. For example, Hungary and the Czech Republic experience only slight proportional increases (to 30.45% and 23.23%, respectively), while Poland's share decreases moderately to 18.95%. These changes are minimal, ensuring that the reduced sample remains representative.

To mitigate country-specific effects on firm performance, the regression models include country fixed effects. This approach controls for economic, policy, and industrial structural differences across the selected CEE countries, ensuring that the observed effects on firm performance are not driven by country-level differences.

*Table 5: Frequency table for country distribution*

| | **Baseline sample (1,283 firms)** | | **Reduced sample (1,166 firms)** | |
|---|---|---|---|---|
| **Country** | **N** | **%** | **N** | **%** |
| Czech Republic | 272 | 21.20% | 271 | 23.23% |
| Hungary | 364 | 28.37% | 355 | 30.45% |
| Poland | 313 | 24.39% | 221 | 18.95% |
| Slovakia | 186 | 14.50% | 186 | 15.95% |
| Slovenia | 148 | 11.53% | 133 | 11.41% |

*Source: Own work.*

Table 6 presents the distribution of firms by size in both samples. The baseline sample (1,283 firms) includes a diverse range of firm sizes, with small firms accounting for 40.14%, medium firms for 35.54%, and large firms for 24.32%. This distribution reflects typical firm size patterns in the manufacturing sector, where SMEs are often more prevalent. In the reduced sample (1,166 firms), the proportional distribution across firm sizes remains nearly identical. Specifically, small firms represent 39.96%, medium firms 35.76%, and large firms 24.28% of the sample. This stability minimizes concerns about sample bias and indicates that the exclusion of firms with missing data did not disproportionately affect any particular firm size category.

To further account for performance differences driven by firm size, firm size fixed effects are included in the regression models. This approach accounts for size-related characteristics such as resource availability, operational complexity, and strategic decision-making, ensuring that the observed effects reflect the impact of management practices and environmental strategies, rather than differences arising from firm size.

*Table 6: Frequency table for firm size distribution*

| | **Baseline sample (1,283 firms)** | | **Reduced sample (1,166 firms)** | |
|---|---|---|---|---|
| **Firm Size** | **N** | **%** | **N** | **%** |
| Small | 515 | 40.14% | 466 | 39.96% |
| Medium | 456 | 35.54% | 417 | 35.76% |
| Large | 312 | 24.32% | 283 | 24.28% |

*Source: Own work.*

Table 7 presents the distribution of firms by age in both samples. To address the limited number of observations among younger firms, the categories of young (0–5 years) and mature firms (6–15 years) were combined into a single group, for ensuring sufficient statistical power. In the baseline sample, young and mature firms together account for 28.61%, while older firms (more than 15 years) represent the majority at 71.29%. In the reduced sample, this distribution remains stable, with young and mature firms comprising 28.72% and older firms 71.20%. These minimal changes confirm that the reduced sample remains representative in terms of firm age distribution.

Due to longer development cycles and capital intensity in manufacturing, older firms dominate the sample. To account for this and minimize bias, firm age fixed effects were included in the regressions, ensuring that observed performance differences reflect management and environmental practices—not firm maturity.

*Table 7: Frequency table for firm age distribution*

| | **Baseline sample (1,283 firms)** | | **Reduced sample (1,166 firms)** | |
|---|---|---|---|---|
| **Firm Age** | **N** | **%** | **N** | **%** |
| Young & Mature firms (0-15 years) | 368 | 28.68% | 336 | 28.82% |
| Large (> 15 years) | 915 | 71.32% | 830 | 71.18% |

*Source: Own work.*

In summary, the final two samples provide a robust and representative basis for exploring the relationship between management practices, firm characteristics, and performance outcomes in the CEE manufacturing sector. Samples attrition due to incomplete data is limited and does not compromise the integrity or generalizability of the findings. While differences in representation across countries, firm sizes and age groups are observed, these distributions reflect the actual composition of the manufacturing sector in the CEE region. Additionally, to account for structural firm characteristics that may influence performance outcomes, country, firm size, and firm age were included as control variables in the regression models. This ensures that the estimated relationships between management practices and firm performance are not confounded by geographic, organizational scale, or maturity-related effects.

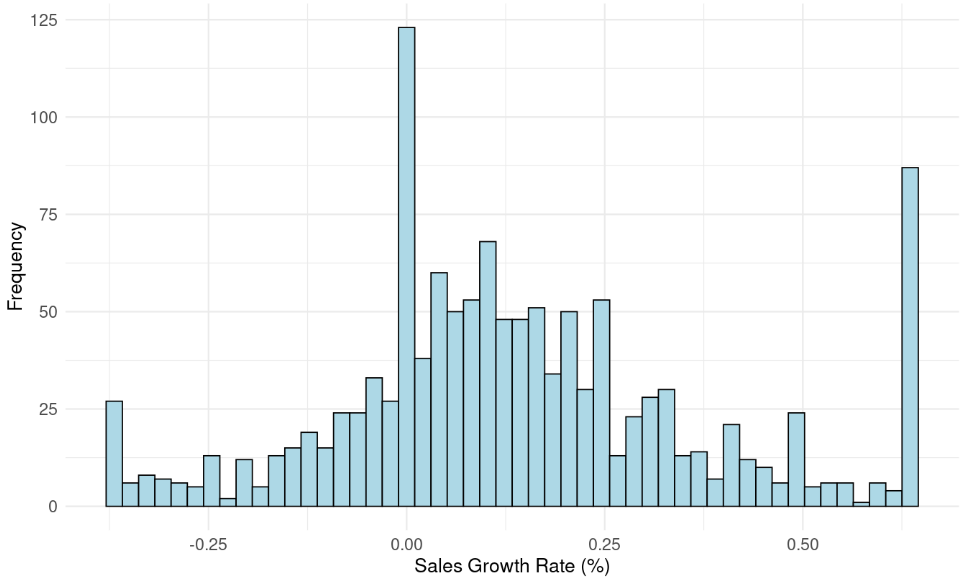
# 5 RESEARCH RESULTS AND ANALYSIS

## 5.1 Descriptive analysis

This section presents descriptive statistics and initial analysis insights into the relationships among the variables, providing a comprehensive data overview prior to hypotheses testing. First, a summary of key characteristics of the performance indicators and management practices is presented. Due to the presence of outliers and volatility in their distributions, several variables — specifically sales growth rate, sales per employee, profit margin, and permanent employees' growth rate — were transformed. These transformations were applied to enhance comparability and improve model robustness, particularly for the subsequent regression analyses. Detailed descriptive statistics and documentation of the original and transformed variables are provided in Appendix A.

The interquartile range (IQR)–based winsorization method, using the conventional threshold of 1.5 × IQR, was applied to the sales growth rate variable. This adjustment affected approximately 6.31% of the observations. The winsorized sales growth rate, based on a dataset of 1,283 observations, has a mean of 14.02% and a standard deviation of 23.15 % (Figure 8).

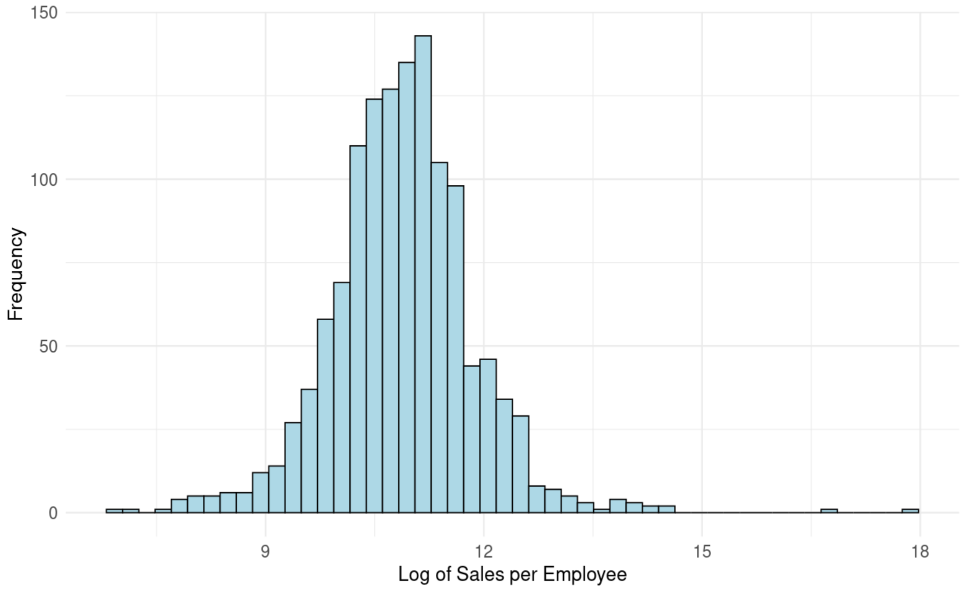
*Figure 8: Sales growth rate (3-year)*




*Source: Own work.*

Sales per employee (EUR) was log-transformed to address extreme variation across firms. Based on 1,283 observations, the transformed variable has a mean of 10.88 and standard deviation of 0.99 (Figure 9). No observations were excluded, but the proportion of statistical outliers decreased from 8.57% pre-transformation to 3.98% post-transformation.

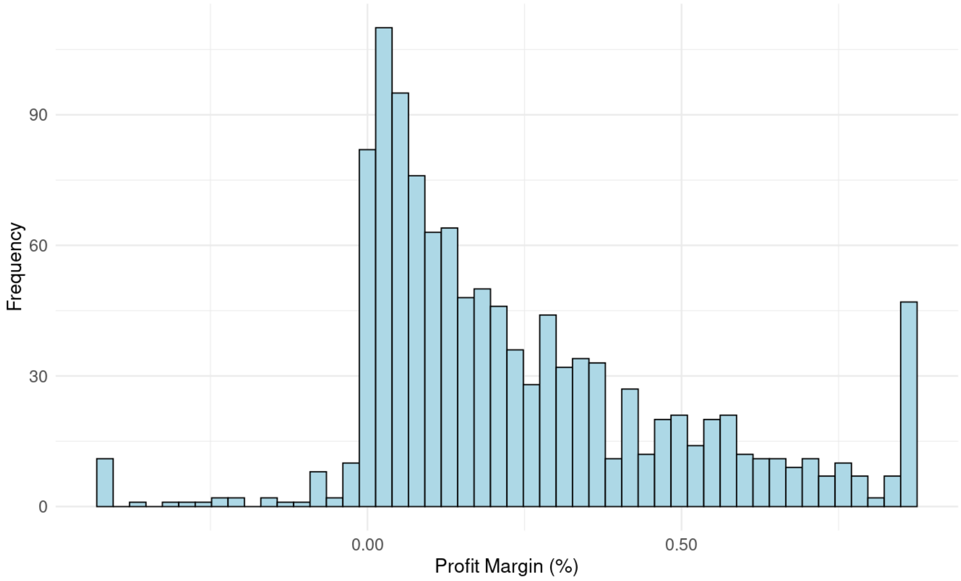
*Figure 9: Log of sales per employee*




*Source: Own work.*

The standard IQR–based winsorization method (1. 5 × IQR) was also applied to the profit margin variable affecting 4.80% of the dataset. Winsorized profit margin with 1,166 observations, has a mean of 24.10 % and a standard deviation of 25.15 % (Figure 10).

*Figure 10: Profit margin*




*Source: Own work.*

Following the presentation of distributions and transformations, descriptive comparisons are made across country and firm size groups for each performance indicator. This provides an initial view of cross-sectional variation and supports later regression analysis by highlighting key differences in firm performance by structural characteristics.

The average sales growth rate varied across countries and firm sizes. As seen in Figure A.4, among the five CEE countries, Slovenia (17.50%) and Hungary (17.16%) recorded the highest mean sales growth rates over the last three years, while Slovakia exhibited the lowest (11.02%). At the firm-size level, medium-sized enterprises experienced the highest average growth (16.23%), followed by large firms (13.11%) and small firms (12.39%) (Figure A.5).

In terms of distribution, 62.90% of the firms have experienced growth of 5% and above. Meanwhile, 21.04% of the firms experienced decline in sales and 16.06% reported relatively stable performance, growing between 0% and 5%. These results indicate that while a significant portion of firms achieved high growth, a notable share also faced stagnation or contraction in their sales performance. *(*Figure A.6).

The mean log of sales per employee (EUR) shows modest variation across countries and firm sizes. Among countries, Slovenia recorded the highest productivity level with a mean log value of 11.49, followed by Slovakia (11.18) and Czech Republic (11.08). Poland exhibited the lowest productivity with a mean of 10.43 (Figure A.10). A similar pattern emerges across firm sizes: large firms had the highest average sales per employee (11.30), followed by medium firms (10.90) and small firms (10.62) (Figure A.11). While log values appear close, these differences translate to substantial disparities in real EUR terms, given the exponential nature of the log scale. For instance, the difference between 10.43 and 11.49 implies more than threefold difference in actual sales per employee.

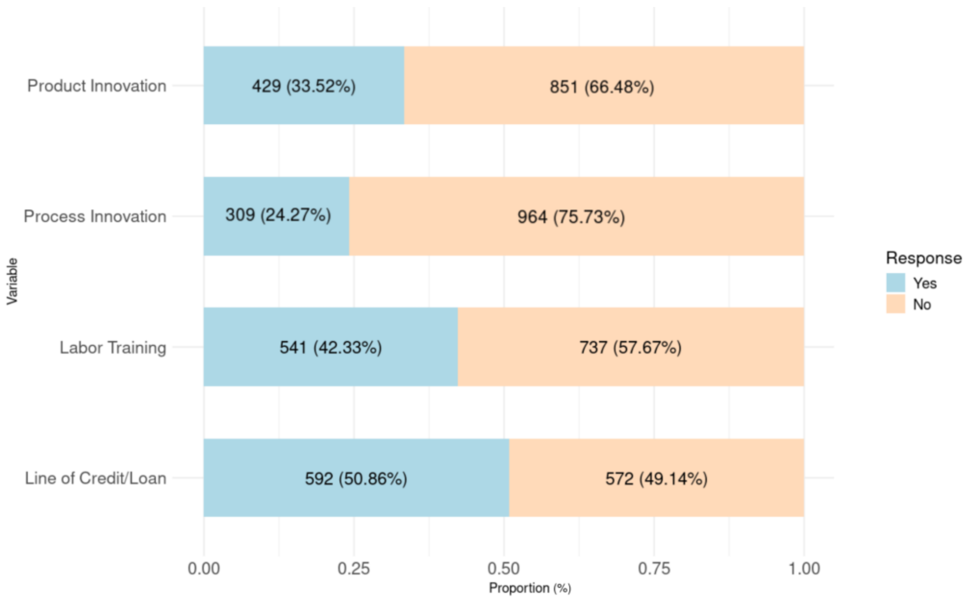
The winsorized profit margin variable displays considerable variation across countries and firm sizes. Among the five CEE countries analysed, Poland shows the highest mean profit margin at 40.77%, followed by Slovenia (27.79%) and Hungary (24.63%). In contrast, Slovakia exhibits the lowest average profit margin at only 6%, suggesting potential structural or cost-related challenges in its manufacturing sector (Figure A.15). When disaggregated by firm size, smaller firms report the highest mean profit margin (26.45%), followed by medium-sized firms (24.63%), while large firms show the lowest mean at 19.46%. This pattern may reflect greater agility or niche specialization among smaller firms, although further investigation is needed to assess causality (Figure A.16).

In terms of performance distribution, the majority of firms fall into the high increase category (>20%), representing 45.53% of the sample, while 30.24% fall within moderate increase (5–20%) and 19.93% within stable margins (0–5%). Only 4.3% of firms reported a decline in profit margins. This distribution reflects an overall positive profitability trend in the region's manufacturing sector (Figure A.17).

Moving forward, the distribution of the remaining independent variables presented in Figure 11 illustrates the extent to which firms have adopted various management practices that are later examined in the regression analysis. Each variable had a specific number of incomplete responses which were answered as "Don't know" or "Does not apply" (if the firm was not in operation three fiscal years prior). The distributions for product innovation, process innovation, and labour training are based on the baseline sample of 1,283 firms, adjusted for incomplete responses, while the distribution of the line of credit/loan variable is based on the reduced sample of 1,166 firms, reflecting the subsample used for profit margin analysis where this variable is applied.

Specifically, 33.52% (429 firms) reported implementing product innovation in the past three years, while 66.48% (851 firms) indicated they had not, with three incomplete responses. For process innovation, 24.27% (309 firms) stated they had adopted this practice in the past three years, whereas 75.73% (964 firms) reported they had not. This variable had an additional 10 incomplete responses. Regarding labour training, 42.33% (541 firms) reported having formal training programs for their employees in the last fiscal year, while 57.67% (737 firms) reported they did not. This variable had five incomplete responses. Related to an active line of credit or loan, 50.86% (592 firms) reported they currently had access, while 49.14% (572 firms) reported they did not. Two incomplete responses were found for this variable.

*Figure 11: Management practices adoption*



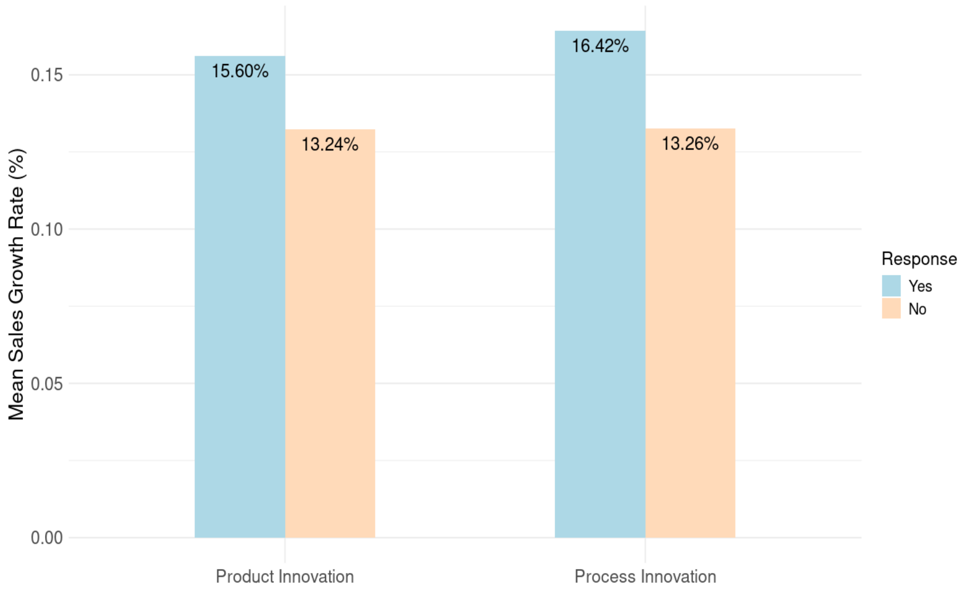

*Source: Own work.*

Among the independent variables, the three-year growth rate of permanent employees is the only independent variable that was also winsorized to mitigate the influence of extreme values and enhance the robustness of the analysis (Figure A.19). Instead of applying the conventional IQR threshold, an adjusted threshold of 2 × IQR was used to adopt a more conservative approach, balancing the retention of meaningful variation with control over outliers. Based on a sample of 1,261 observations (after reducing the baseline sample of 1,283 observations for 22 incomplete responses in the permanent employees' growth rate variable), approximately 9.36% of the values were identified as statistical outliers and winsorized. The resulting variable has a mean of 7.26%, a median of 1.92%, a standard deviation of 17.87%, and 25th and 75th percentiles of 0% and 16.67%, respectively.

When analysing the relationship between innovation practices and firm performance, firms that reported implementing product innovation in the last three years demonstrated a higher mean sales growth rate of 15.60%, compared to 13.24% for those that did not. A similar pattern is observed for process innovation, where implementing firms had a mean sales growth rate of 16.42%, as opposed to 13.26% for non-implementers (Figure 12).

At the country level, the highest adoption of product innovation was observed in the Czech Republic (124 firms) and Slovenia (111 firms), while Slovakia had the lowest uptake with only 36 firms (Figure A.22). The adoption of process innovation is generally lower across countries, but Czech Republic (117 firms) and Slovenia (84 firms) again lead in implementation, with Slovakia remaining the lowest at 23 firms (Figure A.23).

*Figure 12: Mean sales growth rate by innovation practice adoption*




*Source: Own work.*

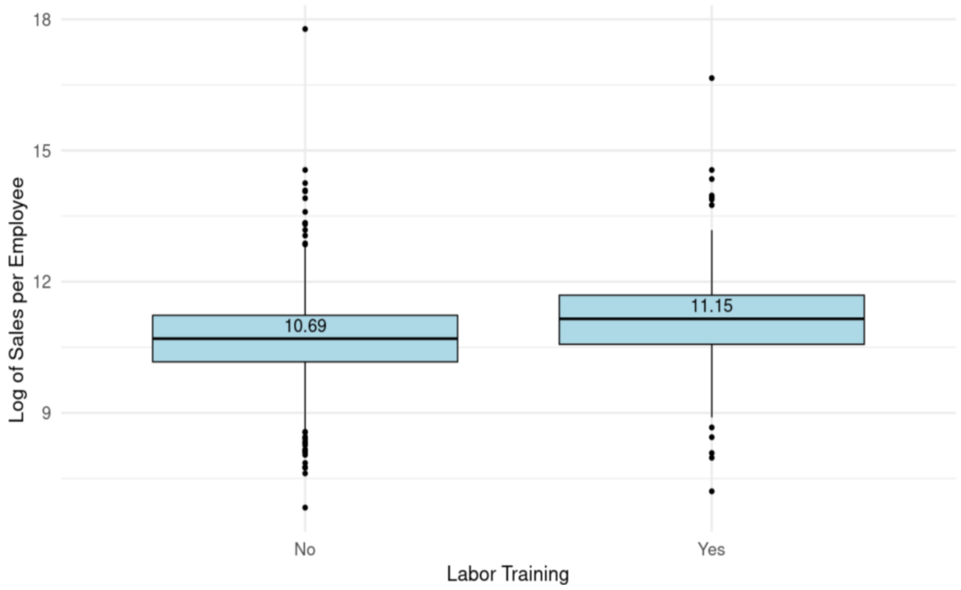
At a firm size level, small firms consistently exhibit the lowest innovation adoption rates. Among them, 393 small firms reported no product innovation, and 436 small firms reported no process innovation, highlighting a potential innovation gap in this segment. Conversely, large and medium-sized firms report comparatively higher levels of innovation activity, particularly in product innovation (Figure A.24 and Figure A.25). These findings suggest that both product and process innovations are associated with stronger firm growth outcomes, and that innovation uptake tends to be higher among larger firms and in countries like the Czech Republic and Slovenia.

Second, when examining labour training and its association with firm productivity, measured as sales per employee (log-transformed), firms that implemented labour training activities in the last fiscal year demonstrated a higher average log sales per employee (11.15) compared to firms that did not implement training (10.69). This suggests a potential positive relationship between workforce training and productivity performance (Figure 13).

Across countries, the highest number of firms reporting implementation of labour training was in the Czech Republic (146 firms) and Hungary (126 firms), while the lowest was in Slovenia (81 firm). However, in Hungary and Poland, a notably higher number of firms reported not conducting labour training — 238 and 213 firms respectively — indicating regional differences in training adoption (Figure A.26).

At firm size level, large firms reported the highest implementation rate of labour training (199 firms), followed closely by medium-sized firms (207 firms). Small firms were least likely to invest in labour training, with 379 reporting no training, compared to only 135 that had implemented it. These patterns suggest that firm size may influence the likelihood of adopting labour training practices, potentially due to differing resource capacities or strategic priorities (Figure A.27).

*Figure 13: Log of sales per employee (EUR) by labour training adoption*




*Source: Own work.*

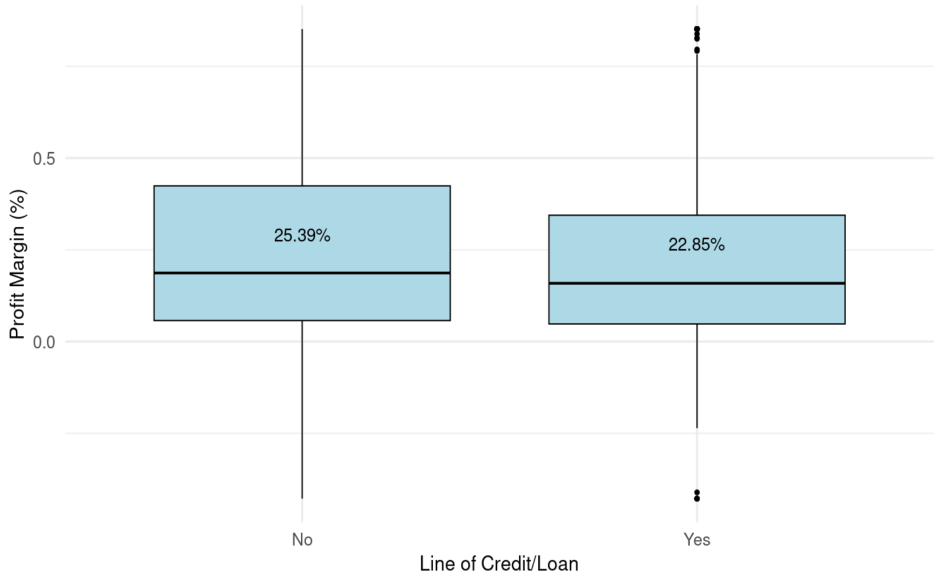
Third, when analysing the relationship between permanent employees' growth and sales growth rate, the following scatterplot indicates a generally positive linear association. While some dispersion is visible—particularly at extreme values—the upward trend line suggests that higher workforce expansion is positively associated with improved firm performance, or stronger sales growth, especially when employee growth exceeds 20% (Figure 14).

*Figure 14: Scatter plot: permanent employees' growth vs. sales growth rate*


*Source: Own work.*

Forth, regarding firm financing, companies that reported active line of credit or loan have a slightly lower average profit margin (22.85%) compared to those without such financing (25.39%), as illustrated in Figure 15. This may indicate that firms without current financing obligations are operating with higher profitability, possibly due to lower debt servicing costs or different capital structures.

*Figure 15: Profit margin by line of credit/loan adoption*



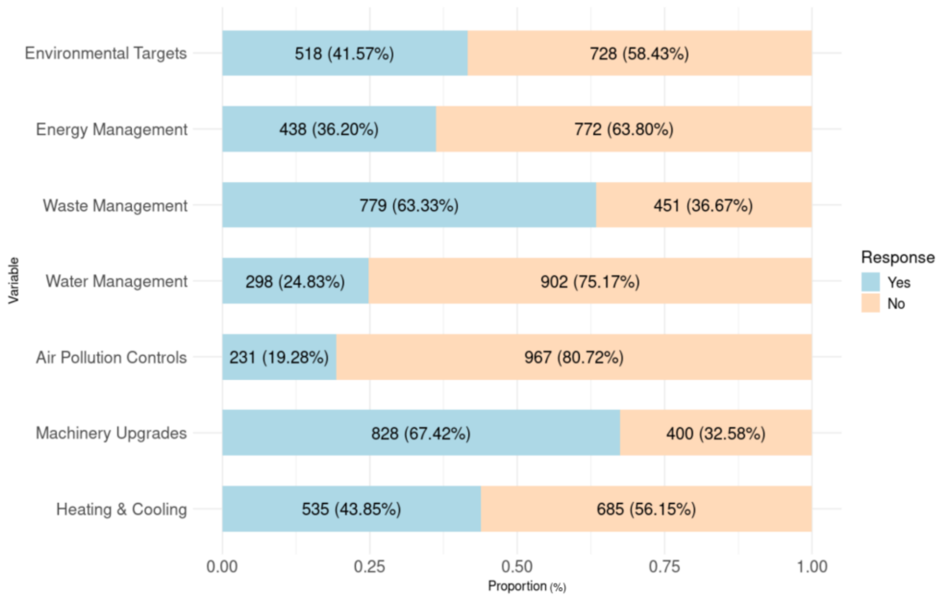

*Source: Own work.*

At the country level, the highest number of firms reporting credit or loan financing were in Hungary (185 firms) and the Czech Republic (153 firms), followed by Slovenia (91 firm). Poland and Slovakia had the fewest firms with such financing, at 85 and 78, respectively. Slovenia stood out with a notably lower number of firms without financing (42 firms), suggesting a relatively more favourable financing landscape (Figure A.28).

When analysed by firm size, medium-sized firms had the highest number of firms currently using credit or loan financing (241 firm), followed by small firms (180 firms) and large firms (171 firm). However, small firms also recorded the highest number of firms without current financing (285 firms), suggesting that access to or reliance on external financing may be more limited in this segment (Figure A.29).

Next, Figure 16 presents the distribution of the environmental variables, specifically, the adoption of environmental targets — used as a performance metric — and the associated independent variables representing environmental management practices. The distributions of the first six variables (environmental targets, energy management, waste management, water management, air pollution controls, and machinery upgrades) are based on the full analytical sample of 1,283 firms, which also serves as the baseline dataset for examining environmental performance. The final variable, heating and cooling improvements, is used only in the analysis of profit margin outcomes, therefore, its distribution is based on the reduced subsample of 1,166 firms.

*Figure 16: Environmental targets and management practices adoption*




*Source: Own work.*

Out of the surveyed firms, 41.57% (518 firms) reported setting environmental targets, while 58.43% (728 firms) did not. This variable had 37 incomplete responses. Adoption of energy management practices was reported by 36.20% (438 firms), while 63.80% (772 firms) indicated non-adoption, with 73 incomplete responses.

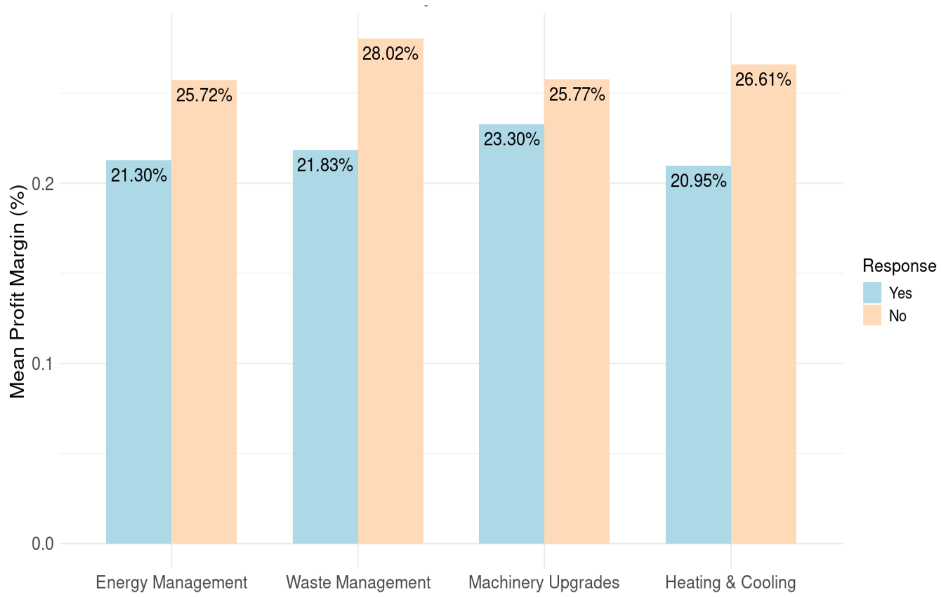
Waste management showed relatively high adoption, with 63.33% (779 firms) implementing the practice and 36.67% (451 firms) not. There were 53 incomplete responses. In contrast, only 24.83% (298 firms) reported adopting water management, while 75.17% (902 firms) had not, with 83 incomplete entries. Adoption of air pollution control measures was the lowest, with just 19.28% (231 firms) indicating implementation, and 80.72% (967 firms) reporting no adoption; this variable had the highest number of incomplete responses at 85.

Machinery upgrades emerged as the most widely adopted practice, with 67.42% (828 firms) indicating implementation and 32.58% (400 firms) not, based on 1,228 valid responses (55 incomplete responses). Lastly, the heating and cooling improvements variable — analysed based on the reduced subsample of 1,166 firms — showed that 43.85% (535 firms) adopted improvements, while 56.15% (685 firms) did not, with 58 incomplete responses.

Regarding the environmental performance, the adoption of environmental targets varies noticeably by both country and firm size. Among the five CEE countries, Hungary stands out with the highest number of firms setting environmental targets (168 firms), followed by the Czech Republic (110 firms) and Slovenia (68 firms). Poland had the lowest adoption rate, with only 59 firms setting environmental targets (Figure A.30). At a firm size level, large and medium-sized firms appear relatively balanced — 174 large firms and 176 medium firms reported setting environmental targets. However, small firms show a much lower adoption, with only 129 adopting compared to 343 that haven't (Figure A.31).

Lastly, Figure 17 illustrates that, on average, firms not adopting environmental practices relevant to the profitability analysis reported higher profit margins compared to those that did. This pattern is consistently observed across all four examined practices — energy management, waste management, machinery upgrades, and heating and cooling improvements. The most pronounced differences appear in waste management (28.02% vs. 21.83%) and heating and cooling improvements (26.61% vs. 20.95%). Notably, firms that adopted energy management practices reported the lowest average profit margin at 21.30%.

*Figure 17: Mean profit margin by environmental practice adoption*




*Source: Own work.*

## 5.2 Hypotheses testing and discussion of results

In this master thesis, 6 hypotheses were developed based on the previously presented literature review. Complete results and procedure for each hypothesis testing can be found in Appendix 3.

H1: Innovation management practices — product and process innovation — positively impact firm economic performance, measured by sales growth rate, in the manufacturing sector.

To examine the relationship between innovation practices and firm performance, a multiple linear regression model was applied, with the sales growth rate over the past three years as the dependent variable. The key independent variables were product and process innovation, both measured as binary indicators of innovation activity within the same period. Control variables included country, firm size, and firm age to account for firm heterogeneity.

The original sample of 1,283 observations was reduced to 1,271 due to 12 incomplete responses in the innovation variables. Cook's Distance analysis identified and removed an additional 101 influential observations (7.95% of the sample), leading to a final analytical sample of 1,170 firms. The distribution of country, firm size, and firm age remained unaffected by these adjustments (Table A.6).

Diagnostic tests largely supported the regression model assumptions (Table A.7). The Durbin-Watson test showed no autocorrelation (DW = 2.025, $p = 0.618$). The RESET test confirmed correct model specification (RESET = 0.518, $p = 0.596$). The Breusch-Pagan test indicated the presence of heteroscedasticity (BP = 31.491, $p < 0.001$), which was addressed by applying robust standard errors to the regression results (White-Huber correction, HC1). Multicollinearity was not a concern, as all VIF values were below 1.5 (Table A.8). Furthermore, the distribution of residuals displayed an approximately normal pattern (Figure A.35). The regression model explained approximately 18.5% of the variance in sales growth rate (adjusted $R^2 = 0.1851$) and was statistically significant overall ($p < 0.001$).

The regression analysis (Table 8) provides partial empirical support for the hypothesis that innovation practices positively influence firm performance, particularly in terms of sales growth. Specifically, product innovation demonstrated a statistically significant and positive effect, with firms that introduced new or significantly improved products in the past three years experiencing, on average, 2.6 percentage points higher sales growth compared to non-innovating firms ($\beta = 0.026$, $p = 0.043$). This finding reinforces the theoretical perspective that product innovation enables firms to better respond to changing market demands and expand market share. These results are consistent with prior studies emphasizing the importance of product innovation in driving firm growth in manufacturing contexts (Artz et al., 2010; Camisón & López, 2010; Na & Kang, 2019). Notably, Na and Kang (2019) employed multiple linear regression and found a statistically significant positive effect of both product and process innovation variables on sales growth across manufacturing firms in Southeast Asian emerging markets.

Process innovation in this study also showed a positive trend, though the effect was not statistically significant ($\beta = 0.026$, $p = 0.075$). This aligns with the understanding that process improvements primarily strengthen internal operational efficiency, which is vital for long-term competitiveness, but may have a more indirect or delayed effect on revenue growth (Reichstein & Salter, 2006; Tavassoli & Karlsson, 2015). The comparatively weaker association suggests that while process innovation contributes to performance, its direct impact on sales growth is less immediate than that of product innovation.

*Table 8: Regression results: Innovation and firm performance (sales growth)*

| **Dependent variable: Sales growth rate (3-year) (%)** | | | | | |
|---|---|---|---|---|---|
| **Predictors** | **Estimate** | **Std. Error** | **t-value** | **p value** | |
| (Intercept)[1] | 0.075 | 0.016 | 4.774 | **<0.001** | *** |
| Product Innovation [YES] | 0.026 | 0.013 | 2.022 | **0.043** | * |
| Process Innovation [YES] | 0.026 | 0.015 | 1.784 | **0.075** | **.** |
| Country [Hungary] | 0.104 | 0.018 | 5.946 | **<0.001** | *** |
| Country [Poland] | 0.033 | 0.016 | 2.003 | **0.045** | * |
| Country [Slovakia] | 0.015 | 0.019 | 0.785 | 0.433 | |
| Country [Slovenia] | 0.061 | 0.020 | 3.032 | **0.003** | ** |
| Firm size [Large] | -0.006 | 0.014 | -0.396 | 0.693 | |
| Firm size [Small] | -0.031 | 0.013 | -2.308 | **0.021** | * |
| Firm age [Young and mature] | -0.029 | 0.013 | 2.209 | **0.027** | * |

Significance levels: *p < 0.001 (***), p < 0.01 (**), p < 0.05 (*), p < 0.10 (.)*

*Source: Own work.*

Among the control variables, firms in Hungary, Poland, and Slovenia reported significantly higher sales growth compared to firms in the baseline country, the Czech Republic. These differences likely reflect variations in national innovation policies, market conditions, and industrial structures. Firm size effects were mixed: small firms experienced lower growth than medium-sized firms, while large firms did not show significant differences in growth compared to medium-sized ones. The age of the firm also influenced performance, with younger and mid-aged firms exhibiting slightly higher growth compared to older firms. This may be indicative of a more agile, innovative approach in younger firms, while older firms might face structural challenges or slower adaptation to market changes.

Overall, the findings offer partial support for the hypothesis that innovation, more specifically, product innovation—plays a critical role in enhancing firm performance in the CEE manufacturing sector. While product innovation is directly linked to higher sales growth, process innovation can contribute by strengthening operational efficiency. Together, these forms of innovation act as complementary drivers of competitiveness. This reinforces the need for firms to invest in both product development and process improvements to sustain performance, particularly in transitional economies like those in CEE, as emphasized by institutional sources such as the OECD (2021b).

H2a: Labour training positively impacts firm economic performance, measured by sales per employee, in the manufacturing sector.

[1] The reference (baseline) categories used in the regression analysis are as follows: Czech Republic for the country variable, medium-sized firms for firm size, and old firms for firm age.

A multiple linear regression analysis was conducted to examine the impact of labour training on firm economic performance, measured by the log-transformed sales per employee (EUR) and labour training adoption as the key independent variable, both referring to the last fiscal year. Control variables included country and firm size to account for firm heterogeneity. Initially, firm age was also tested as a control, but it was excluded due to its statistical insignificance and negligible contribution to model explanatory power.

The original dataset of 1,283 observations was reduced to 1,278 after removing 5 incomplete responses in the labour training variable. Cook's Distance analysis identified and removed 64 influential observations (5.01% of the sample), resulting in a final analytical sample of 1,214 firms. The distribution of country and firm size variables remained unaffected by these adjustments (Table A.10).

Diagnostic tests largely supported the regression model assumptions (Table A.11). The Durbin-Watson test indicated no autocorrelation (DW = 1.924, $p = 0.173$). The RESET test confirmed the correct model specification (RESET = 0.375, $p = 0.688$). Although the Breusch-Pagan test indicated the presence of heteroscedasticity (BP = 48.013, $p < 0.001$), robust standard errors (White-Huber correction, HC1) were applied to final regression results to adjust for this issue. Multicollinearity was not a concern, as all VIF values remained below 1.2 (Table A.12). Furthermore, the distribution of residuals displayed an approximately normal pattern (Figure A.39). The regression model explained approximately 24.24% of the variance in logged sales per employee (adjusted $R^2 = 0.2424$) and was statistically significant overall ($p < 0.001$).

The regression results provide strong support for the hypothesis that labour training positively influences firm economic performance, as measured by sales per employee (Table 9). Firms that implemented labour training programs achieved, on average, a 20.8% higher sales per employee compared to those that did not, holding other factors constant ($\beta = 0.208$, $p < 0.001$). This statistically significant result reinforces the theoretical argument that workforce development directly enhances labour productivity and operational efficiency. It aligns with previous research (Martins, 2021; Toner, 2011; Zwick, 2006) emphasizing that investments in employee training can build firm-specific human capital and improve output per worker — a key performance driver in manufacturing.

Additionally, the analysis reveals notable variations across control variables. Firms in Slovenia reported significantly higher labour productivity relative to the baseline (Czech Republic), while firms in Hungary and Poland showed significantly lower productivity. Regarding firm size, large enterprises outperformed medium-sized firms in terms of sales per employee, whereas small firms lagged behind. These patterns highlight that contextual factors such as country-specific conditions and organizational scale also shape labour productivity outcomes. Altogether, the findings affirm the hypothesis that labour training is a critical lever for boosting economic performance in CEE manufacturing firms and highlight the broader strategic value of investing in workforce development.

*Table 9: Regression results: Labour training and firm performance (sales per employee)*

| **Dependent variable: Log of sales per employee (EUR)** | | | | | |
|---|---|---|---|---|---|
| **Predictors** | **Estimate** | **Std. Error** | **t-value** | **p value** | |
| (Intercept)[2] | 10.954 | 0.050 | 219.667 | **<0.001** | *** |
| Labour Training [YES] | 0.208 | 0.042 | 4.951 | **<0.001** | *** |
| Country [Hungary] | -0.349 | 0.053 | -6.560 | **<0.001** | *** |
| Country [Poland] | -0.513 | 0.063 | -8.094 | **<0.001** | *** |
| Country [Slovakia] | 0.015 | 0.068 | 0.226 | 0.821 | |
| Country [Slovenia] | 0.354 | 0.058 | 6.084 | **<0.001** | *** |
| Firm size [Large] | 0.270 | 0.053 | -5.122 | **<0.001** | *** |
| Firm size [Small] | -0.165 | 0.046 | -3.579 | **<0.001** | *** |

Significance levels: *p < 0.001 (***), p < 0.01 (**), p < 0.05 (*), p < 0.10 (.)*

*Source: Own work.*

H2b: An increase in the number of permanent employees positively impacts firm economic performance, measured by sales growth rate, in the manufacturing sector.

To investigate the relationship between the growth rate of permanent employees and firm performance, a multiple linear regression model was applied, with sales growth rate as the dependent variable and permanent employees' growth rate as the key independent variable, both referring to the last three fiscal years. Control variables included country and firm size to account for firm heterogeneity. Firm age was initially included as a control variable; however, it was excluded from the final model after it was found to be statistically insignificant and its inclusion reduced the model fit.

The original dataset of 1,283 observations was reduced to 1,261 after excluding 22 incomplete responses concerning the permanent employee growth rate. To ensure the robustness of the regression results, Cook's Distance analysis identified and removed 84 influential observations (6.66% of the sample), resulting in a final analytical sample of 1,177 firms. The distribution of country and firm size variables remained unaffected by these adjustments (Table A.14).

Diagnostic tests largely supported the regression model assumptions (Table A.15). The Durbin-Watson test indicated no autocorrelation (DW = 2.016, p = 0.559). The RESET test confirmed the correct model specification (RESET = 0.925, p = 0.397). The Breusch-Pagan test detected heteroscedasticity (BP = 37.469, p < 0.001), which was addressed by applying robust standard errors to the regression results (White-Huber correction, HC1).

[2] The reference (baseline) categories used in the regression analysis are as follows: Czech Republic for the country variable and medium-sized firms for firm size.

Multicollinearity was not a concern, as all VIF values remained well below the threshold of 1.1 (Table A.16). Furthermore, the distribution of residuals displayed an approximately normal pattern (Figure A.43). The regression model explained approximately 30.10% of the variance in sales growth rate (adjusted $R^2 = 0.301$) and was statistically significant overall ($p < 0.001$).

The analysis confirms the hypothesis that an increase in the number of permanent employees positively impacts firm economic performance, as measured by sales growth rate (Table 10). A 1% increase in permanent employees over a three-year period was associated with a 0.63 percentage point increase in sales growth rate ($\beta = 0.633$, $p < 0.001$), holding other factors constant. This significant result highlights the critical role of workforce expansion in supporting firm growth, particularly in manufacturing contexts that rely heavily on operational continuity and sector-specific expertise, where a stable and growing permanent workforce supports firms' capacity to meet market demand and sustain output quality. It aligns with existing research emphasizing the value of workforce continuity and accumulated human capital in driving firm performance (Han et al., 2025; Lim & Mali, 2022; ILO, 2020). For instance, Han et al. (2025), using a fixed-effects panel regression analysis, found that employment stability improves long-term firm performance, particularly in volatile industries. Likewise, Lim and Mali (2022), applying multiple linear regression, showed that firms with a higher share of permanent contracts achieve greater efficiency.

*Table 10: Regression results: Permanent employees' growth and firm performance (sales growth)*

| **Dependent variable: Sales growth rate (3-year) (%)** | | | | | |
|---|---|---|---|---|---|
| **Predictors** | **Estimate** | **Std. Error** | **t-value** | **p value** | |
| (Intercept)[3] | 0.085 | 0.013 | 6.425 | **<0.001** | *** |
| Perm. Employees Growth Rate | 0.633 | 0.032 | 19.530 | **<0.001** | *** |
| Country [Hungary] | 0.044 | 0.015 | 2.894 | **0.004** | ** |
| Country [Poland] | 0.013 | 0.015 | 0.891 | 0.373 | |
| Country [Slovakia] | -0.035 | 0.017 | -2.019 | **0.044** | * |
| Country [Slovenia] | 0.034 | 0.018 | 1.923 | **0.055** | **.** |
| Firm size [Large] | -0.005 | 0.013 | -0.428 | 0.669 | |
| Firm size [Small] | -0.020 | 0.012 | -1.634 | 0.103 | |

Significance levels: *p < 0.001 (***), p < 0.01 (**), p < 0.05 (*), p < 0.10 (.)*

*Source: Own work.*

While the effects of firm size were not statistically significant, country-level differences were observed: firms in Hungary reported slightly higher sales growth compared to the

[3] The reference (baseline) categories used in the regression analysis are as follows: Czech Republic for the country variable and medium-sized firms for firm size.

Czech Republic, while those in Slovakia showed a modestly negative effect. Importantly, to address potential concerns about reverse causality, a Pearson correlation test between the model residuals and the independent variable (permanent employees' growth rate) confirmed no evidence of endogeneity ($r \approx 0.000$, $p = 1.000$) (Table A.17). Taken together, these findings affirm that permanent workforce expansion is not merely a byproduct of firm success, but a meaningful strategic lever that can enhance firm adaptability, output consistency, and growth in CEE manufacturing firms. Thus, H2b was supported.

H3: External financing — line of credit or loan — positively impacts firm economic performance, measured by profit margin, in the manufacturing sector.

To investigate the relationship between external financing (line of credit or loan) and firm profitability, a multiple linear regression model was applied, with profit margin in the last fiscal year as the dependent variable. The key independent variable was the current use of external financing, specifically an active line of credit or loan. Control variables included country, firm size, and firm age to account for firm heterogeneity.

The original dataset of 1,166 observations (used for profitability analysis) was reduced to 1,164 after removing two incomplete responses in line of credit/loan variable. Cook's Distance analysis identified and removed further 71 influential observations (6.10% of the sample), resulting in a final analytical sample of 1,093 firms. The distribution of country, firm size and firm age variables remained unaffected by these adjustments (Table A.19).

Diagnostic tests largely supported the regression model assumptions (Table A.20). The Durbin-Watson test showed no autocorrelation ($DW = 1.894$, $p = 0.475$). RESET test confirmed correct model specification ($RESET = 1.323$, $p = 0.276$). Breusch-Pagan test indicated the presence of heteroscedasticity ($BP = 42.021$, $p < 0.001$), which was mitigated by applying robust standard errors to the regression results (White-Huber correction, HC1). Multicollinearity was not a concern, as all VIF values remained below 1.1 (Table A.21). Furthermore, the distribution of residuals displayed an approximately normal pattern (Figure A.47). The regression model explained approximately 28.73% of the variance in profit margin (adjusted $R^2 = 0.2873$) and was statistically significant overall ($p < 0.001$).

The analysis does not support the hypothesis that external financing through credit lines or loans improves firm profitability (Table 11). On the contrary, the regression results reveal a statistically significant negative association between active use of credit or loans and profit margin ($\beta = -0.024$, $p = 0.036$). Firms that reported using such financing instruments experienced, on average, a 2.4 percentage point lower profit margin than those not relying on them, after controlling for other factors. This unexpected finding suggests that access to external finance may not always translate into improved financial outcomes, at least in the context of CEE manufacturing firms.

These results are contradicting to earlier studies (Beck & Demirguc-Kunt, 2006; Altaf & Shah, 2017; Garcia-Teruel & Martinez-Solano, 2007), which argued that access to external finance enhances firm performance by providing liquidity for growth and investment. Possible explanations include the high costs of borrowing for smaller or riskier firms, as well as the possibility that firms resorting to external financing may already be experiencing internal liquidity constraints or financial stress (Love & Sánchez, 2009; World Bank, 2019a; OECD, 2020).

*Table 11: Regression results: External financing and firm performance (profit margin)*

| **Dependent variable: Profit margin (%)** | | | | | |
|---|---|---|---|---|---|
| **Predictors** | **Estimate** | **Std. Error** | **t-value** | **p value** | |
| (Intercept)[4] | 0.228 | 0.015 | 15.486 | **<0.001** | *** |
| Line of Credit / Loan [YES] | -0.024 | 0.011 | -2.098 | **<0.036** | * |
| Country [Hungary] | -0.021 | 0.014 | -1.440 | 0.150 | |
| Country [Poland] | 0.196 | 0.020 | 9.848 | **<0.001** | *** |
| Country [Slovakia] | -0.152 | 0.012 | -12.523 | **<0.001** | *** |
| Country [Slovenia] | 0.061 | 0.019 | 3.237 | **0.001** | ** |
| Firm size [Large] | -0.036 | 0.013 | -2.665 | **0.008** | ** |
| Firm size [Small] | 0.024 | 0.013 | 1.836 | **0.067** | . |
| Firm Age [Young and Mature] | -0.025 | 0.012 | -2.084 | **0.037** | * |

Significance levels: *p < 0.001 (***), p < 0.01 (**), p < 0.05 (*), p < 0.10 (.)*

*Source: Own work.*

Among control variables, significant profit margin differences emerged across countries and firm characteristics. Firms in Poland and Slovenia reported higher profit margins than those in the Czech Republic (baseline), while Slovak firms exhibited lower profitability. In terms of firm size, large firms reported lower margins than medium-sized firms. Firm age had a minor but significant effect, with younger and mature firms displaying slightly lower profitability than older firms. Despite these variations, a Pearson correlation test between the model residuals and the external financing variable showed no significant correlation ($r \approx 0.000$, $p = 1.000$), confirming no evidence of endogeneity or reverse causality in the regression model (Table A.22).

Taken together, the findings challenge the conventional assumption that access to finance is uniformly beneficial. Instead, they highlight a more nuanced dynamic in which the implications of external borrowing depend heavily on firm context, financial health, and the nature of the lending environment within the CEE region. Thus, Hypothesis H3 is rejected.

H4a: The adoption of environmental management practices — energy management, waste management, water management, air pollution control measures, and machinery upgrades

[4] The reference (baseline) categories used in the regression analysis are as follows: Czech Republic for the country variable, medium-sized firms for firm size, and old firms for firm age.

— leads to improved firm environmental performance, indicated by the adoption of environmental targets, in the manufacturing sector.

To examine the relationship between environmental practices and environmental performance, a binary logistic regression was conducted. The dependent variable constructed as composite indicator, reflects the adoption of environmental targets for energy efficiency, $CO_2$ and other pollution emissions reduction. The key independent variables were five binary indicators of specific environmental practices: energy management, waste management, water management, air pollution controls, and machinery upgrades. All variables refer to the last three fiscal years. Control variables included country, firm size, and firm age. The original dataset of 1,283 observations was reduced to 1,166 due to incomplete responses in the key variables. The distribution of country, firm size, and firm age remained unaffected during the cleaning process (Table A.24).

The final regression model met key diagnostic assumptions. Pseudo $R^2$ values indicated acceptable model fit (McFadden's $R^2 = 0.213$; $r^2ML = 0.250$; $r^2CU = 0.337$) (Table A.25). Multicollinearity was not a concern, with all VIF values well below 1.5 (Table A.26). The model's discriminative power was strong, with an AUC of 0.850 (Figure A.48).

The regression model was statistically significant (Likelihood Ratio $\chi^2(12) = 335.85$, $p < 0.001$). The analysis of deviance confirmed that all five environmental practices contributed significantly to the model, with energy management having the largest effect (Deviance = 192.5, $p < 0.001$) (Table A.27).

The results provide overall strong support for the hypothesis that the adoption of environmental management practices significantly increases the likelihood of firms setting formal environmental targets (Table 12). Among the green practices assessed, energy management emerged as the most influential predictor ($\beta = 1.247$, $p < 0.001$), with an odds ratio of 3.48, indicating that firms implementing energy-saving strategies were 3.5 times more likely to adopt formal environmental goals than those that did not. Similarly, air pollution controls (OR = 1.74, $p = 0.007$), water management (OR = 1.68, $p = 0.005$), and waste management (OR = 1.42, $p = 0.028$) were all positively and significantly associated with environmental targets adoption. Machinery upgrades showed positive, but non-significant effect (OR = 1.31, $p = 0.10$), suggesting a limited contribution in this model.

The analysis revealed that CEE manufacturing firms adopt various environmental practices—such as energy and water management, waste reduction, air pollution controls, and machinery upgrades—reflecting alignment with EU Green Deal goals and decarbonization strategies (European Commission, 2023). Firms implementing most of these measures showed a significantly higher likelihood of setting environmental targets for energy efficiency and emissions reduction. This supports prior evidence that green operational strategies reduce environmental impact and enhance compliance with regulatory expectations (ISO, 2015; EIB, 2023; Derhab & Elkhwesky, 2023; Zhang & Tang, 2019).

*Table 12: Regression results: Environmental management practices and targets adoption*

| Dependent variable: Environmental targets (1=Yes, 0=No) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Predictors** | **Estimate** | **Std. Error** | **z-value** | **p value** | **Odds ratio** | **95% CI** | |
| (Intercept)[5] | -1.166 | 0.217 | -5.374 | **<0.001** | 0.312 | [0.203, 0.474] | *** |
| Energy Management [YES] | 1.247 | 0.164 | 7.627 | **<0.001** | 3.481 | [2.530, 4.805] | *** |
| Waste Management [YES] | 0.353 | 0.161 | 2.198 | **0.028** | 1.423 | [1.039, 1.950] | * |
| Water Management [YES] | 0.520 | 0.186 | 2.805 | **0.005** | 1.683 | [1.169, 2.421] | ** |
| Air Pollution Controls [YES] | 0.552 | 0.203 | 2.716 | **0.007** | 1.737 | [1.167, 2.592] | ** |
| Machinery Upgrades [YES] | 0.270 | 0.164 | 1.650 | **0.100** | 1.310 | [0.951, 1.808] | . |
| Country [Hungary] | 0.100 | 0.199 | 0.502 | 0.616 | 1.105 | [0.748, 1.634] | |
| Country [Poland] | -1.190 | 0.226 | -5.260 | **<0.001** | 0.304 | [0.194, 0.472] | *** |
| Country [Slovakia] | -0.035 | 0.241 | -0.144 | 0.886 | 0.966 | [0.602, 1.548] | |
| Country [Slovenia] | -0.228 | 0.252 | -0.905 | 0.366 | 0.796 | [0.485, 1.303] | |
| Firm size [Large] | 0.418 | 0.183 | 2.284 | **0.022** | 1.520 | [1.061, 2.178] | * |
| Firm size [Small] | -0.503 | 0.162 | -3.098 | **0.002** | 0.605 | [0.439, 0.831] | ** |
| Firm Age [Young and Mature] | 0.113 | 0.156 | 0.723 | 0.470 | 1.119 | [0.824, 1.518] | |

Significance levels: *p < 0.001 (***), p < 0.01 (**), p < 0.05 (*), p < 0.10 (.)*

*Source: Own work.*

[5] The reference (baseline) categories used in the regression analysis are as follows: Czech Republic for the country variable, medium-sized firms for firm size, and old firms for firm age.

Control variables further revealed that firms in Poland were significantly less likely to adopt environmental targets compared to the Czech Republic. In terms of firm size, small firms were less likely to adopt such targets, while large firms were more likely to do so, suggesting that greater scale may facilitate green investments. No statistically significant differences were observed for firms in other countries or across firm age groups. Taken together, these results largely support H4a, underlying the importance of proactive environmental practices in driving formal sustainability commitments within the CEE manufacturing sector.

H4b: The adoption of environmental management practices — energy management, waste management, machinery upgrades and heating and cooling improvements — positively impacts firm economic performance, measured by profit margin, particularly over longer investment horizons, given the potential delayed return on such investments, in the manufacturing sector.

To assess the relationship between environmental practices and firm performance, a multiple linear regression model was estimated using profit margin in the last fiscal year as the dependent variable. Key independent variables included the adoption of four environmental practices: energy management, waste management, machinery upgrades, and heating and cooling improvements, over the past three fiscal years. Country, firm size, and firm age were included as control variables to account for firm heterogeneity.

The original dataset of 1,168 observations was first reduced to 1,086 due to incomplete responses in the independent variables. To further ensure the robustness of the results, Cook's Distance analysis was conducted to identify influential observations. A total of 68 firms (6.26% of the sample) were flagged and removed, resulting in a final analytical sample of 1,018 firms. The distribution of country, firm size and firm age variables remained unaffected by these adjustments (Table A.29).

Diagnostic tests largely supported the regression model assumptions (Table A.30). The RESET test (RESET = 2.014, $p = 0.267$) confirmed the model's functional form was appropriate, and the Durbin-Watson test (DW = 1.973, $p = 0.283$) indicated no signs of autocorrelation. Given the presence of heteroscedasticity, as confirmed by the Breusch-Pagan test (BP = 44.63, p-value $< 0.001$), robust standard errors (White-Huber correction, HC1) were applied. Multicollinearity was not a concern, with all VIF values below 1.5 (Table A.31). Furthermore, the distribution of residuals displayed an approximately normal pattern (Figure A.52). The regression model explained approximately 29.26% of the variance in profit margin (adjusted $R^2 = 0.2926$) and was statistically significant overall ($p < 0.001$).

The analysis does not support the hypothesis that the adoption of environmental management practices positively impacts firm profitability in the short term (Table 13). Among the practices examined, only energy management demonstrated a statistically significant relationship with profit margin; however, the association was negative ($\beta = -0.042$, p =

0.001). This indicates that firms implementing energy-saving initiatives experienced, on average, a 4.2 percentage point lower profit margin compared to non-adopters, holding other factors constant. Other environmental practices—waste management, machinery upgrades, and heating and cooling improvements—did not show statistically significant effects on profit margins in this model. These findings suggest that while environmental strategies may offer operational or reputational benefits, they do not necessarily yield immediate financial returns.

This result contrasts with the initial theoretical expectation that environmental investments might enhance economic performance by increasing resource efficiency or market value. Instead, the findings challenge the assumption of an immediate win-win between environmental responsibility and profitability (Porter & van der Linde, 1995; Böttcher & Müller, 2015). Environmental practices often involve high upfront costs and complex changes, with benefits emerging over time. In the short term, firms may face reduced profit margins due to operational, investment, and compliance-related expenses (OECD, 2022; Horbach et al., 2012).

*Table 13: Regression results: Environmental management practices and firm performance (profit margin)*

| **Dependent variable: Profit margin (%)** | | | | | |
|---|---|---|---|---|---|
| **Predictors** | **Estimate** | **Std. Error** | **t-value** | **p value** | |
| (Intercept)[6] | 0.209 | 0.017 | 12.604 | **<0.001** | *** |
| Energy Management [YES] | -0.042 | 0.013 | -3.13 | **0.001** | * |
| Waste Management [YES] | -0.020 | 0.013 | -1.619 | 0.106 | |
| Machinery Upgrades [YES] | 0.003 | 0.013 | 0.238 | 0.812 | |
| Heating and Cooling Improvements [YES] | 0.010 | 0.012 | 0.841 | 0.400 | |
| Country [Hungary] | 0.018 | 0.016 | 1.155 | 0.249 | |
| Country [Poland] | 0.216 | 0.020 | 10.840 | **<0.001** | *** |
| Country [Slovakia] | -0.137 | 0.013 | -10.622 | **<0.001** | *** |
| Country [Slovenia] | 0.075 | 0.019 | 3.917 | **<0.001** | *** |
| Firm size [Large] | -0.018 | 0.014 | -1.229 | 0.219 | |
| Firm size [Small] | 0.041 | 0.013 | 3.085 | **0.002** | ** |
| Firm Age [Young and Mature] | -0.024 | 0.012 | -1.942 | **0.052** | **.** |

Significance levels: *p < 0.001 (***), p < 0.01 (**), p < 0.05 (*), p < 0.10 (.)*

*Source: Own work.*

[6] The reference (baseline) categories used in the regression analysis are as follows: Czech Republic for the country variable, medium-sized firms for firm size, and old firms for firm age.

Control variables revealed notable patterns. Firms in Poland and Slovenia reported significantly higher profit margins relative to the baseline country, Czech Republic. Conversely, Slovak firms exhibited lower profitability. In terms of firm size, small firms showed higher profit margins than medium firms, while large firms had no significant difference.

Despite the lack of short-term profit gains, institutional perspectives from the European Commission (2022a, 2023) and EIB (2023), as well as empirical work by Green et al. (2012) and Horbach et al. (2012), emphasize the long-term strategic value of environmental practices. These include better alignment with sustainability regulations, integration into global green supply chains, and enhanced stakeholder credibility. Therefore, while the hypothesis was not supported in this analysis, the absence of immediate financial returns does not invalidate the importance of green investments. Instead, it highlights the need for complementary policy incentives and support mechanisms to bridge the gap between environmental responsibility and financial viability in the manufacturing sector.

In summary, the study confirms that selected management practices — specifically in the area of innovation and labour — have a positive impact on firm economic performance in the CEE manufacturing sector. Notably, environmental practices also show a significant positive contribution to environmental performance. However, the relationship between external financing, green management practices, and profitability is more complex and context-dependent, highlighting the need for careful strategic implementation and supportive policy frameworks (Table 14).

*Table 14: Summary of hypotheses testing findings*

| No. | Hypothesis | Findings |
| --- | --- | --- |
| H1 | Innovation management practices — product and process innovation — positively impact firm economic performance, measured by sales growth rate, in the manufacturing sector. | Partially supported (1 out of 2 variables significant) |
| H2a | Labour training positively impacts firm economic performance, measured by sales per employee, in the manufacturing sector. | Supported |
| H2b | An increase in the number of permanent employees positively impacts firm economic performance, measured by sales growth rate, in the manufacturing sector. | Supported |
| H3 | External financing — line of credit or loan — positively impacts firm economic performance, measured by profit margin, in the manufacturing sector. | Not supported |
| H4a | The adoption of environmental management practices — energy management, waste management, water management, air pollution control measures, and machinery upgrades — leads to improved firm environmental performance, indicated by the adoption of environmental targets, in the manufacturing sector. | Largely Supported (4 out of 5 variables significant) |
| H4b | The adoption of environmental management practices — energy management, waste management, machinery upgrades, and heating and cooling improvements — positively impacts firm economic performance, measured by profit margin, particularly over longer investment horizons, given the potential delayed return on such investments, in the manufacturing sector. | Not supported |

*Source: Own work.*

### 5.3 Limitations and opportunities for future research

This thesis acknowledges several important data and methodological limitations, while also highlighting opportunities for future research to build upon these findings. The study utilized cross-sectional survey data from the 2018 EBRD-EIB-WBG Enterprise Survey, which, although extensive, inherently restricts the analysis to a single point in time. However, it is worth noting that while the survey design is cross-sectional, it includes retrospective questions on firm performance (e.g., sales growth, employment changes) over the previous three years, which partially captures short-term dynamics. Nonetheless, this retrospective element remains limited in fully observing long-term effects of management practices such as environmental investments, which often materialize over extended periods. Future research would benefit from true longitudinal data collection, allowing scholars to explore how changes in innovation activities, labour practices, financing structures, or environmental strategies influence firm performance over time. While the dataset used in the empirical analysis was carefully filtered to ensure consistency and alignment with the research objectives, several limitations arise from the applied sampling criteria that may affect the generalizability of the results.

First, the sample includes only fully privately owned manufacturing firms with independent financial reporting. As a result, the findings may not extend to state-owned enterprises, group-affiliated firms, or entities lacking formal financial structures, which could exhibit different management practices, access to resources and performance dynamics.

Second, the exclusion of firms with incomplete responses — particularly for financial variables such as sales and cost of sales data — may introduce response bias. Firms with better-established internal reporting systems and more structured management are more likely to be retained, which could skew the sample toward relatively better-performing or more transparent firms.

Third, this study focuses on five CEE countries — Czech Republic, Hungary, Poland, Slovakia, and Slovenia — selected for their shared post-transition economic characteristics and industrial relevance. However, the findings may not be fully generalizable to other CEE countries with different institutional environments, policy frameworks, or market dynamics. Moreover, the sample is not evenly distributed across the selected countries. Although country-fixed effects are included in the regression models to account for national-level heterogeneity, unobserved factors, such as policy incentives, infrastructure, or market dynamics, may still influence firm behaviour. Future research could explore how variations in institutional conditions across the broader CEE region shape firm management strategies and performance.

Finally, although the sample includes both SMEs and large enterprises, the distribution is slightly skewed toward small and medium-sized firms. This may influence the overall results, as SMEs often face different constraints and adopt different management strategies compared to larger firms — particularly in areas such as innovation, financing, and the implementation of environmental practices. Consequently, the findings may be more reflective of SME-specific dynamics, and caution is advised when generalizing to larger, resource-rich firms. Additionally, the merging of young (0–5 years) and mature (6–15 years) firms into a single age group — necessitated by limited observations — reduces the ability to analyse differences in management practices and performance outcomes across firm lifecycle stages. This may obscure variation in innovation intensity, financing needs, or environmental adoption patterns that typically differ between early-stage and mid-stage firms.

Despite these limitations, the final baseline and reduced samples (N = 1,283 and N = 1,166, respectively) are sufficiently large and diverse to support robust statistical analysis. Country, firm size, and firm age were included as control variables to reduce internal bias and enhance model reliability. However, imbalances within specific subgroups, such as firms from smaller countries (e.g., Slovenia) or less-represented age and size segments, should be acknowledged. Future studies could strengthen generalizability and subgroup analysis by employing larger and more balanced samples across countries, firm sizes, and age categories.

Another consideration relates to the treatment of outliers and data variability. To manage the influence of extreme values and improve the robustness of the analysis, IQR-based winsorization and log transformation was applied to the majority of the performance metrics variables and adjusted IQR winsorization was applied to one of the independent variables - permanent employees' growth rate. These methods effectively reduce the distorting impact of outliers while preserving the core structure of the data, and they represent essential steps for improving the reliability of multiple linear regression outcomes. Despite these transformations aimed at improving distribution symmetry, some degree of skewness in the data persisted. However, as natural data variation remains, future research could compare findings between winsorized and non-winsorized models to assess the sensitivity of the results to these data adjustments.

Furthermore, a limitation concerns the measurement of firm performance itself. The analysis focused on selected performance indicators, notably sales growth, sales per employee, and profit margin, which are robust proxies for firm economic performance. However, they do not capture the full breadth of firm outcomes, such as market share evolution, cost efficiencies, brand value enhancements, or innovation outputs like patents and product launches. Future research could expand these measures to develop a more comprehensive understanding of management practices' effectiveness in manufacturing firms.

As the data relies on manager self-reporting, the possibility of response bias cannot be discounted. Managers might overstate or understate their firm's engagement in certain practices or performance levels. Complementing survey data with objective firm-level metrics or qualitative insights, such as case studies, would enhance the robustness and depth of future analyses.

Moreover, this study primarily relied on categorical (binary) variables to capture management practices and firm characteristics. While this approach effectively captures adoption, it does not account for the intensity or scale of implementation. Future research could benefit from incorporating more granular measures — such as the number of training hours and implemented environmental actions, or financial investment in sustainability — to better reflect the depth of engagement and improve the explanatory power of regression models. Similarly, the binary indicator used for environmental targets could be refined into an ordinal scale (e.g., 0–3) to reflect the degree of environmental commitment, addressing the limited variability observed in this study.

Additionally, while this thesis focuses on internal management practices, it is important to acknowledge potential endogeneity concerns that may affect causal interpretation. For example, firms already performing well may be more likely to innovate, expand their workforce, or gain access to external financing, while more profitable firms are more likely to afford training or green investments. Addressing such issues through more advanced econometric techniques could further strengthen causal interpretations in future analyses.

In conclusion, while this study provides valuable insights into the relationship between management practices and firm performance in CEE manufacturing, future research has ample opportunities to extend and deepen these findings. By leveraging larger and more balanced datasets, employing longitudinal designs, and refining performance measures, future studies can further enrich the understanding of how firms navigate innovation, labour management, financing decisions, and environmental strategies in an evolving economic and policy landscape. Another promising direction lies in examining interaction effects, for example whether the combination of particular management practices, such as innovation and environmental strategies, produces synergistic benefits, beyond the sum of their individual effects, providing insights into more integrated approaches that align competitiveness with sustainability. Such efforts will not only deepen insights but also enhance the practical relevance of future findings for both policymakers and business leaders. Altogether, these future research pathways can help advance the analysis, ultimately supporting firms and policymakers in designing more effective strategies for competitiveness and sustainability in the dynamic CEE manufacturing sector.

# 6 CONCLUSION

In this master’s thesis, I explored the relationship between management practices and firm performance in the manufacturing sector of the CEE region. Specifically, the study examined the impacts of innovation activities, labour management, external financing, and environmental practices on economic and environmental outcomes of manufacturing firms, using cross-sectional data from the 2018 EBRD-EIB-WBG Enterprise Survey. The empirical analysis was grounded in approximately 1,283 firm-level observations for the main analyses, with a slightly smaller sample of 1,166 firms for the profitability models, offering new insights into how firms across the CEE region navigate competitiveness and sustainability challenges in a rapidly evolving economic landscape.

The first set of key findings revealed that product innovation management practice significantly enhanced firm performance, especially in terms of sales growth. This confirms theoretical expectations and supports previous studies (Artz et al., 2010; Camisón & López, 2010; Na & Kang, 2019), which emphasize the role of innovation in driving firm growth. Furthermore, process innovation showed a positive, although non-significant, contribution to sales growth, underlining its importance for operational efficiency and need of combination with other organizational changes (Tavassoli & Karlsson, 2015).

The second group of findings focused on labour management practices. The results showed that both labour training and permanent employment growth have a positive and statistically significant impact on economic performance, measured by sales per employee and sales growth rate, respectively. These findings align with existing institutional and academic literature (Toner, 2011; Lim & Mali, 2022; OECD, 2021c), which highlight the role of human capital in improving productivity and enhancing firm resilience in competitive markets.

Conversely, the findings related to external financing presented a more nuanced picture. Firms using credit lines or loans were associated with lower profit margins, suggesting that debt financing, while essential for liquidity, may not uniformly translate into improved profitability. This challenges conventional assumptions in the literature (Beck & Demirguc-Kunt, 2006; Altaf & Shah, 2017), highlighting the need for cautious financial management in the CEE manufacturing context.

Lastly, the study revealed a dual outcome of environmental practices. While the adoption of green management practices significantly improved environmental performance, their short-term impact on profitability was limited, with some practices even associated with marginally lower profit margins. This illustrates the long-term nature of returns on sustainability investments and highlights the role of policy support in bridging the gap between environmental responsibility and financial viability (OECD, 2022; European Commission, 2022a).

Overall, this research provides valuable insights for policymakers and business leaders alike. For policymakers, the findings emphasize the need for supportive frameworks that encourage sustainable investment while mitigating short-term financial burdens. For business leaders, the results suggest the importance of strategic alignment between management practices and long-term competitiveness. While this thesis contributes meaningfully to the understanding of firm behaviour in the CEE region, future research is encouraged to build on these findings by utilizing longitudinal data, broader performance indicators, and exploring potential interaction effects between management practices to deepen insights into how firms can better balance economic performance with sustainability objectives.

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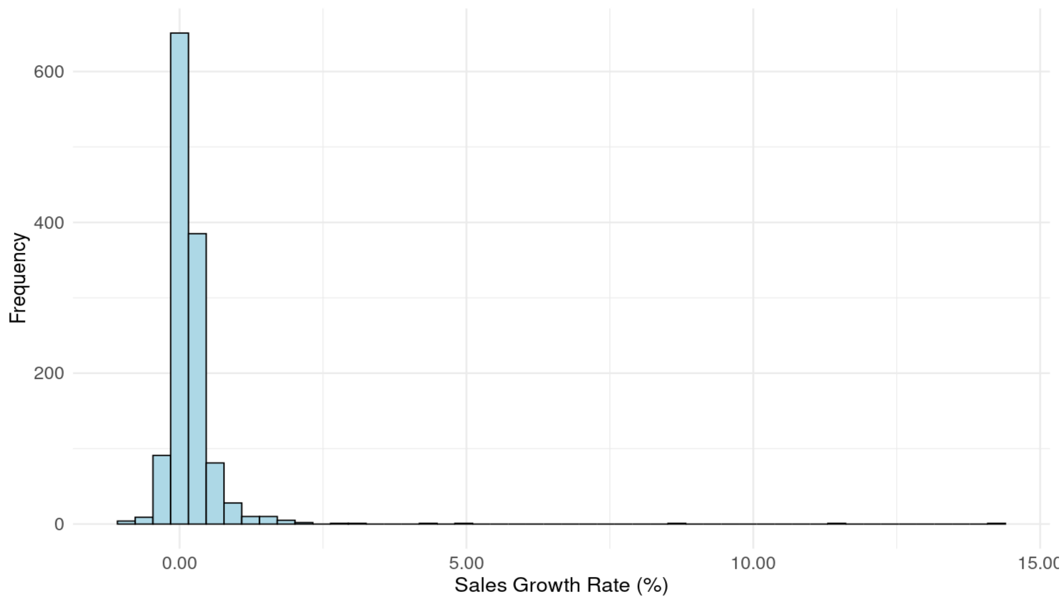
# APPENDICES

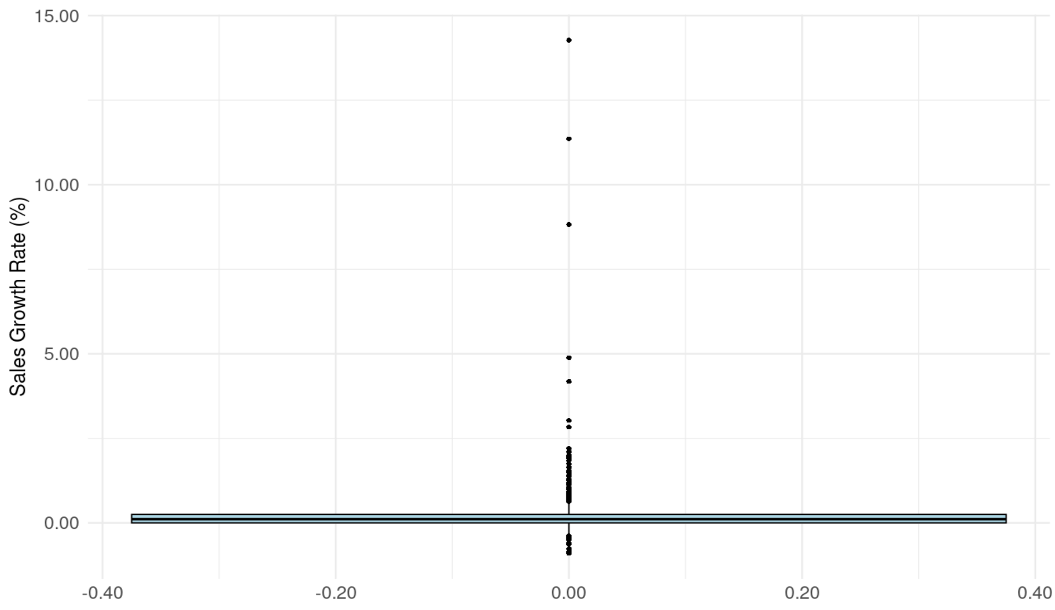
## Appendix 1: Variable transformations and descriptive statistics

*Figure A.1: Sales growth rate (3-year) (pre-transformation)*



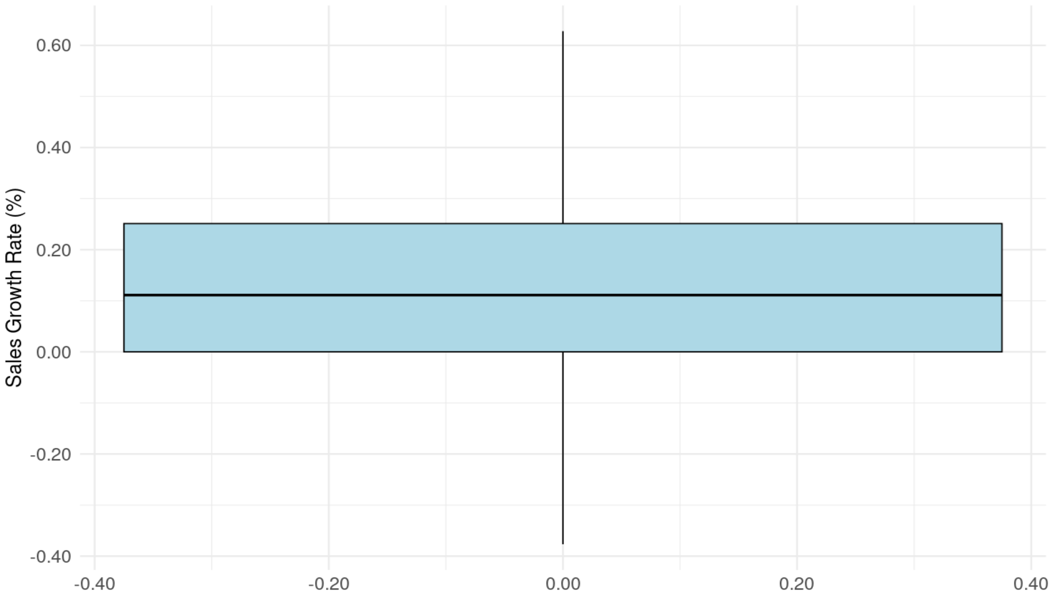

*Source: Own work.*

*Figure A.2: Sales growth rate (3-year) outliers (pre-transformation)*



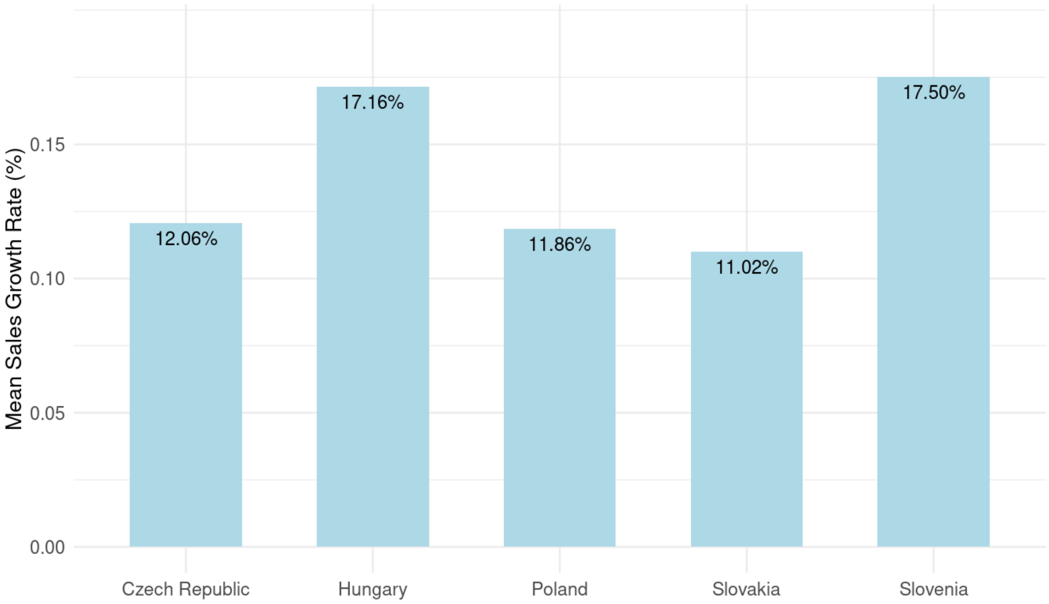

*Source: Own work.*

*Figure A.3: Sales growth rate (3-year) outliers (post-transformation)*



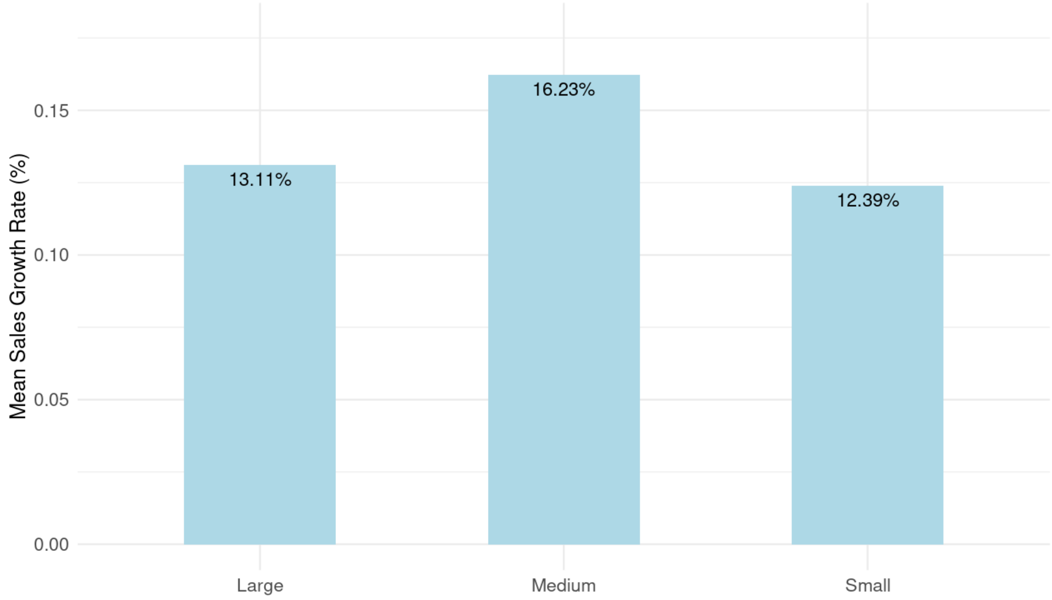

*Source: Own work.*

*Figure A.4: Mean sales growth rate by country*



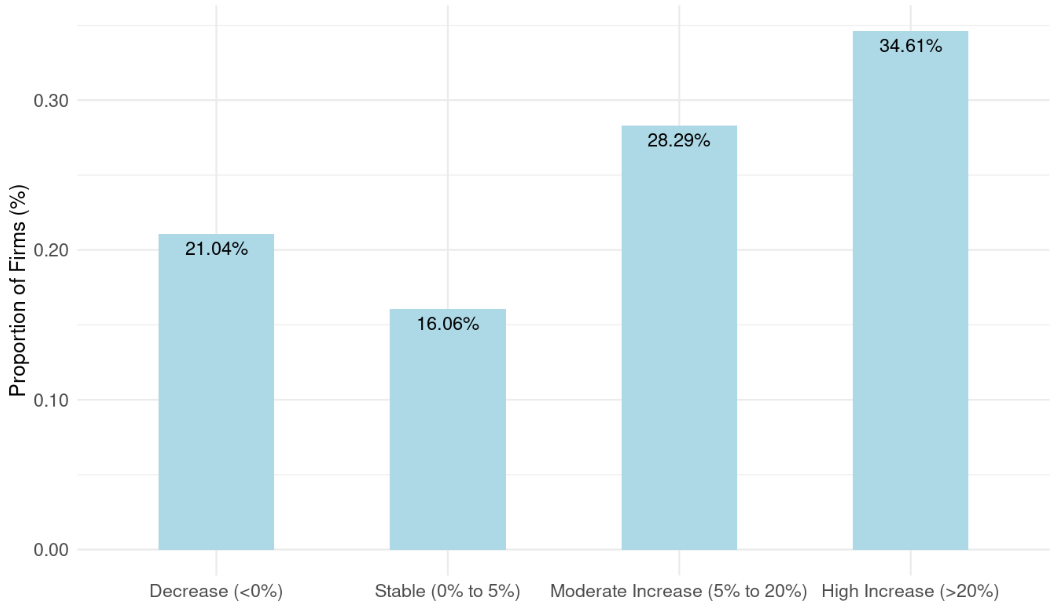

*Source: Own work.*

*Figure A.5: Mean sales growth rate by firm size*




*Source: Own work.*

*Figure A.6: Proportion of firms by sales growth category*



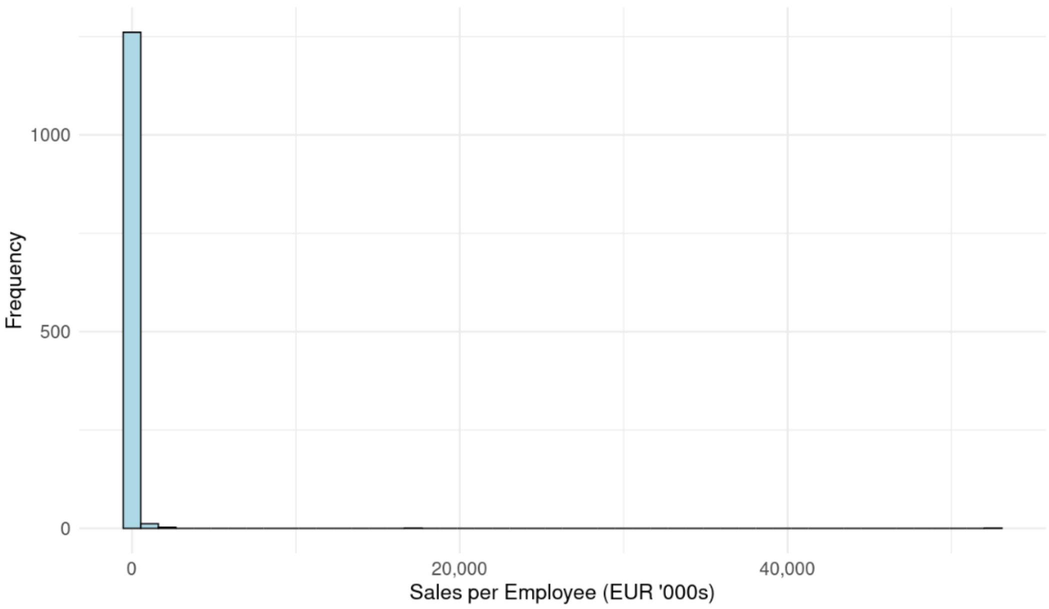

*Source: Own work.*

*Table A.1: Descriptive statistics of sales growth rate variable (pre and post transformation)*

| Descriptive statistics | Original variable | IQR-winsorized variable |
|---|---|---|
| Mean | 0.1991 | 0.1402 |
| Median | 0.1111 | 0.1111 |
| Min | -0.8966 | -0.3767 |
| Max | 14.2727 | 0.6278 |
| SD | 0.6769 | 0.2315 |
| Skewness | 12.9249 | 0.3153 |
| Kurtosis | 229.7703 | 3.0199 |
| IQR | 0.2511 | 0.2511 |

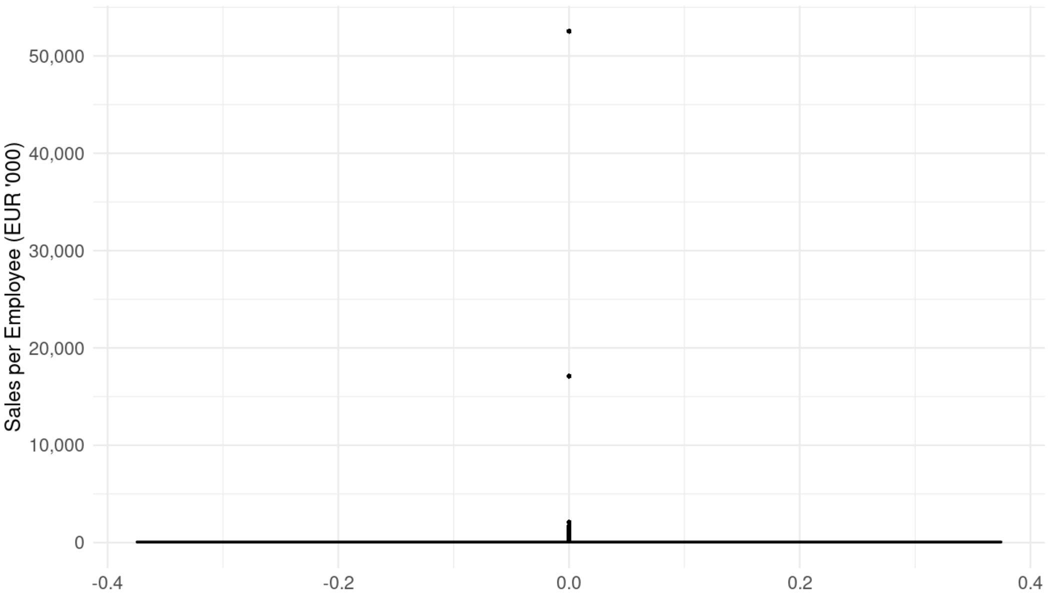
*Source: Own work.*

*Figure A.7: Sales per employee (pre-transformation)*



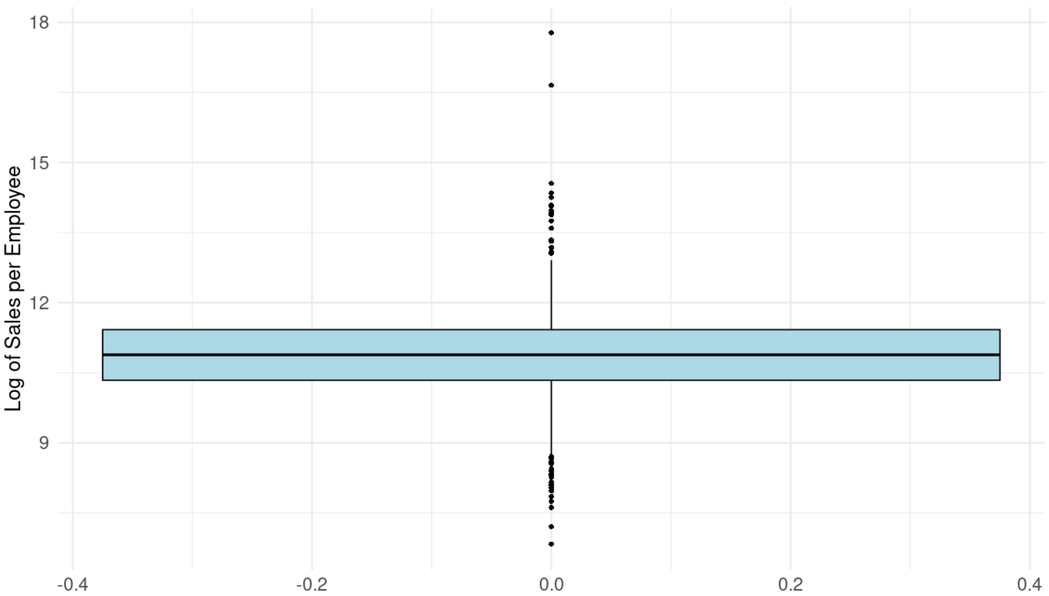

*Source: Own work.*

*Figure A.8: Sales per employee outliers (pre-transformation)*



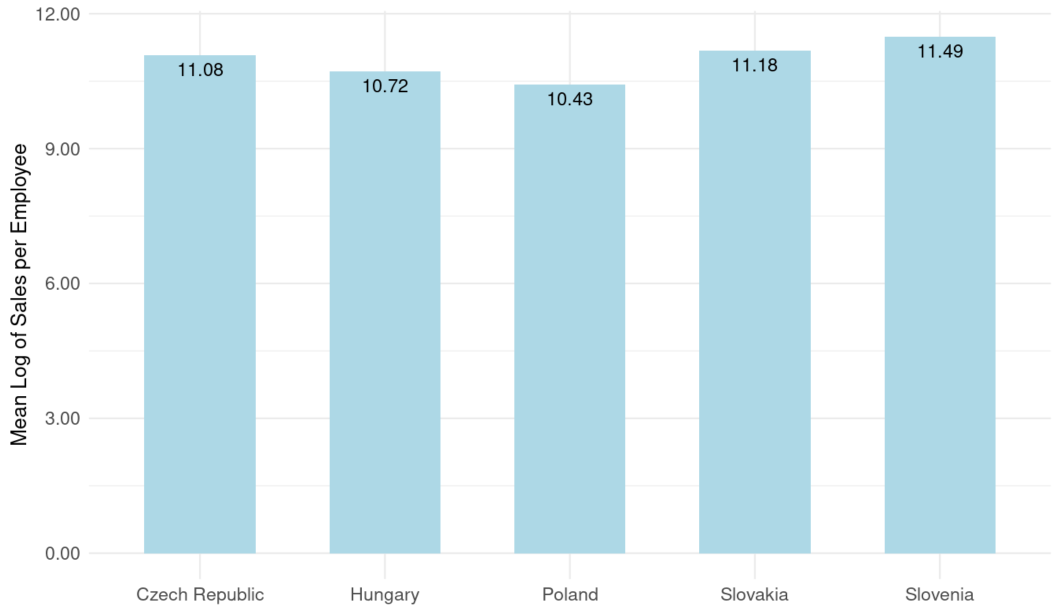

*Source: Own work.*

*Figure A.9: Log of sales per employee outliers (post-transformation)*



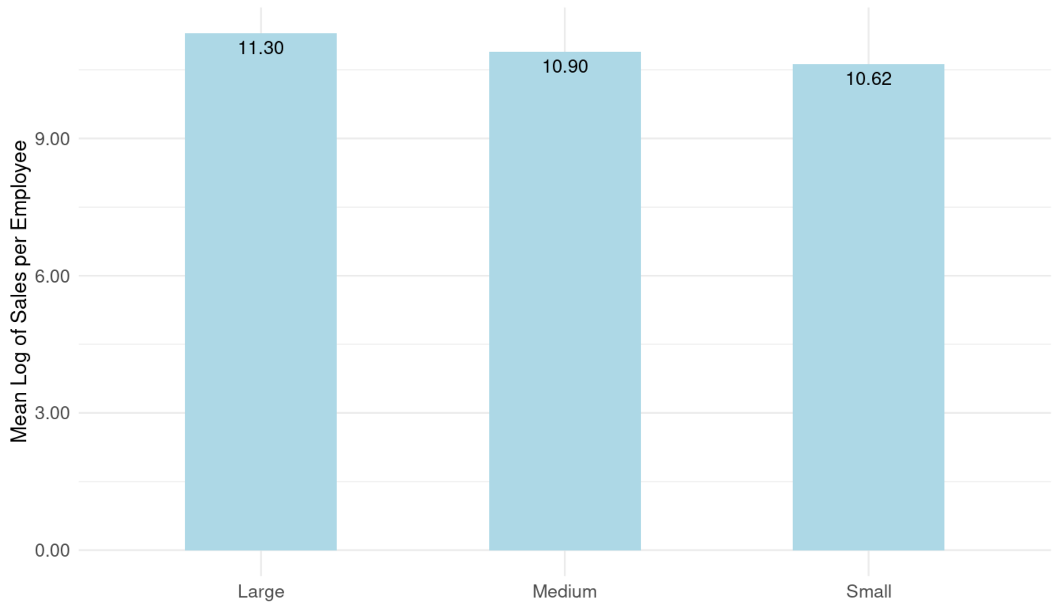

*Source: Own work.*

*Figure A.10: Mean log of sales per employee by country*




*Source: Own work.*

*Figure A.11: Mean log of sales per employee by firm size*



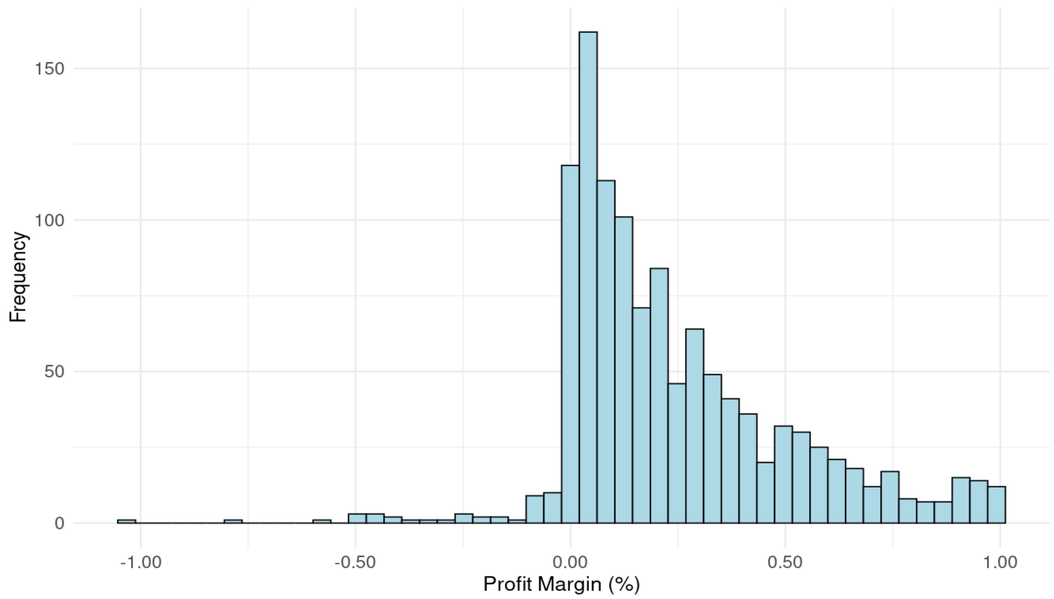

*Source: Own work.*

*Table A.2: Descriptive statistics of sales per employee variable (pre and post transformation)*

| Descriptive statistics | Original variable | Log-transformed variable |
|---|---|---|
| Mean | 141,320.00 | 10.88 |
| Median | 53,411.00 | 10.89 |
| Min | 930.00 | 6.84 |
| Max | 52,539,341.00 | 17.77 |
| SD | 1,549,386.00 | 0.99 |
| Skewness | 31.33 | 0.35 |
| Kurtosis | 1,036.37 | 6.71 |
| IQR | 60,487.40 | 1.08 |

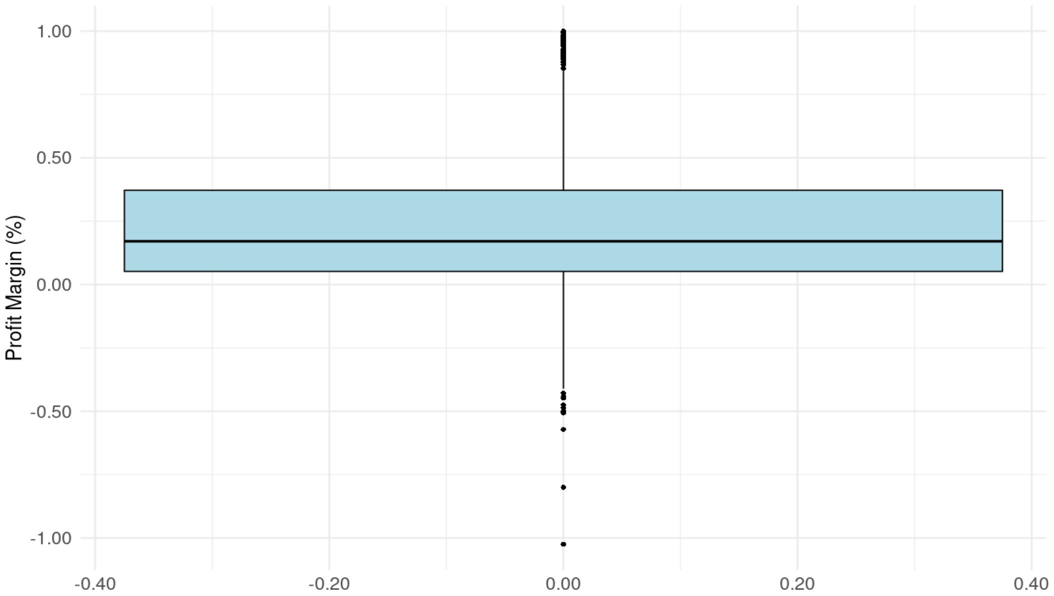
*Source: Own work.*

*Figure A.12: Profit margin (pre-transformation)*



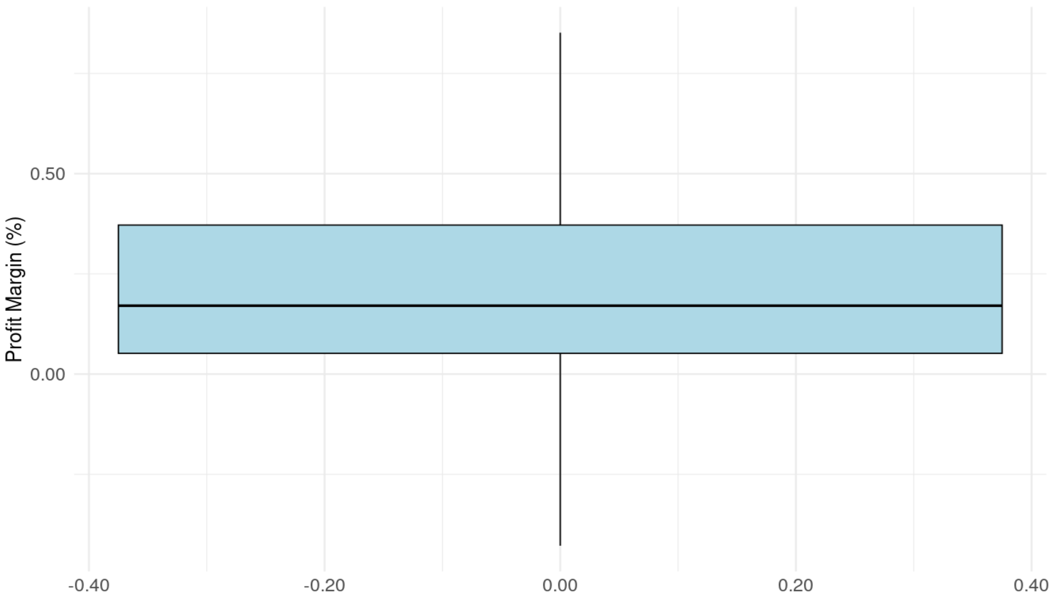

*Source: Own work.*

*Figure A.13: Profit margin outliers (pre-transformation)*



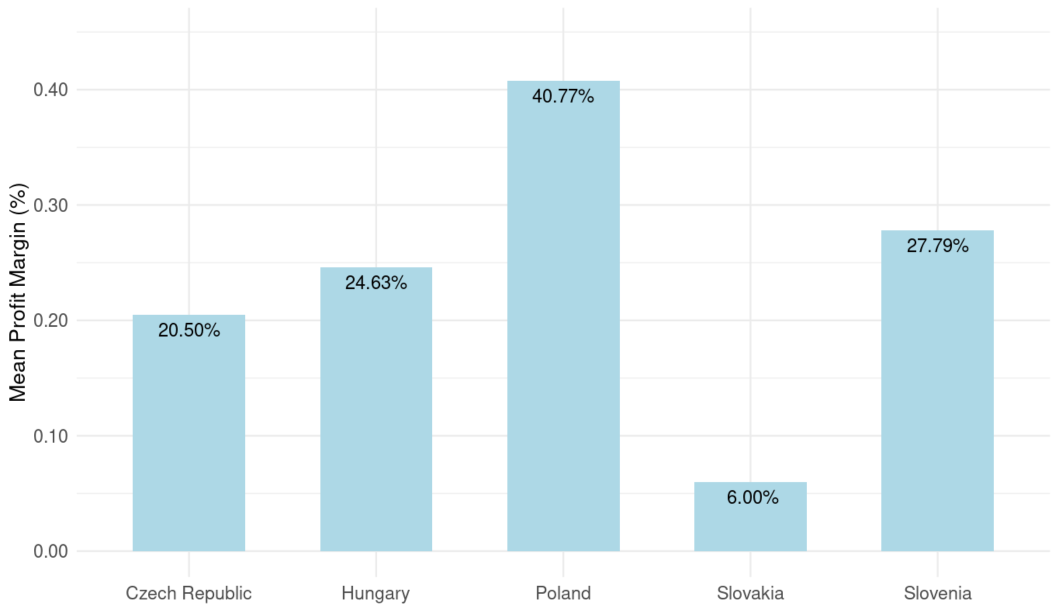

*Source: Own work.*

*Figure A.14: Profit margin outliers (post-transformation)*



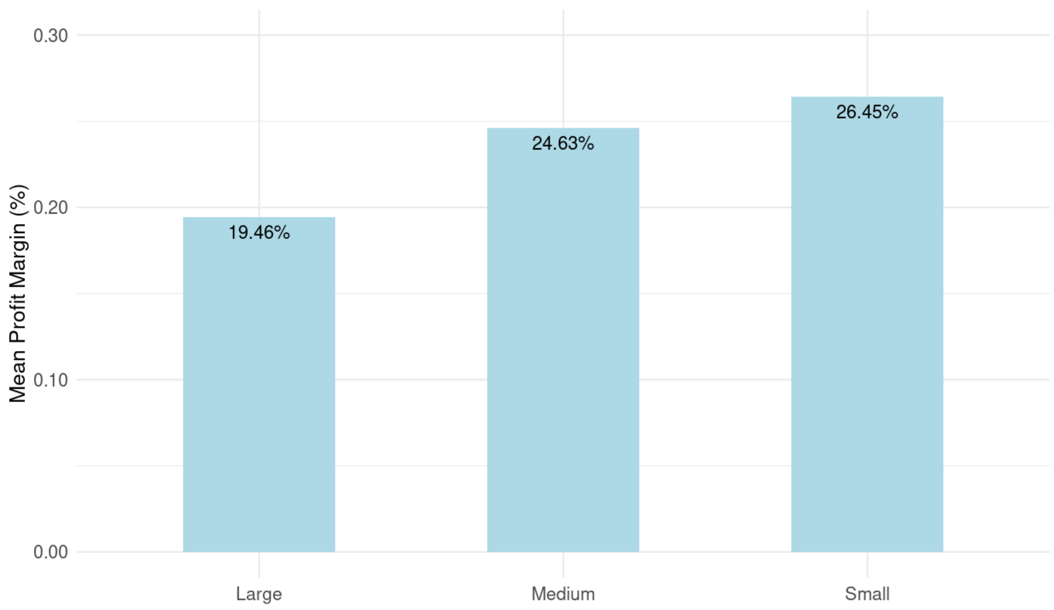

*Source: Own work.*

*Figure A.15: Mean profit margin by country*



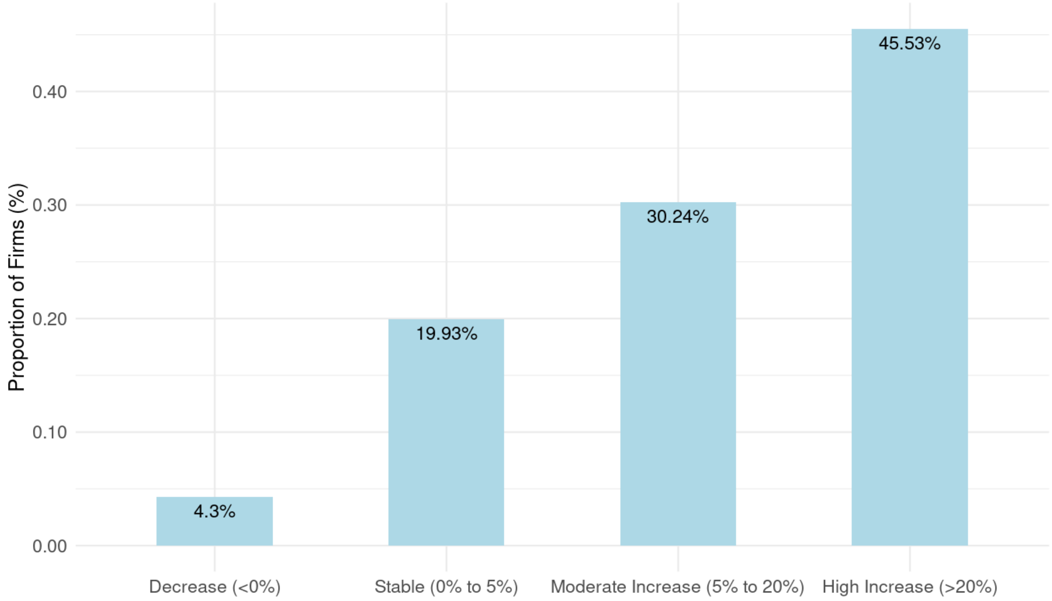

*Source: Own work.*

*Figure A.16: Mean profit margin by firm size*




*Source: Own work.*

*Figure A.17: Proportion of firms by profit margin growth category*



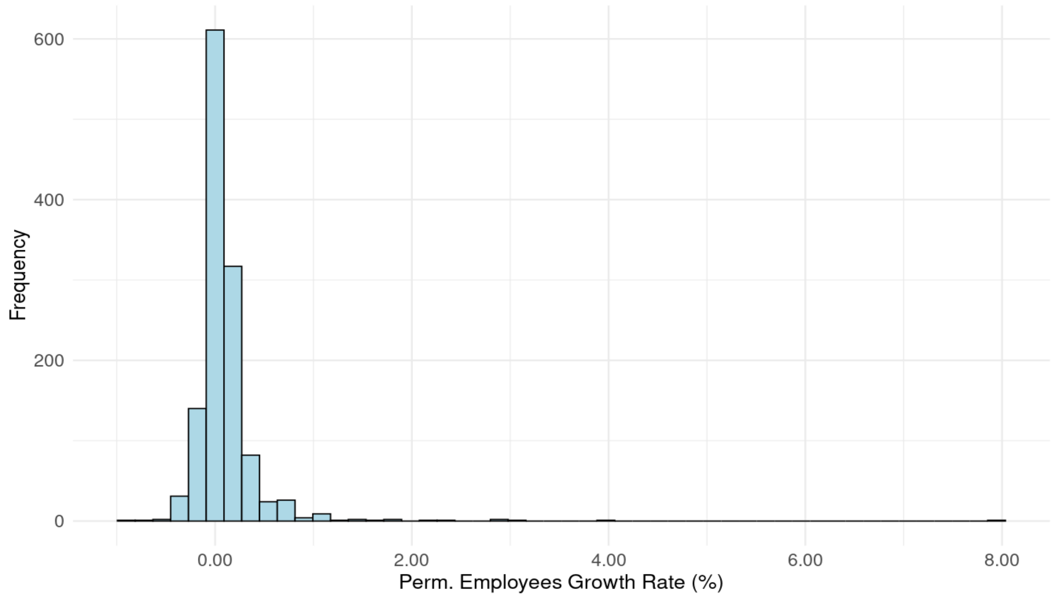

*Source: Own work.*

*Table A.3: Descriptive statistics of profit margin variable (pre and post transformation)*

| **Descriptive statistics** | **Original variable** | **IQR-winsorized variable** |
|---|---|---|
| Mean | 0.2433 | 0.2410 |
| Median | 0.1706 | 0.1706 |
| Min | -1.0244 | -0.4280 |
| Max | 0.9994 | 0.8516 |
| SD | 0.2645 | 0.2515 |
| Skewness | 0.7144 | 0.7426 |
| Kurtosis | 4.2088 | 3.2924 |
| IQR | 0.3199 | 0.3199 |

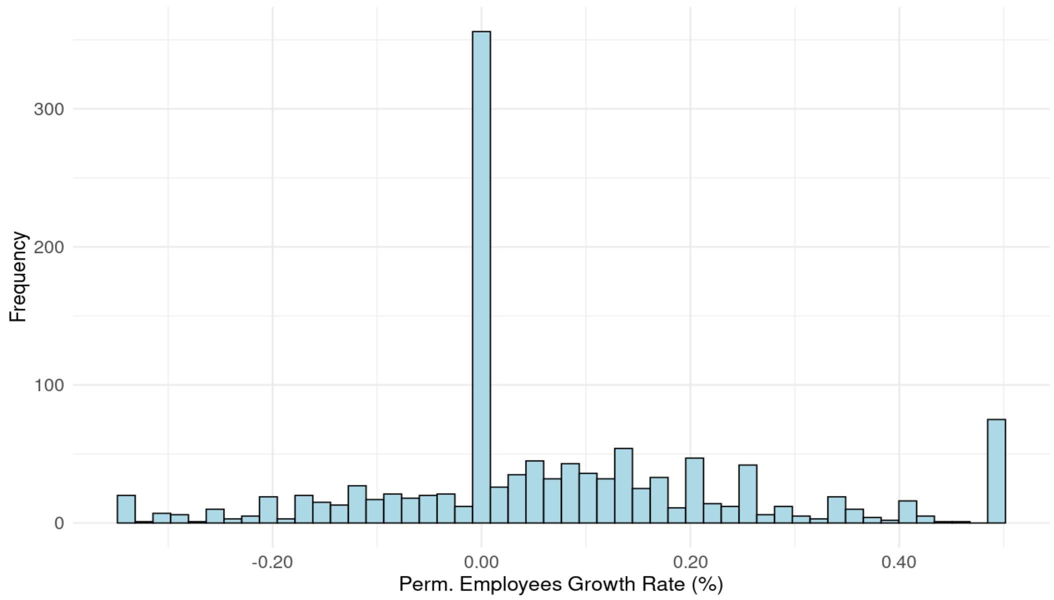
*Source: Own work.*

*Figure A.18: Permanent employees' growth rate (pre-transformation)*



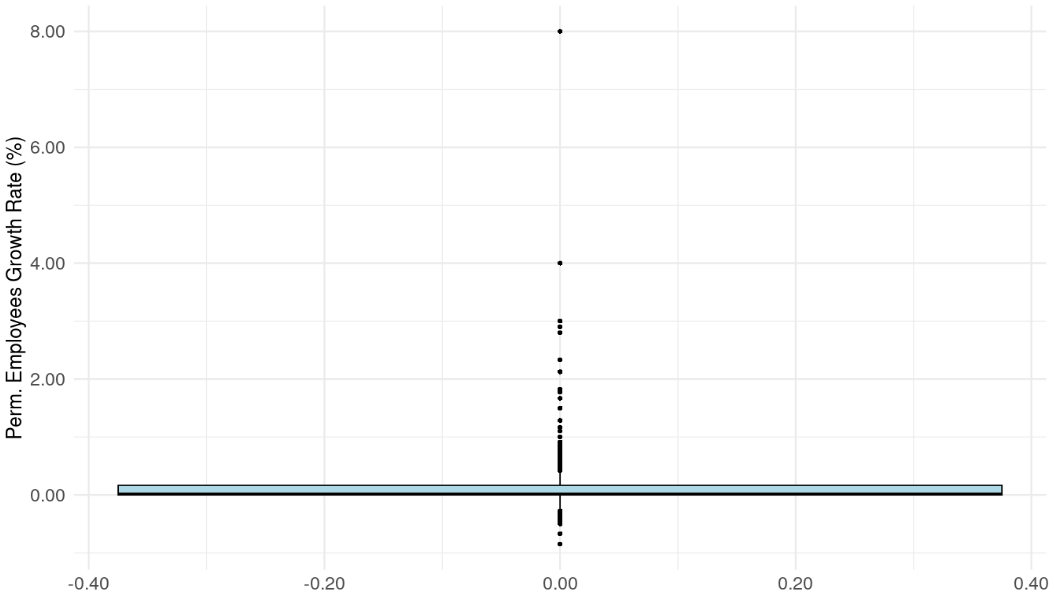

*Source: Own work.*

*Figure A.19: Permanent employees' growth rate (post-transformation)*



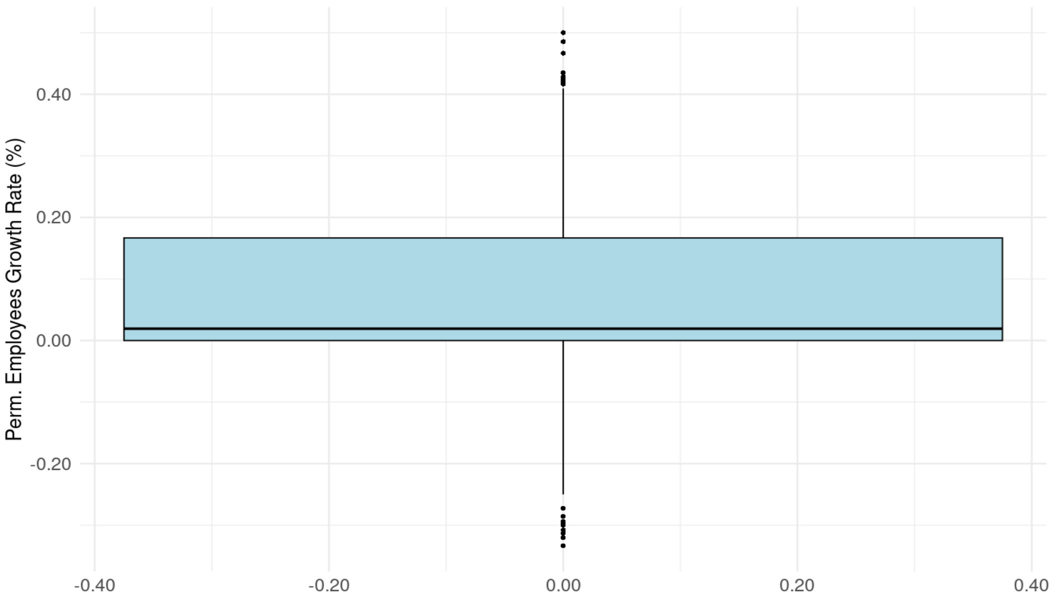

*Source: Own work.*

*Figure A.20: Permanent employees' growth rate outliers (pre-transformation)*




*Source: Own work.*

*Figure A.21: Permanent employees' growth rate outliers (post-transformation)*




*Source: Own work.*

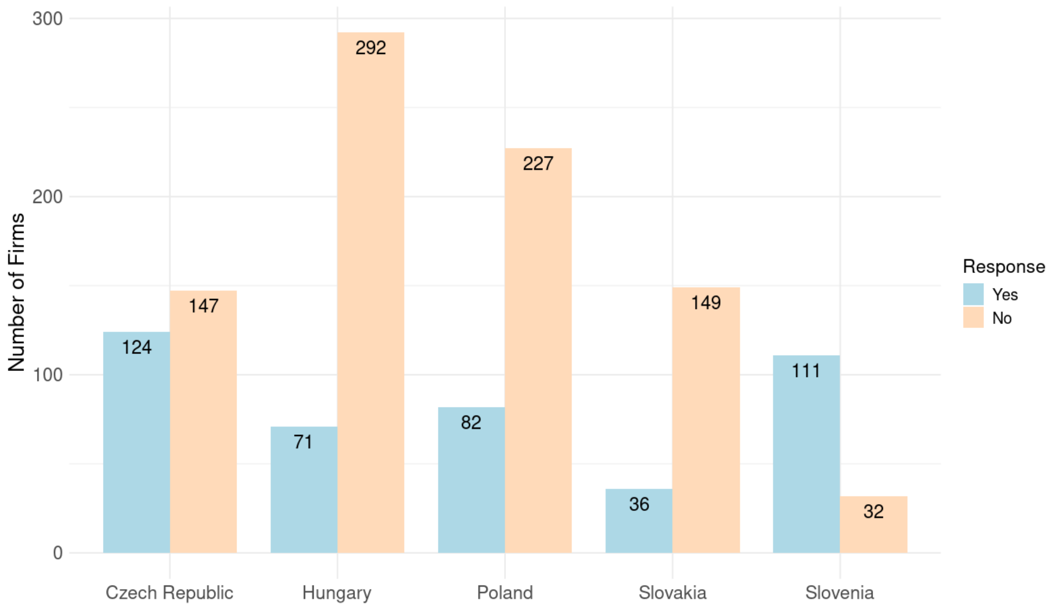
*Table A.4: Descriptive statistics of permanent employees' growth rate variable (pre and post transformation)*

| **Descriptive statistics** | **Original variable** | **IQR-winsorized variable** |
|---|---|---|
| Mean | 0.1031 | 0.0726 |
| Median | 0.0192 | 0.0192 |
| Min | -0.8470 | -0.3333 |
| Max | 8.0000 | 0.5000 |
| SD | 0.3771 | 0.1787 |
| Skewness | 9.8866 | 0.5544 |
| Kurtosis | 172.5875 | 3.4995 |
| IQR | 0.1666 | 0.1666 |

*Source: Own work.*

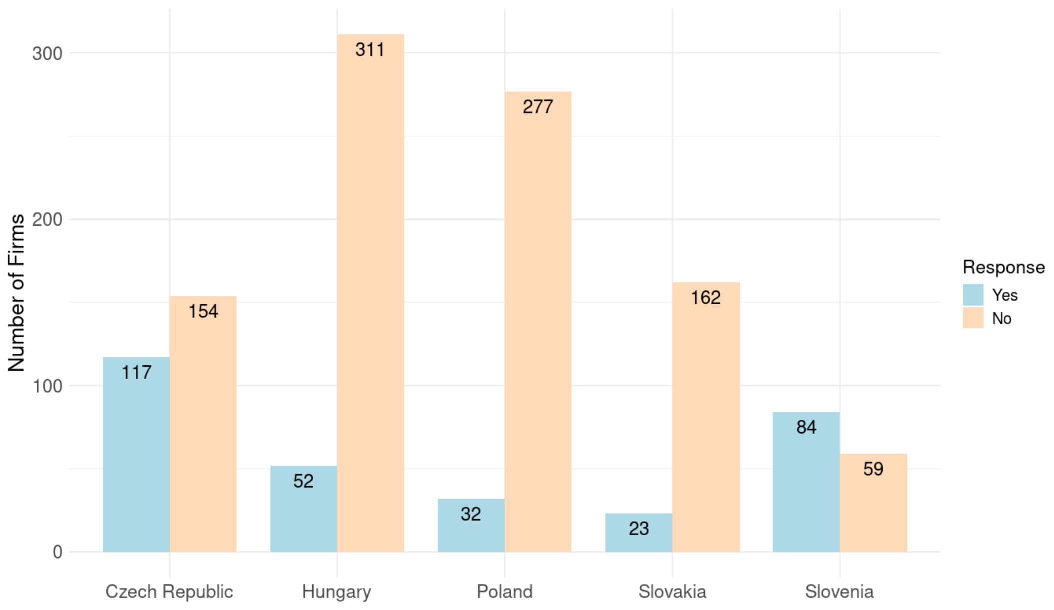
**Appendix 2: Survey questions analysis**

*Figure A.22: Product innovation by country*



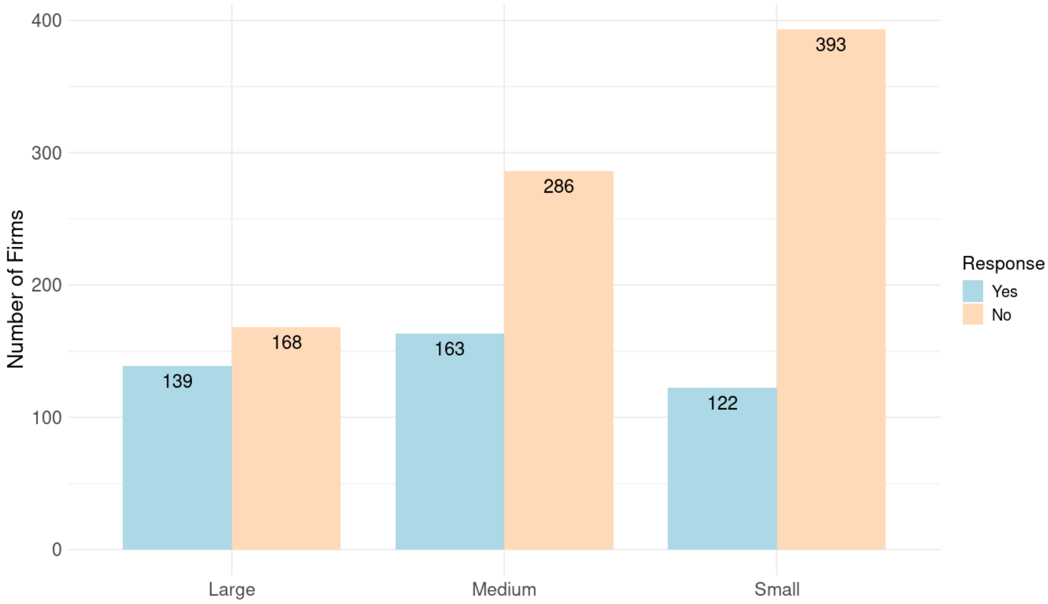

*Source: Own work.*

*Figure A.23: Process innovation by country*



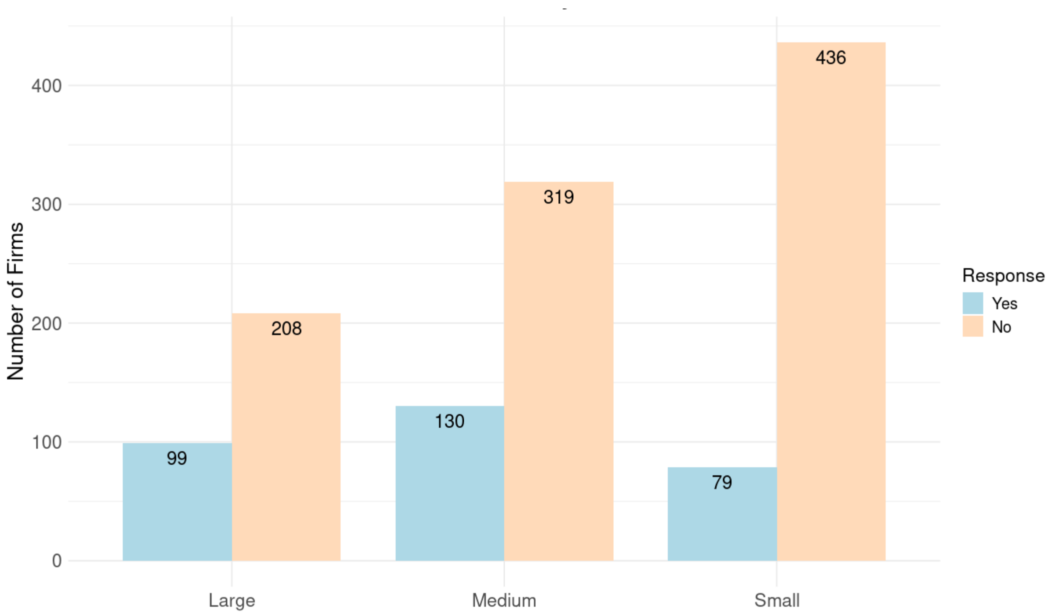

*Source: Own work.*

*Figure A.24: Product innovation by firm size*



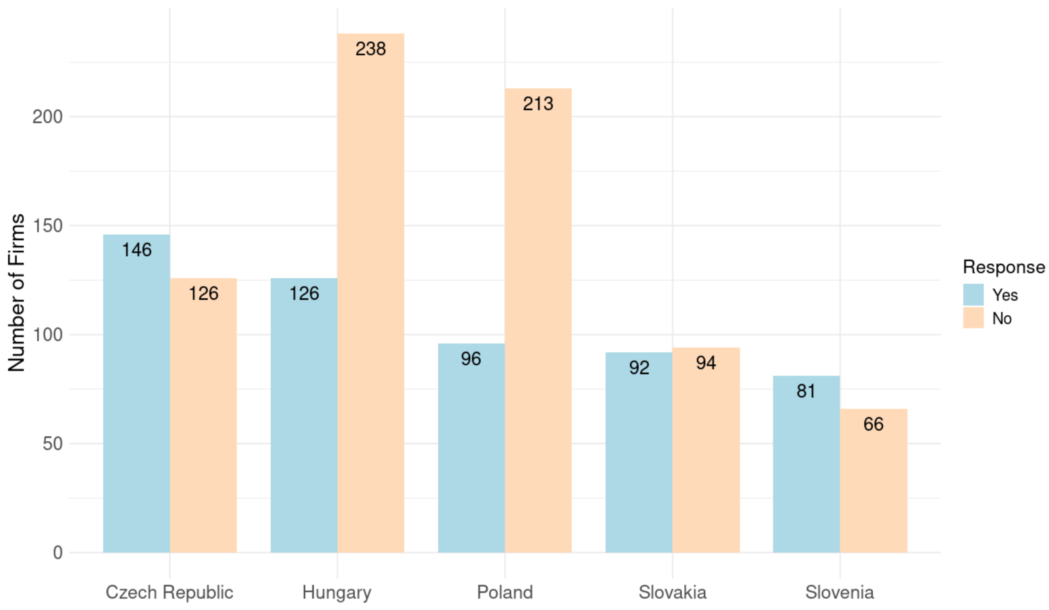

*Source: Own work.*

*Figure A.25: Process innovation by firm size*



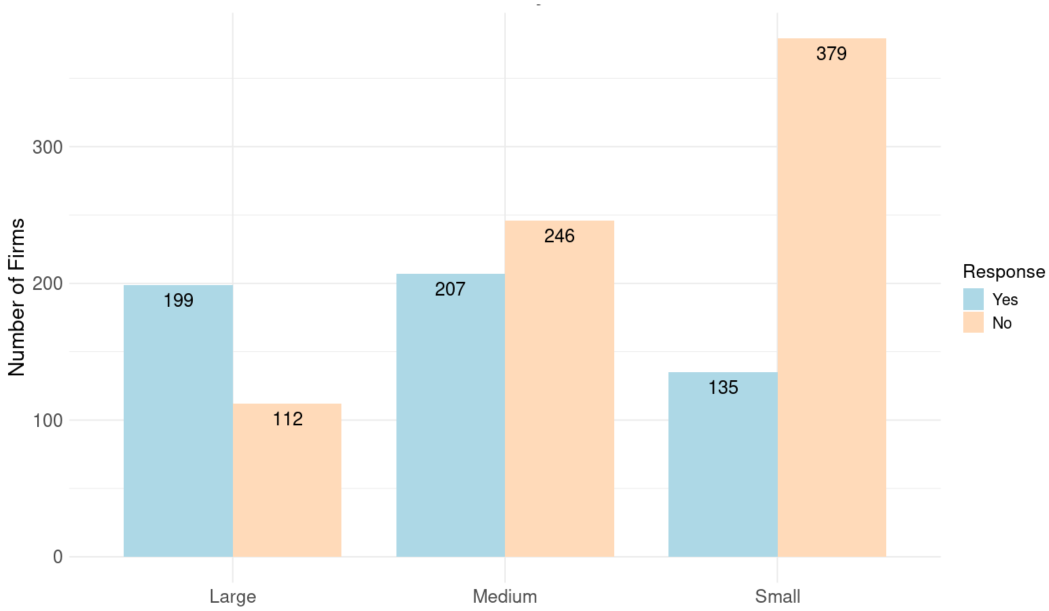

*Source: Own work.*

*Figure A.26: Labour training by country*



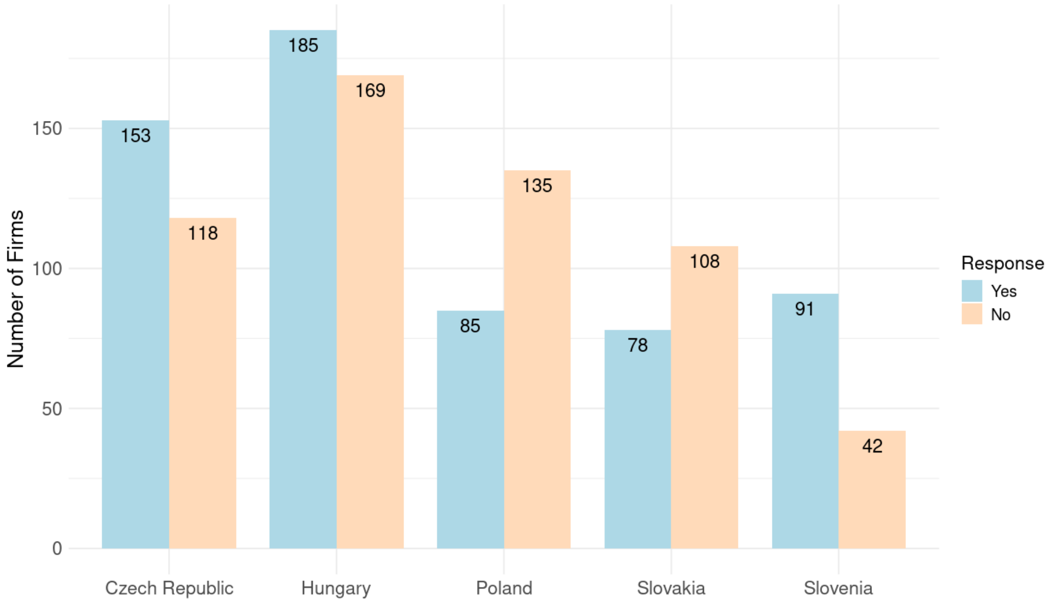

*Source: Own work.*

*Figure A.27: Labour training by firm size*



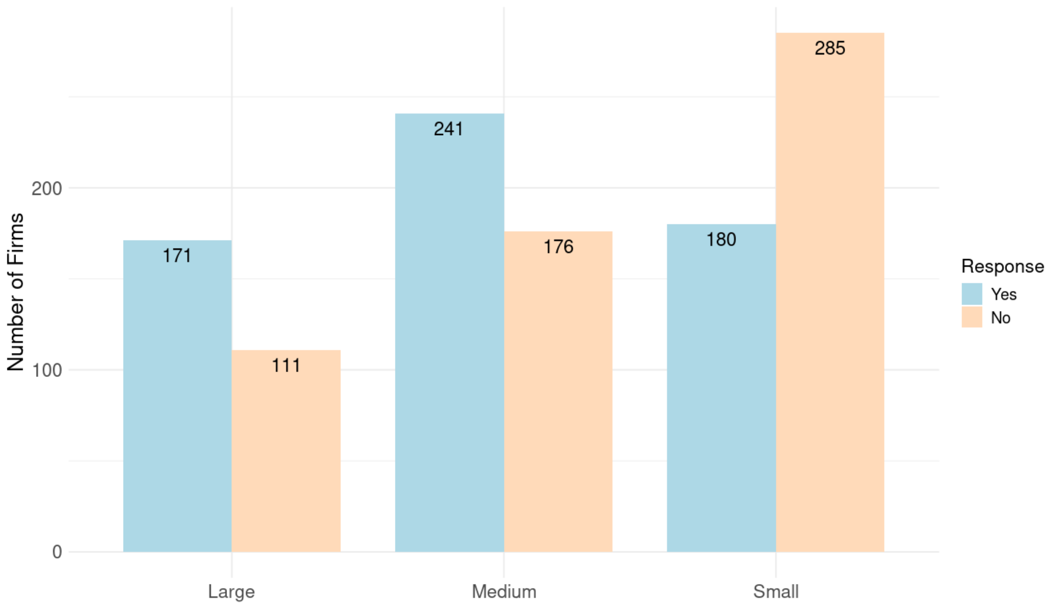

*Source: Own work.*

*Figure A.28: Line of credit/loan by country*



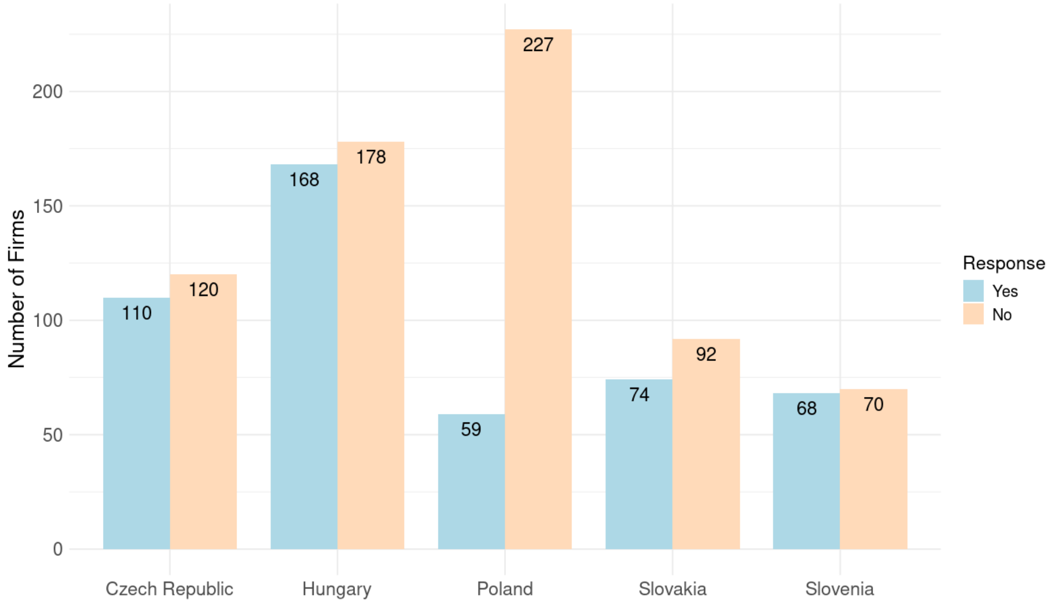

*Source: Own work.*

*Figure A.29: Line of credit/loan by firm size*



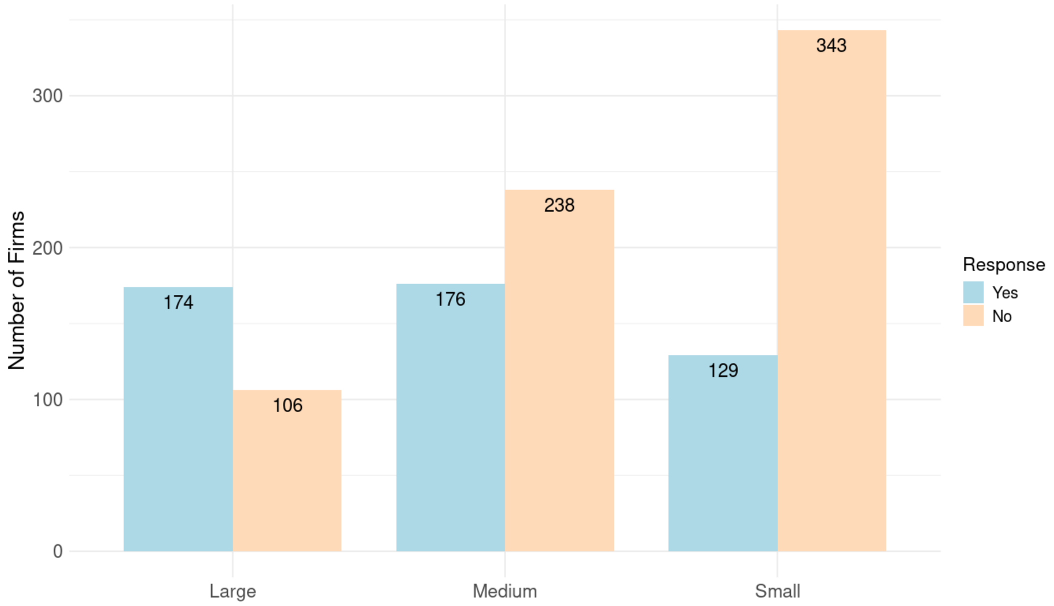

*Source: Own work.*

*Figure A.30: Environmental targets adoption by country*




*Source: Own work.*

*Figure A.31: Environmental targets adoption by firm size*

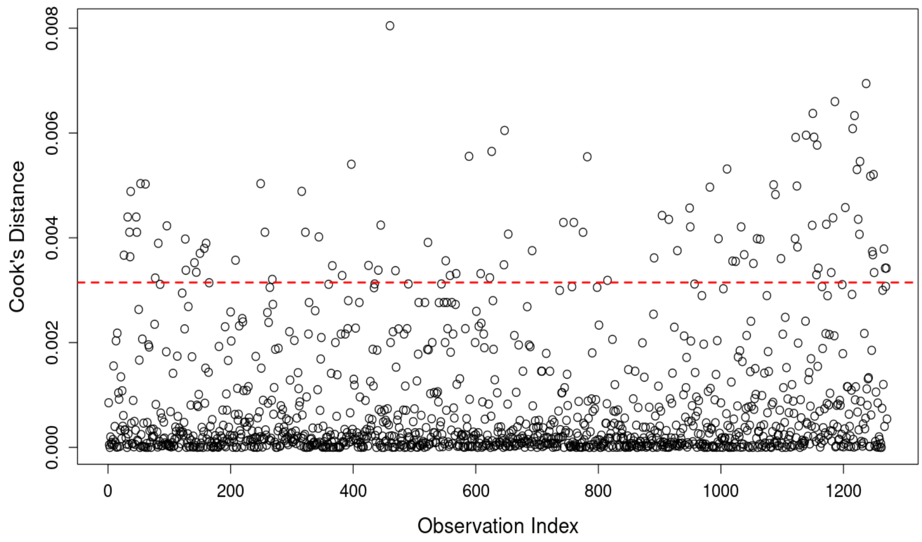



*Source: Own work.*

## Appendix 3: Hypotheses testing

**H1:** Innovation management practices — product and process innovation — positively impact firm economic performance, measured by sales growth rate, in the manufacturing sector.

*Figure A.32: H1 - Cook's distance plot*




*Source: Own work.*

*Table A.5: Sample description: Innovation and firm performance (sales growth)*

| **Sample description** | **N** |
|---|---|
| Baseline sample size | 1,283 |
| Missing values in product innovation | 3 |
| Missing values in process innovation | 10 |
| Total combined missing values | 12 |
| Sample size after excluding missing values | 1,271 |
| Number of Cook's influential points | 101 |
| Percentage of removed Cook's influential points | 7.95% |
| Final sample size (post Cook's removal) | 1,170 |

*Source: Own work.*

*Table A.6: Sample distribution after Cook's distance outliers' removal: Innovation and firm performance (sales growth)*

| **Country** | **N** |
|---|---|
| Czech Republic | 248 |
| Hungary | 344 |
| Poland | 296 |
| Slovakia | 166 |
| Slovenia | 116 |
| **Firm Size** | **N** |
| Small | 471 |
| Medium | 411 |
| Large | 288 |
| **Firm Age** | **N** |
| Young and Mature | 312 |
| Old | 858 |

*Source: Own work.*

**Multiple linear regression model:** *Sales Growth Rate = β0 + β1 Product Innovation +β2 Process Innovation + β4 Country + β5 Firm Size + β6 Firm Age + ϵ*

*Table A.7: Diagnostic test results for multiple linear regression model: Innovation and firm performance (sales growth)*

| **Diagnostic test** | **Statistic** | **Degrees of freedom** | **p-value** | **Conclusion** |
|---|---|---|---|---|
| Breusch-Pagan Test | BP = 31.491 | df = 9 | **<0.001** | Significant (present heteroscedasticity) |
| Durbin-Watson Test | DW = 2.025 | - | 0.618 | Non-significant (no autocorrelation) |
| RESET Test | RESET = 0.518 | df1 = 2<br>df2 = 1,158 | 0.596 | Non-significant (correct functional form) |

*Source: Own work.*

To account for heteroscedasticity, final regression results are reported with robust standard errors based on White-Huber correction (HC1), applied via the coeftest function in R.

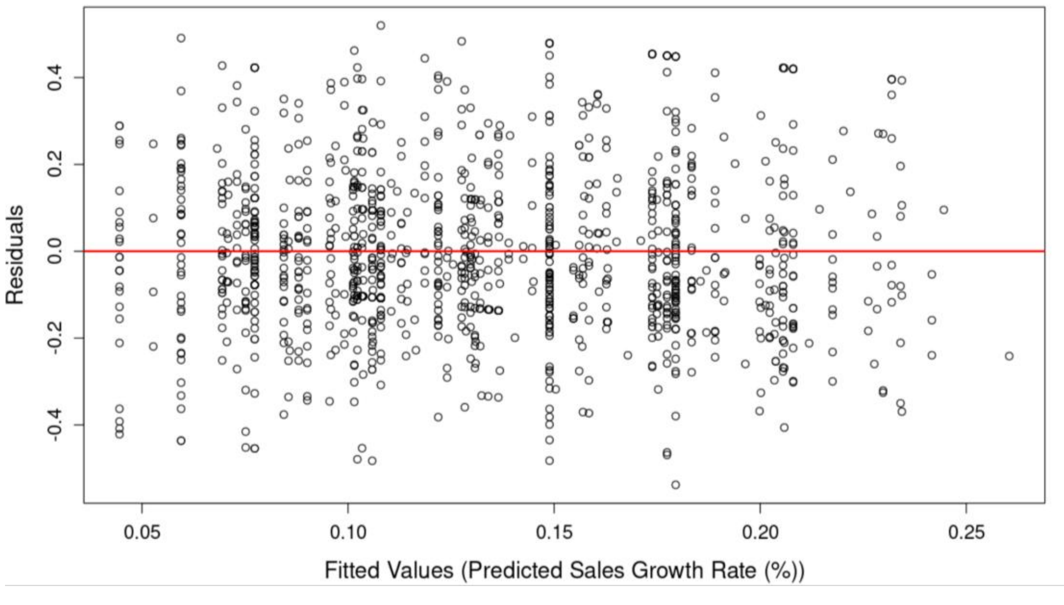
*Table A.8: Multicollinearity (VIF test) results: Innovation and firm performance (sales growth)*

| Variable | GVIF | DF | GVIF |
|---|---|---|---|
| Product Innovation | 1.272 | 1 | 1.128 |
| Process Innovation | 1.280 | 1 | 1.132 |
| Country | 1.402 | 4 | 1.043 |
| Firm Size | 1.100 | 2 | 1.024 |
| Firm Age | 1.022 | 1 | 1.011 |

*Source: Own work.*

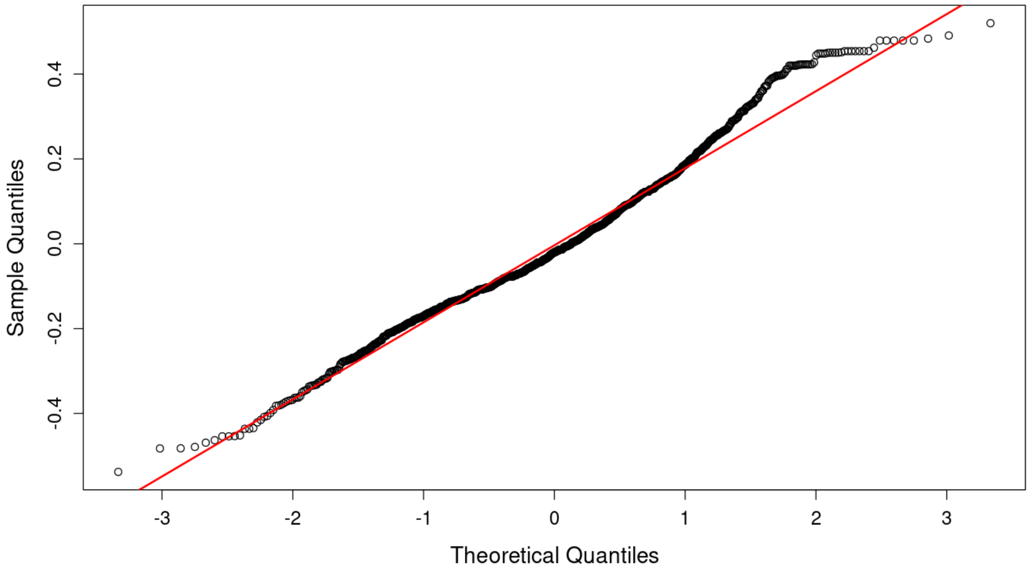
Figure A.33 indicates the presence of heteroscedasticity, which was addressed in the regression model by applying robust standard errors.

*Figure A.33: H1 – Residuals vs. Fitted values*



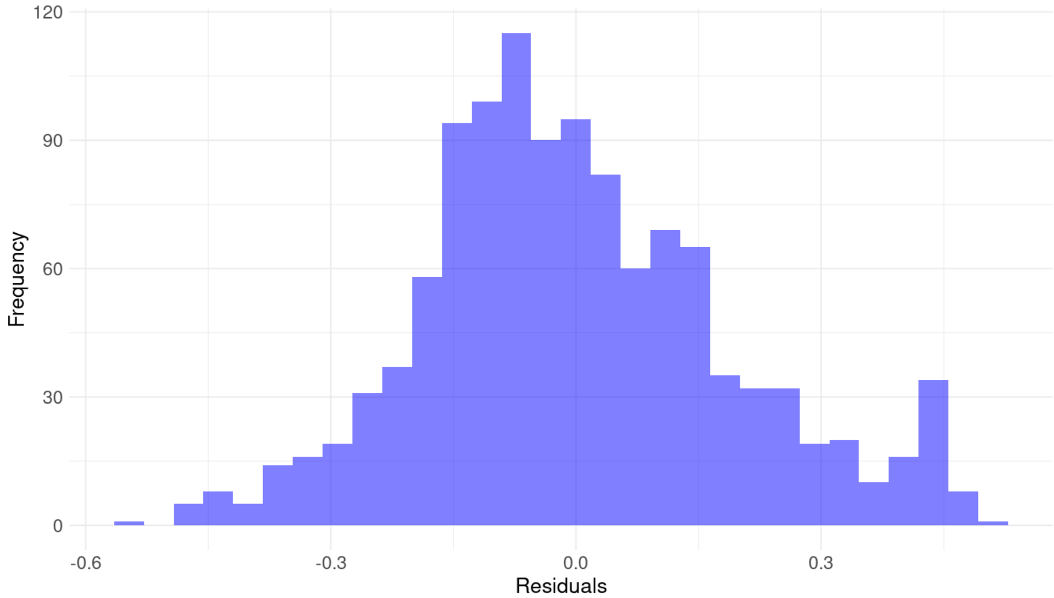

*Source: Own work.*

*Figure A.34: H1 - Q-Q plot of residuals*




*Source: Own work.*

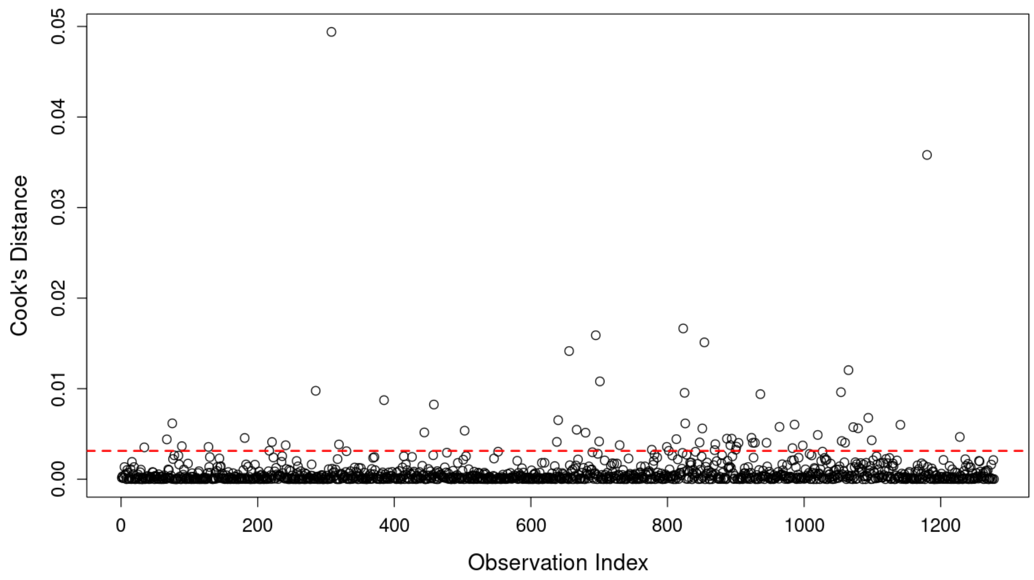
*Figure A.35: H1 – Residual distribution*




*Source: Own work.*

**H2a:** Labour training positively impacts firm economic performance, measured by sales per employee, in the manufacturing sector.

*Figure A.36: H2a – Cook's distance plot*




*Source: Own work.*

*Table A.9: Sample description: Labour training and firm performance (sales per employee)*

| **Sample description** | **N** |
|---|---|
| Baseline sample size | 1,283 |
| Missing values in labour training | 5 |
| Sample size after excluding missing values | 1,278 |
| Number of Cook's influential points | 64 |
| Percentage of removed Cook's influential points | 5.01% |
| Final sample size (post Cook's removal) | 1,214 |

*Source: Own work.*

*Table A.10: Sample distribution after Cook's distance outliers' removal: Labour training and firm performance (sales per employee)*

| Country | N |
|---|---|
| Czech Republic | 263 |
| Hungary | 357 |
| Poland | 277 |
| Slovakia | 173 |
| Slovenia | 144 |
| **Firm Size** | **N** |
| Small | 493 |
| Medium | 431 |
| Large | 290 |

*Source: Own work.*

**Multiple linear regression model:**

*Log (Sales per Employee (EUR)) = β0 + β1 Labour Training + β2 Country + β3 Firm Size + ϵ*

*Table A.11: Diagnostic test results for multiple linear regression model: Labour training and firm performance (sales per employee)*

| Diagnostic test | Statistic | Degrees of freedom | p-value | Conclusion |
|---|---|---|---|---|
| Breusch-Pagan Test | BP = 28.013 | df = 7 | **<0.001** | Significant (present heteroscedasticity) |
| Durbin-Watson Test | DW = 1.924 | - | 0.173 | Non-significant (no autocorrelation) |
| RESET Test | RESET = 0.375 | df1 = 2<br>df2 = 1,204 | 0.688 | Non-significant (correct functional form) |

*Source: Own work.*

To account for heteroscedasticity, final regression results are reported with robust standard errors based on White-Huber correction (HC1), applied via the coeftest function in R.

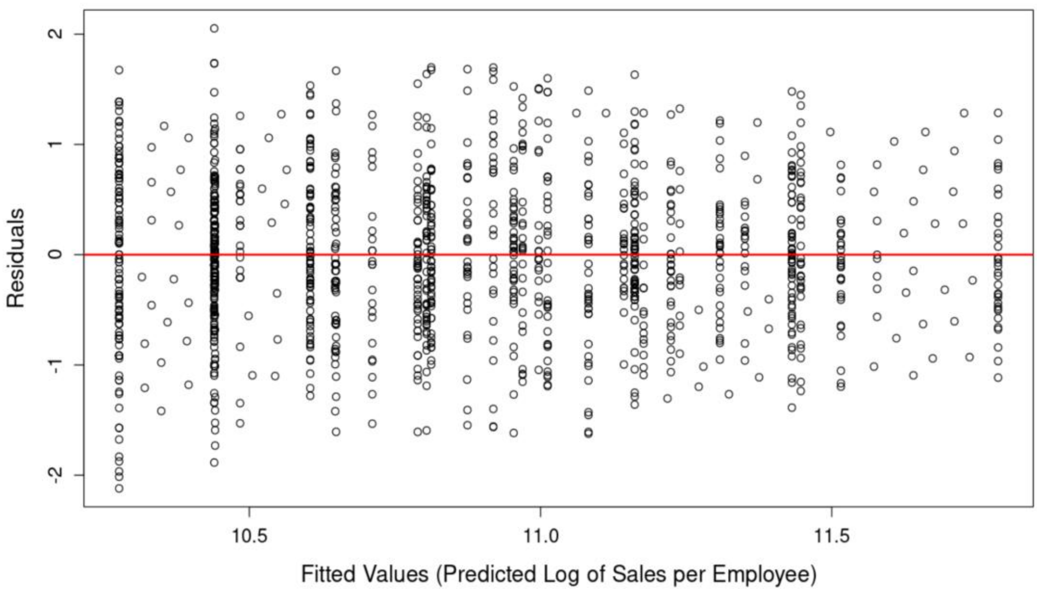
*Table A.12: Multicollinearity (VIF test) results: Labour training and firm performance (sales per employee)*

| **Variable** | **GVIF** | **DF** | **GVIF** |
|---|---|---|---|
| Labour Training | 1.148 | 1 | 1.071 |
| Country | 1.082 | 4 | 1.010 |
| Firm Size | 1.154 | 2 | 1.036 |

*Source: Own work.*

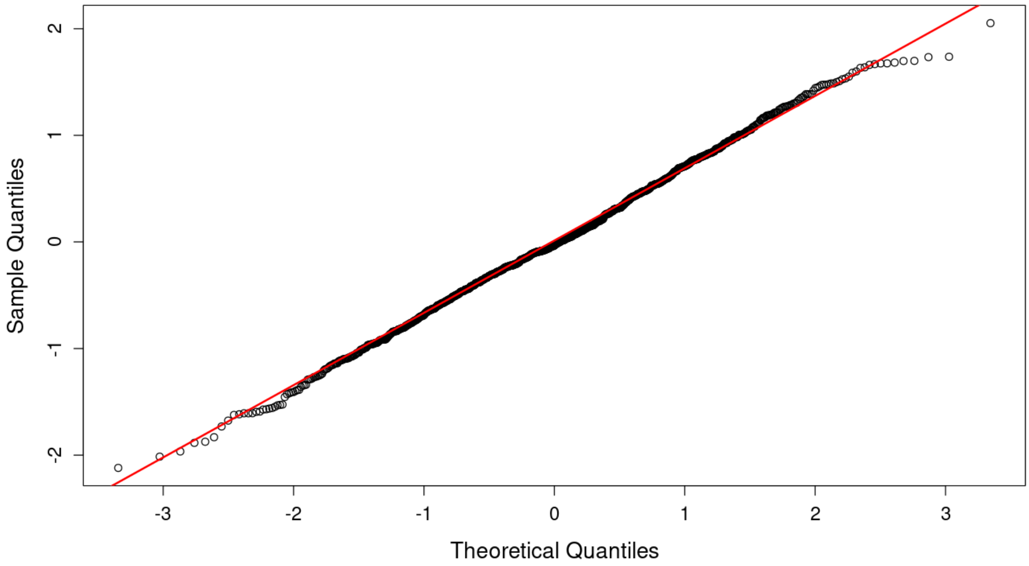
Figure A.37 indicates the presence of heteroscedasticity, which was addressed in the regression model by applying robust standard errors.

*Figure A.37: H2a - Residuals vs. Fitted values*



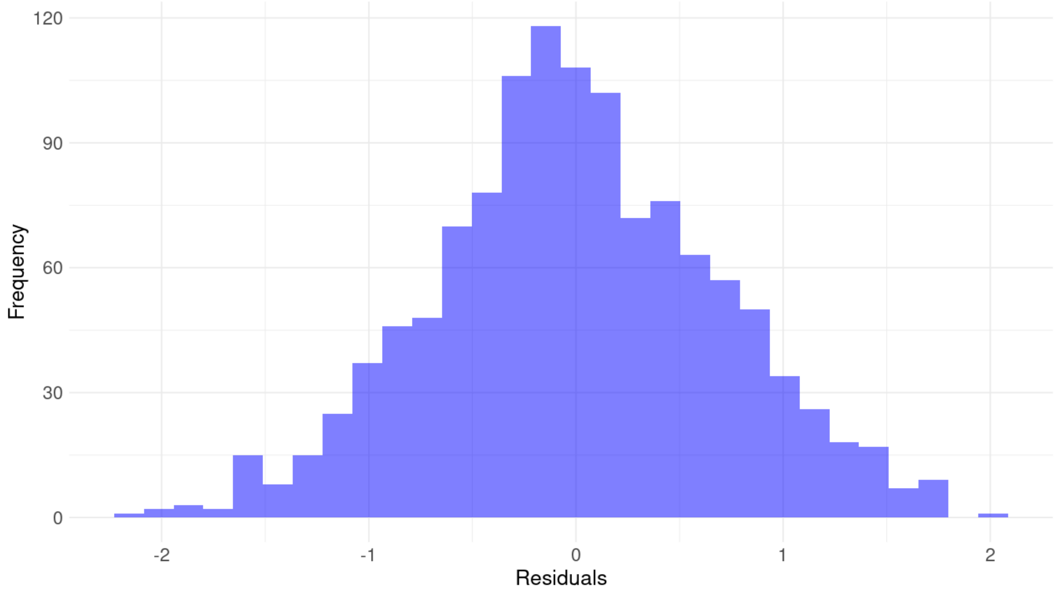

*Source: Own work.*

*Figure A.38: H2a - Q-Q plot of residuals*




*Source: Own work.*

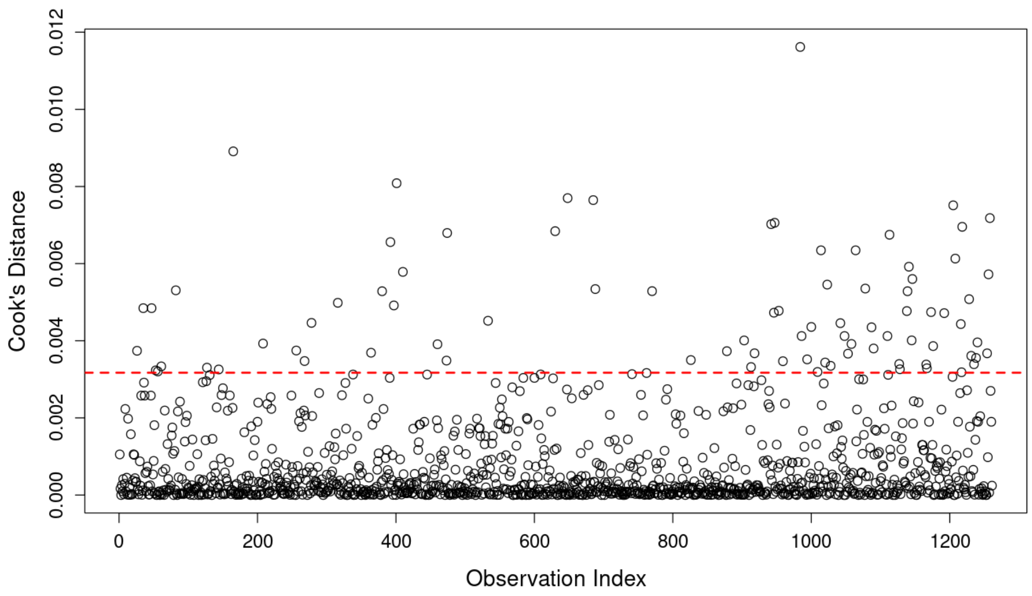
*Figure A.39: H2a - Residual distribution*




*Source: Own work.*

**H2b:** An increase in the number of permanent employees positively impacts firm economic performance, measured by sales growth rate, in the manufacturing sector.

*Figure A.40: H2b – Cooks distance plot*




*Source: Own work.*

*Table A.3: Sample description: Permanent employees' growth and firm performance (profit margin)*

| **Sample description** | **N** |
|---|---|
| Baseline sample size | 1,283 |
| Missing values in permanent employees' growth rate | 22 |
| Sample size after excluding missing values | 1,261 |
| Number of Cook's influential points | 84 |
| Percentage of removed Cook's influential points | 6.66% |
| Final sample size (post Cook's removal) | 1,177 |

*Source: Own work.*

*Table A.4: Sample distribution after Cook's distance outliers' removal: Permanent employees' growth and firm performance (profit margin)*

| **Country** | **N** |
|---|---|
| Czech Republic | 258 |
| Hungary | 351 |
| Poland | 288 |
| Slovakia | 161 |
| Slovenia | 119 |
| **Firm Size** | **N** |
| Small | 472 |
| Medium | 420 |
| Large | 285 |

*Source: Own work.*

**Multiple linear regression model:**

*Sales growth rate = β0 + β1 Perm. Employees Growth Rate + β2 Country + β3 Firm Size + ϵ*

*Table A.5: Diagnostic test results for multiple linear regression model: Permanent employees' growth and firm performance (profit margin)*

| **Diagnostic test** | **Statistic** | **Degrees of freedom** | **p-value** | **Conclusion** |
|---|---|---|---|---|
| Breusch-Pagan Test | BP = 37.469 | df = 7 | **<0.001** | Significant (present heteroscedasticity) |
| Durbin-Watson Test | DW = 2.016 | - | 0.559 | Non-significant (no autocorrelation) |
| RESET Test | RESET = 0.925 | df1 = 2<br>df2 = 1,167 | 0.397 | Non-significant (correct functional form) |

*Source: Own work.*

To account for heteroscedasticity, final regression results are reported with robust standard errors based on White-Huber correction (HC1), applied via the coeftest function in R.

*Table A.6: Multicollinearity (VIF test) results: Permanent employees' growth and firm performance (profit margin)*

| **Variable** | **GVIF** | **DF** | **GVIF** |
|---|---|---|---|
| Perm. Employees Growth Rate | 1.027 | 1 | 1.014 |
| Country | 1.079 | 4 | 1.010 |
| Firm Size | 1.059 | 2 | 1.015 |

*Source: Own work.*

*Table A.7: Pearson's correlation test between regression model residuals and permanent employees' growth rate*

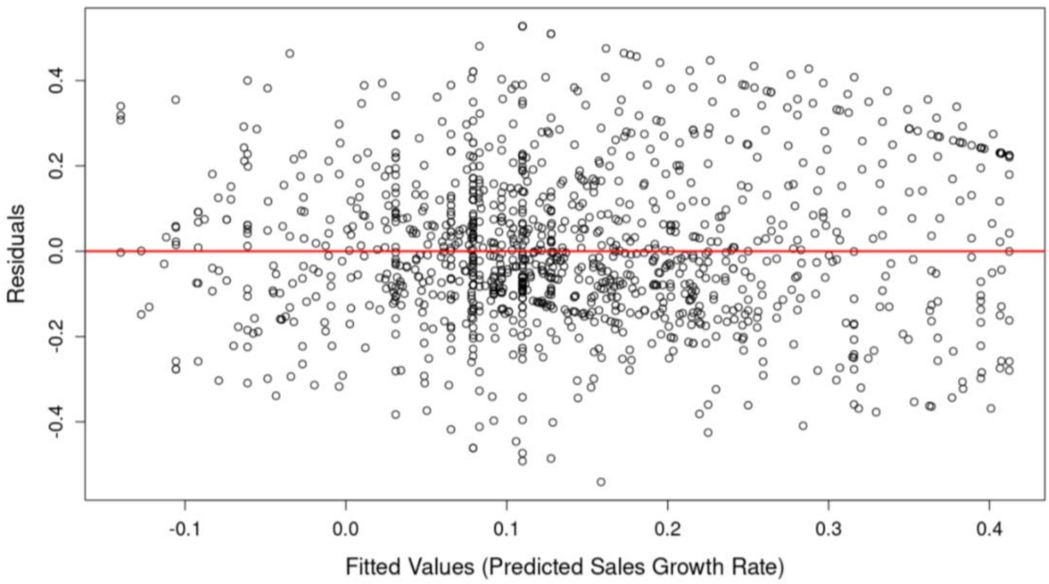
| **Variable 1** | **Variable 2** | **Pearson's r** | **t-value** | **df** | **p-value** | **95% CI (lower)** | **95% CI (upper)** |
|---|---|---|---|---|---|---|---|
| Residuals of reg. model | Perm. Employees Growth Rate | 0.000 | 0.000 | 1,175 | 1.000 | -0.057 | 0.057 |

*Source: Own work.*

Pearson's r and t-value were extremely small (r = –3.09e–18, t = –1.06e–16) and are reported as 0.000 for clarity.

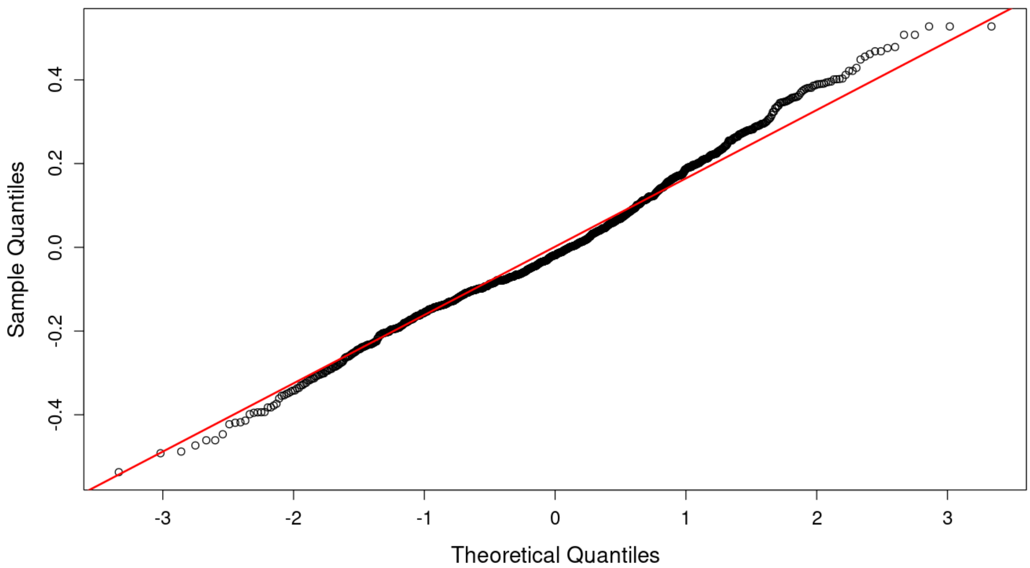
Figure A.41 indicates the presence of heteroscedasticity, which was addressed in the regression model by applying robust standard errors.

*Figure A.41: H2b - Residuals vs. Fitted values*



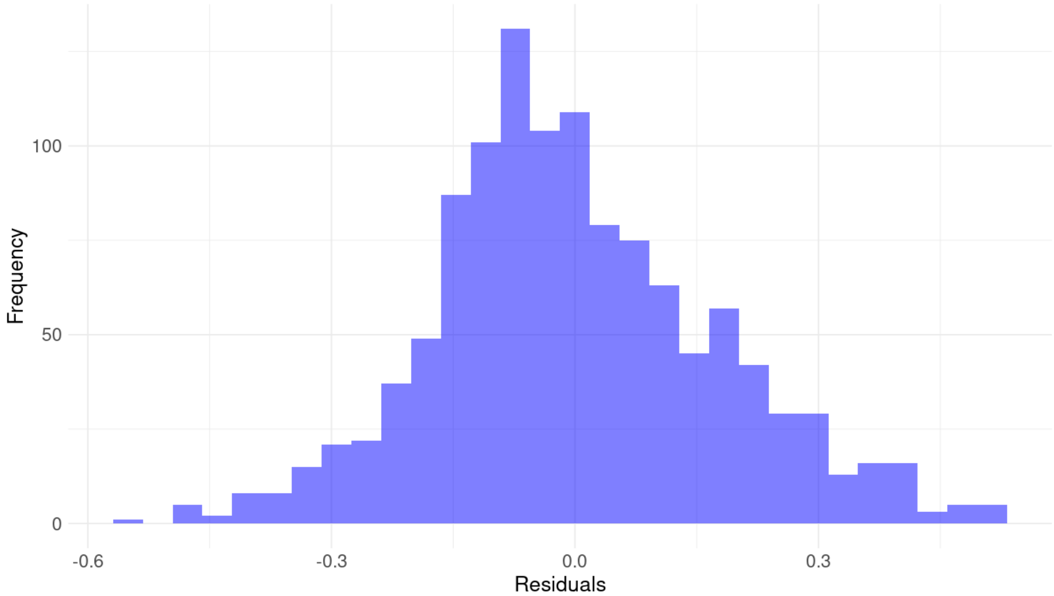

*Source: Own work.*

*Figure A.42: H2b - Q-Q plot of residuals*




*Source: Own work.*

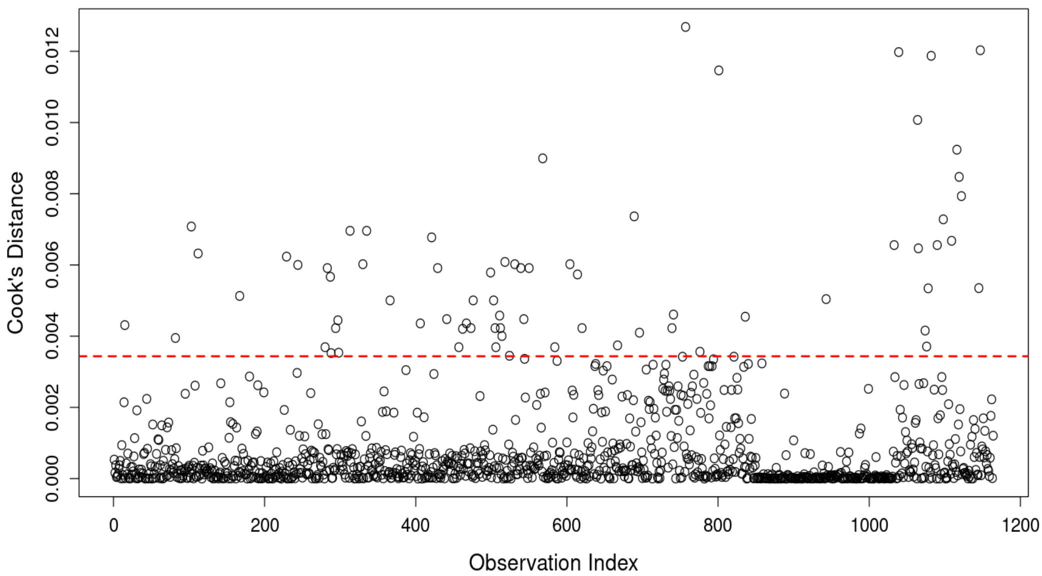
*Figure A.43: H2b - Residual distribution*




*Source: Own work.*

**H3:** External financing — line of credit or loan — positively impacts firm economic performance, measured by profit margin, in the manufacturing sector.

*Figure A.44: H3 - Cook's distance plot*




*Source: Own work.*

*Table A.8: Sample description: External financing and firm performance (profit margin)*

| **Sample description** | **N** |
|---|---|
| Subsample size (used for profitability analysis) | 1,166 |
| Missing values in line of credit/loan | 2 |
| Sample size after excluding missing values | 1,164 |
| Number of Cook's influential points | 71 |
| Percentage of removed Cook's influential points | 6.10% |
| Final sample size (post Cook's removal) | 1,093 |

*Source: Own work.*

*Table A.9: Sample distribution after Cook's distance outliers' removal: External financing and firm performance (profit margin)*

| **Country** | **N** |
|---|---|
| Czech Republic | 264 |
| Hungary | 316 |
| Poland | 211 |
| Slovakia | 185 |
| Slovenia | 117 |
| **Firm Size** | **N** |
| Small | 441 |
| Medium | 394 |
| Large | 258 |
| **Firm Age** | **N** |
| Young and Mature | 311 |
| Old | 782 |

*Source: Own work.*

**Multiple linear regression model:**

*Profit Margin = β0 + β1 Line of Credit/Loan + β2 Country + β3 Firm Size + β4 Firm Age + ϵ*

*Table A.10: Diagnostic test results for multiple linear regression model: External financing and firm performance (profit margin)*

| **Diagnostic test** | **Statistic** | **Degrees of freedom** | **p-value** | **Conclusion** |
|---|---|---|---|---|
| Breusch-Pagan Test | BP = 34.021 | df = 8 | **<0.001** | Significant (present heteroscedasticity) |
| Durbin-Watson Test | DW = 1.894 | - | 0.475 | Non-significant (no autocorrelation) |
| RESET Test | RESET = 1.323 | df1 = 2<br>df2 = 1,082 | 0.276 | Non-significant (correct functional form) |

*Source: Own work.*

To account for heteroscedasticity, final regression results are reported with robust standard errors based on White-Huber correction (HC1), applied via the coeftest function in R.

*Table A.11: Multicollinearity (VIF test) results: External financing and firm performance (profit margin)*

| **Variable** | **GVIF** | **DF** | **GVIF** |
|---|---|---|---|
| Line of Credit / Loan | 1.072 | 1 | 1.035 |
| Country | 1.100 | 4 | 1.012 |
| Firm Size | 1.101 | 2 | 1.024 |
| Firm Age | 1.027 | 1 | 1.014 |

*Source: Own work.*

*Table A.12: Pearson's correlation test between regression model residuals and external financing*

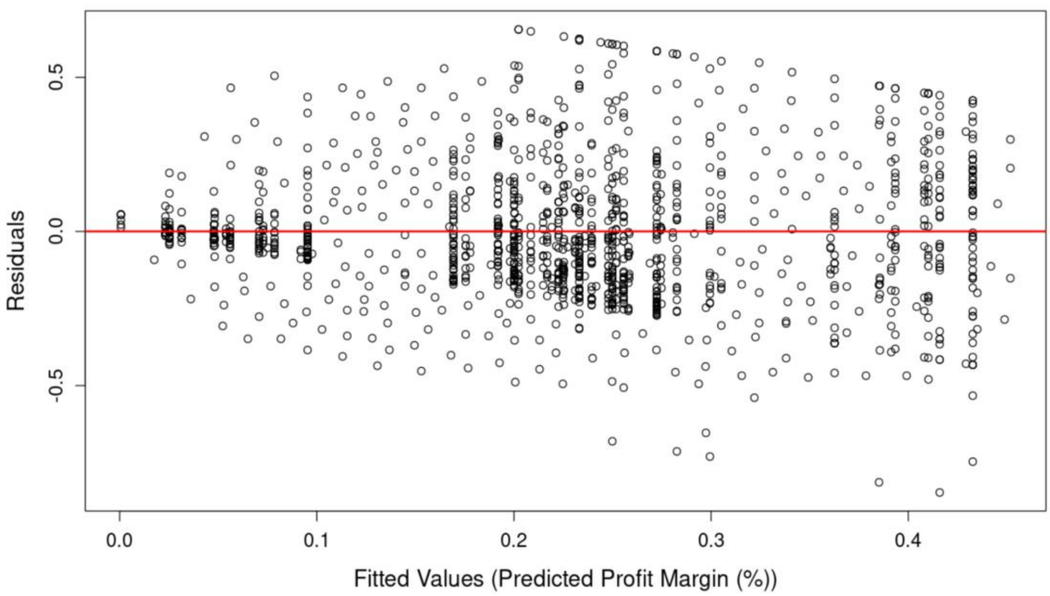
| **Variable 1** | **Variable 2** | **Pearson's r** | **t-value** | **df** | **p-value** | **95% CI (lower)** | **95% CI (upper)** |
|---|---|---|---|---|---|---|---|
| Residuals of reg. model | Line of Credit / Loan | 0.000 | 0.000 | 1,091 | 1.000 | -0.059 | 0.059 |

*Source: Own work.*

Pearson's r and t-value were extremely small (r = 3.93e–17, t = 1.30e–15) and are reported as 0.000 for clarity.

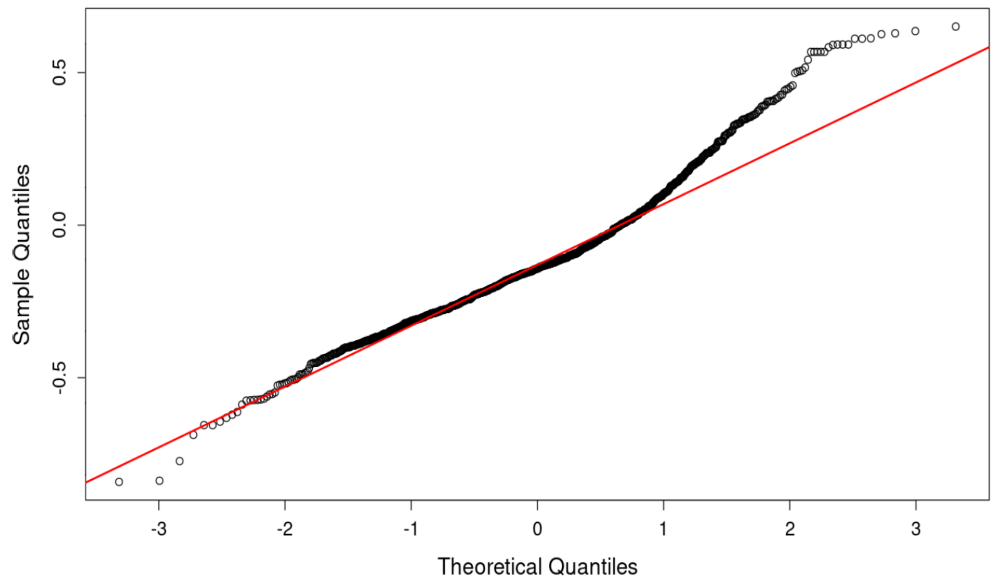
Figure A.45 indicates the presence of heteroscedasticity, which was addressed in the regression model by applying robust standard errors.

*Figure A.45: H3 - Residuals vs. Fitted values*



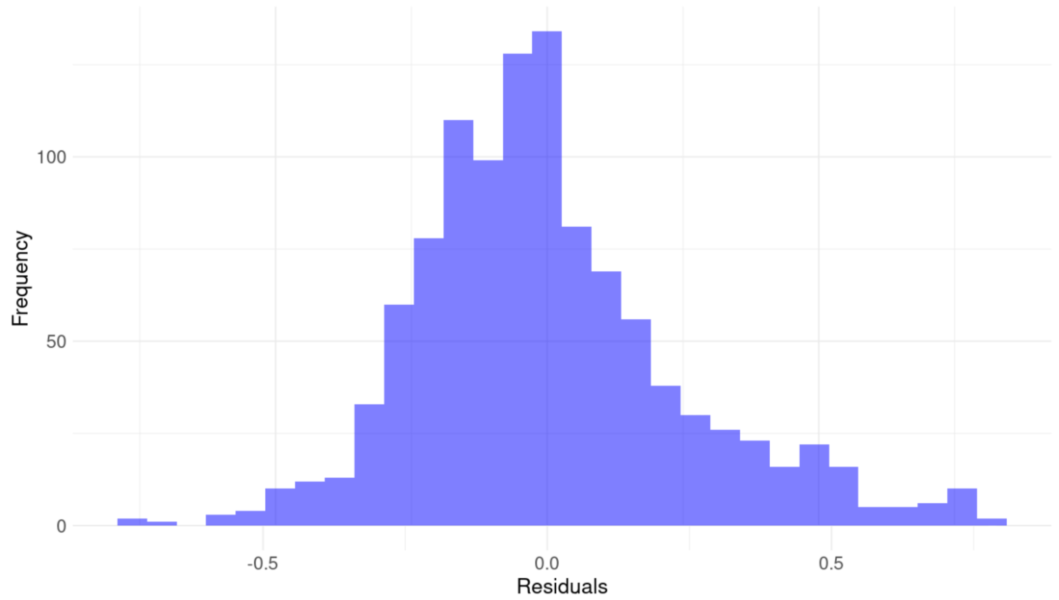

*Source: Own work.*

*Figure A.46: H3 - Q-Q plot of residuals*




*Source: Own work.*

*Figure A.47: H3 - Residual distribution*




*Source: Own work.*

**H4a:** The adoption of environmental management practices — energy management, waste management, water management, air pollution control measures, and machinery upgrades — leads to improved firm environmental performance, indicated by the adoption of environmental targets, in the manufacturing sector.

*Table A.13: Sample description: Environmental management practices and targets adoption*

| **Sample description** | **N** |
|---|---|
| Baseline sample size | 1,283 |
| Missing values in environmental targets | 37 |
| Missing values in energy management | 73 |
| Missing values in waste management | 53 |
| Missing values in water management | 83 |
| Missing values in air pollution controls | 85 |
| Missing values in machinery upgrades | 55 |
| Total combined missing values | 117 |
| Final sample size | 1,166 |

*Source: Own work.*

*Table A.14: Sample distribution after missing values removal: Environmental management practices and targets adoption*

| **Country** | **N** |
|---|---|
| Czech Republic | 230 |
| Hungary | 346 |
| Poland | 286 |
| Slovakia | 166 |
| Slovenia | 138 |
| **Firm Size** | **N** |
| Small | 472 |
| Medium | 414 |
| Large | 280 |
| **Firm Age** | **N** |
| Young and Mature | 333 |
| Old | 833 |

*Source: Own work.*

**Binary logistic regression model:**

*Environmental Targets = β0 + β1 Energy Management +β2 Waste Management + β3 Water Management + β4 Air Pollution Controls + β5 Machinery Upgrades + β6 Country + β7 Firm Size + β8 Firm Age + ϵ*

*Table A.15: Goodness-of-Fit indicators for binary logistic regression model: Environmental management practices and targets adoption*

| **Goodness-of-Fit Measure** | **Value** |
|---|---|
| McFadden | 0.213 |
| $r^2$ (ML) | 0.250 |
| $r^2$ (CU) | 0.337 |

*Source: Own work.*

*Table A.16: Multicollinearity (VIF test) results: Environmental management practices and targets adoption*

| **Variable** | **GVIF** | **DF** | **GVIF** |
|---|---|---|---|
| Energy Management | 1.295 | 1 | 1.138 |
| Waste Management | 1.211 | 1 | 1.100 |
| Water Management | 1.317 | 1 | 1.148 |
| Air Pollution Controls | 1.279 | 1 | 1.131 |
| Machinery Upgrades | 1.165 | 1 | 1.079 |
| Country | 1.278 | 4 | 1.031 |
| Firm Size | 1.091 | 2 | 1.022 |
| Firm Age | 1.034 | 1 | 1.017 |

*Source: Own work.*

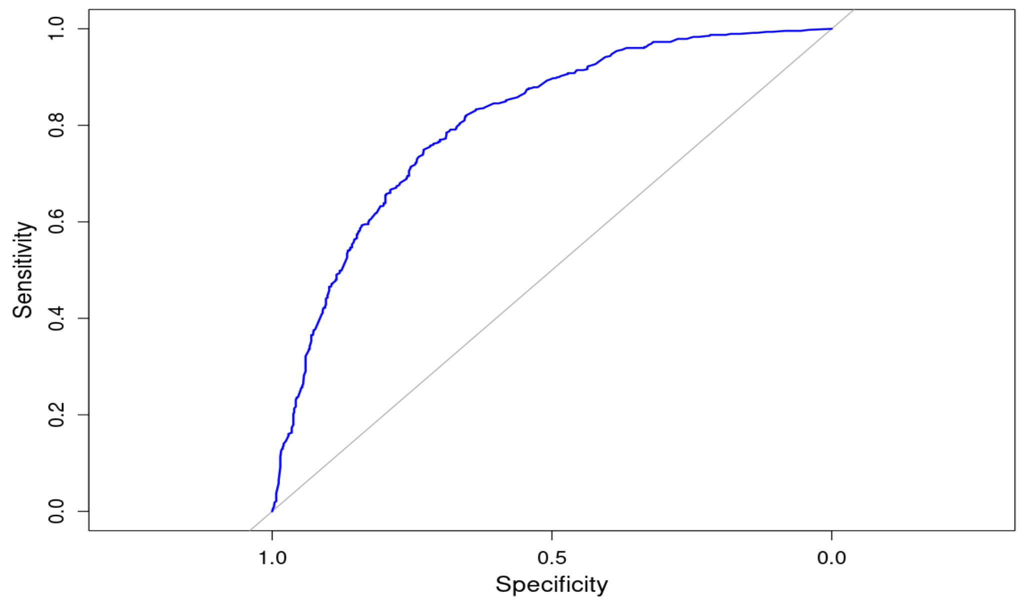
*Table A.17: Analysis of deviance (likelihood ratio test Chisq): Environmental management practices and targets adoption*

| **Variable** | **Df** | **Deviance** | **Resid. Df** | **Resid. Dev.** | **p-value** | |
|---|---|---|---|---|---|---|
| NULL | | | 1,165 | 1,579.1 | | |
| Energy Management | 1 | 192.500 | 1,164 | 1,386.6 | **<0.001** | *** |
| Waste Management | 1 | 21.295 | 1,163 | 1,365.3 | **<0.001** | *** |
| Water Management | 1 | 25.600 | 1,162 | 1,339.7 | **<0.001** | *** |
| Air Pollution Controls | 1 | 10.922 | 1,161 | 1,328.8 | **0.001** | *** |
| Machinery Upgrades | 1 | 7.303 | 1,160 | 1,321.5 | **0.007** | ** |
| Country | 4 | 52.717 | 1,156 | 1,268.8 | **<0.001** | *** |
| Firm Size | 2 | 24.993 | 1,154 | 1,243.8 | **<0.001** | *** |
| Firm Age | 1 | 0.522 | 1,153 | 1,243.3 | 0.470 | |

*Source: Own work.*

The ROC curve analysis yielded an AUC of 0.8047, indicating a good level of model discrimination between the classes showed in Figure A.48.

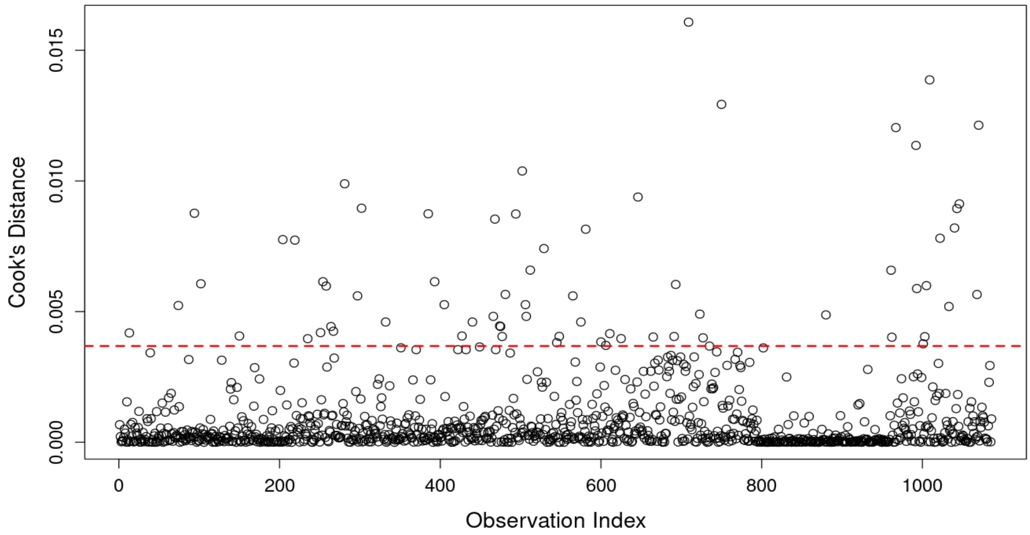
*Figure A.48: H4a - ROC Curve*




*Source: Own work.*

**H4b:** The adoption of environmental management practices — energy management, waste management, machinery upgrades and heating and cooling improvements — positively impacts firm economic performance, measured by profit margin, particularly over longer investment horizons, given the potential delayed return on such investments, in the manufacturing sector.

*Figure A.49: H4b - Cook's Distance plot*




*Source: Own work.*

*Table A.18: Sample description: Environmental management practices and firm performance (profit margin)*

| **Sample description** | **N** |
|---|---|
| Subsample size (used for profitability analysis) | 1,166 |
| Missing values in energy management | 62 |
| Missing values in waste management | 45 |
| Missing values in machinery upgrades | 43 |
| Missing values in heating and cooling improvements | 50 |
| Total combined missing values | 80 |
| Sample size after excluding missing values | 1,086 |
| Number of Cook's influential points | 68 |
| Percentage of removed Cook's influential points | 6.26% |
| Final sample size (post Cook's removal) | 1,018 |

*Source: Own work.*

*Table A.19: Sample distribution after Cook's distance outliers' removal: Environmental management practices and firm performance (profit margin)*

| **Country** | **N** |
|---|---|
| Czech Republic | 235 |
| Hungary | 312 |
| Poland | 192 |
| Slovakia | 168 |
| Slovenia | 111 |
| **Firm Size** | **N** |
| Small | 413 |
| Medium | 363 |
| Large | 242 |
| **Firm Age** | **N** |
| Young and Mature | 292 |
| Old | 726 |

*Source: Own work.*

**Multiple linear regression model:**

*Profit Margin = β0 + β1 Energy Management +β2 Waste Management + β3 Heating and Cooling Improvements + β4 Machinery Upgrades + β5 Country + β6 Firm Size + β7 Firm Age + ϵ*

*Table A.20: Diagnostic test results for multiple linear regression model: Environmental management practices and firm performance (profit margin)*

| **Diagnostic test** | **Statistic** | **Degrees of freedom** | **p-value** | **Conclusion** |
|---|---|---|---|---|
| Breusch-Pagan Test | BP = 44.63 | df = 11 | **<0.001** | Significant (present heteroscedasticity) |
| Durbin-Watson Test | DW = 1.973 | - | 0.283 | Non-significant (no autocorrelation) |
| RESET Test | RESET = 2.014 | df1 = 2<br>df2 = 1,004 | 0.267 | Non-significant (correct functional form) |

*Source: Own work.*

To account for heteroscedasticity, final regression results are reported with robust standard errors based on White-Huber correction (HC1), applied via the *coeftest* function in R.

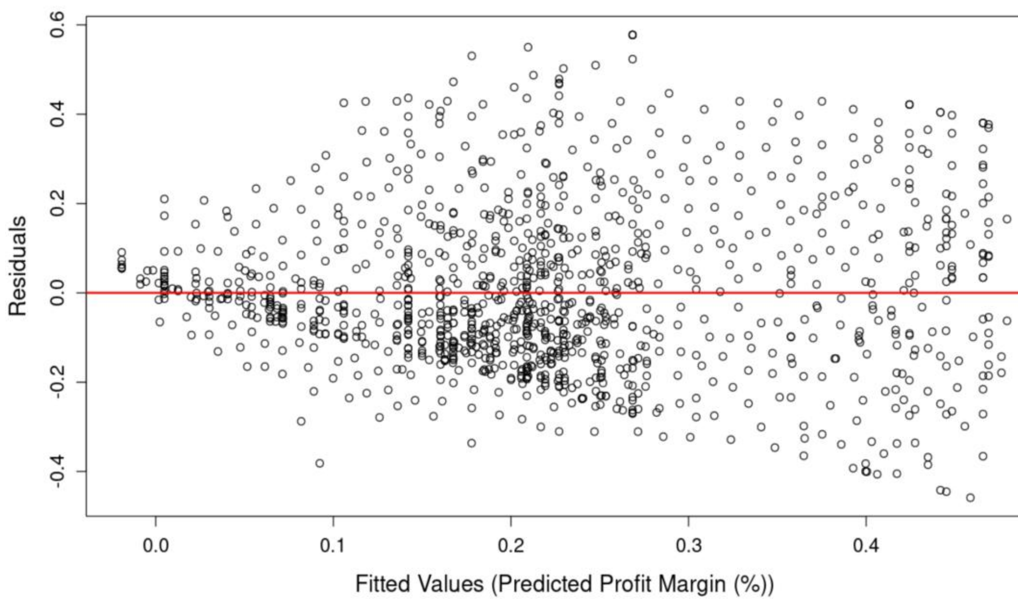
*Table A.21: Multicollinearity (VIF test) results: Environmental management practices and firm performance (profit margin)*

| **Variable** | **GVIF** | **DF** | **GVIF** |
|---|---|---|---|
| Energy Management | 1.379 | 1 | 1.175 |
| Waste Management | 1.262 | 1 | 1.124 |
| Machinery Upgrades | 1.271 | 1 | 1.128 |
| Heating and Cooling Improvements | 1.329 | 1 | 1.153 |
| Country | 1.249 | 4 | 1.028 |
| Firm Size | 1.243 | 2 | 1.056 |
| Firm Age | 1.035 | 1 | 1.018 |

*Source: Own work.*

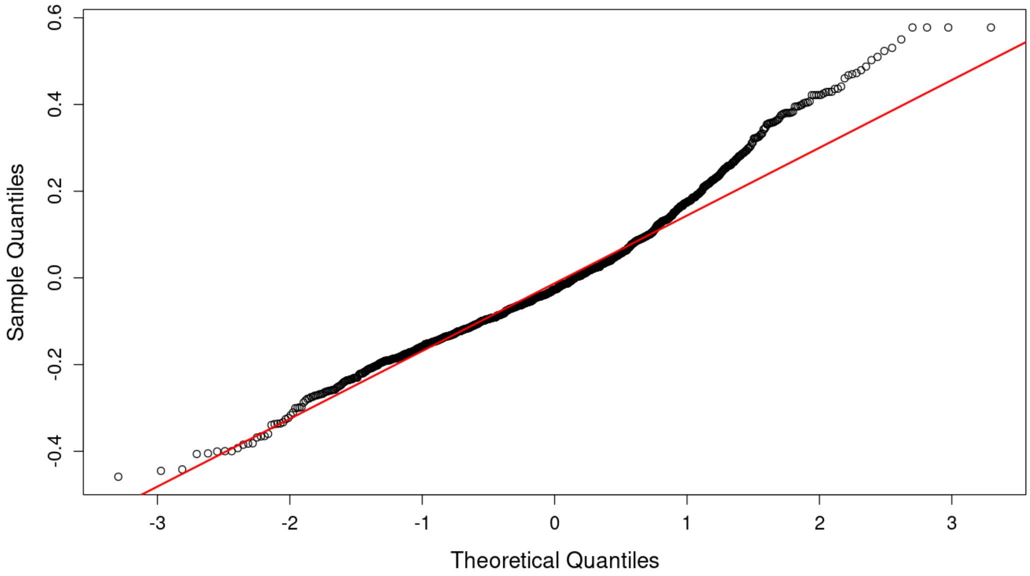
The plot indicates the presence of heteroscedasticity, which was addressed in the regression model by applying robust standard errors (Figure A.50).

*Figure A.50: H4b - Residuals vs. Fitted values*



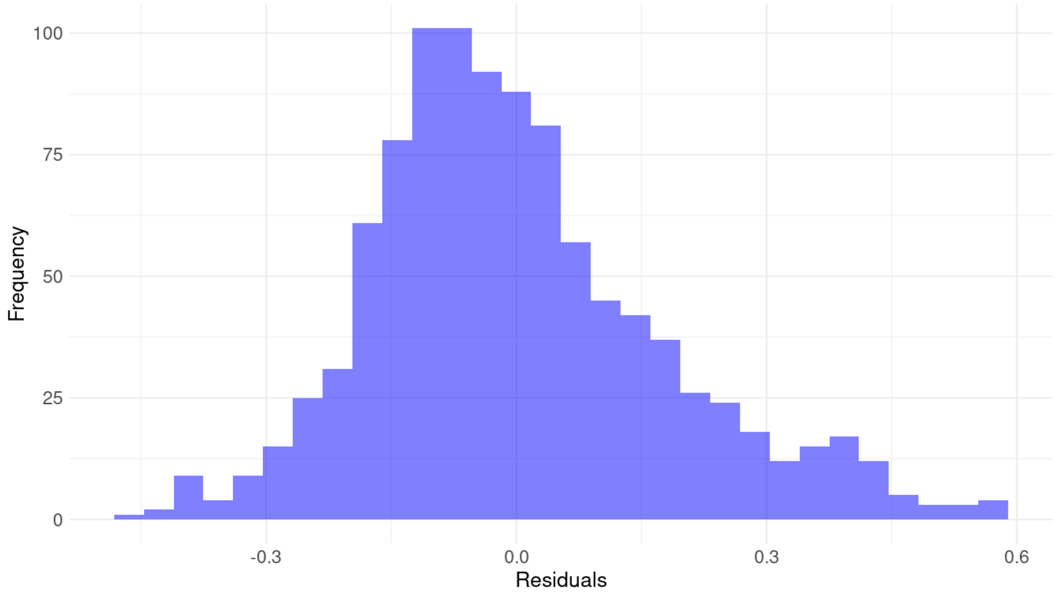

*Source: Own work.*

*Figure A.51: H4b - Q-Q plot of residuals*




*Source: Own work.*

*Figure A.52: H4b - Residual distribution*




*Source: Own work.*