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Review

Sustainability in Action: Macro-Level Evidence from Europe (2008–2023) on ESG, Green Employment, and SDG-Aligned Economic Performance

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Abstract

During the past two decades, researchers and professionals have increasingly explored the financial and macroeconomic implications of sustainable business practices, particularly through the lens of environmental, social, and governance (ESG) metrics. This review synthesizes evidence from financial economics and sectoral labor analysis to assess the impact of ESG performance and green employment on corporate financial performance (CFP) and broader economic growth. Using a discounted cash-flow framework and sectoral panel data from European economies (2008–2023), the findings reveal that robust ESG practices improve operating profits, reduce financial risk and support higher dividend distributions, while green jobs contribute significantly to Gross Value Added (GVA) and Gross Domestic Product (GDP), with each additional green job adding approximately EUR 101.920 to GVA and EUR 135.000 to GDP, in annual terms. Sectoral impacts are especially pronounced in construction, energy, and financial services, with annual contributions ranging from EUR 10.4 to EUR 11.1 million in GVA and EUR 13.7 to EUR 14.8 million in GDP. These results underscore the dual role of ESG as a financial indicator and strategic sustainability tool, advancing key United Nations Sustainable Development Goals (SDGs), including SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 17 (Partnerships for the Goals). The integration of green employment metrics into national productivity frameworks and corporate ESG strategies offers practical guidance to policymakers, investors, and cross-sector partners committed to sustainable development.

Keywords: ESG; sustainability metrics; SDGs; sectoral financial performance; idiosyncratic risk; green employment

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1. Introduction

Sustainability is a multidimensional principle that encompasses environmental stewardship, social responsibility, and long-term economic viability. It aims to meet present needs without compromising the ability of future generations to meet their needs. Within this framework, corporate social responsibility (CSR) and environmental, social, and governance (ESG) practices have emerged as strategic priorities for firms seeking competitive advantage and long-term resilience. ESG metrics serve as measurable proxy for sustainability performance, enabling companies to align with global initiatives such as the Sustainable Development Goals (SDGs) of the United Nations and to communicate their responsible practices to investors and stakeholders.

Corporate social responsibility (CSR) is increasingly emerging as a strategic priority for firms seeking competitive advantage. The reputation of a company and the perception of the market of its CSR efforts have become key factors in assessing both the market value and the corporate financial performance (CFP), (see also [1]). Recognizing the importance of CSR, major global initiatives such as the Principles for sustainable investment (https://www.unpri.org/about-us/about-the-pri, accessed on 15 May 2025) have called on businesses to adopt responsible practices aimed at advancing environmental sustainability and social well-being. As a result of this process, environmental, social, and governance (ESG) factors have allowed companies to disseminate their responsible practices throughout the wider market.

Parallel to the rise of ESG in corporate strategy, the transition toward sustainable economic models has placed increasing emphasis on the role of green employment, jobs that contribute to preserving or restoring environmental quality. Although the environmental and social benefits of green labor are widely acknowledged, its direct economic contribution remains underexplored. Understanding the financial and macroeconomic value of green employment is essential for designing effective policies and corporate strategies that support both sustainability and economic growth.

The concept of green employment has gained prominence as a strategic component of sustainable development policy and practice. Green jobs are broadly defined by the International Labor Organization (ILO) as decent work that contributes to the preservation or restoration of environmental quality, encompassing both emerging sectors, such as renewable energy and energy efficiency, and the greening of traditional industries (https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@dgreports/@gender/documents/poster/wcms_101679.pdf, accessed on 28 July 2025). This multifaceted notion reflects the convergence of environmental sustainability, economic resilience, and social equity. Scholarly contributions have emphasized the role of green employment in facilitating low-carbon transitions, promoting inclusive labor markets, and driving innovation in education and skills development; see also, [2] (OECD, 2020) (https://www.oecd.org/content/dam/oecd/en/publications/reports/2014/02/greener-skills-and-jobs_g1g3e70b/9789264208704-en.pdf, accessed on 28 July 2025). Empirical evidence from Eurostat and UNEP further illustrates the expansion of green jobs throughout the European Union, particularly in sectors such as waste management, sustainable agriculture, and clean energy technologies (Eurostat (https://ec.europa.eu/eurostat, Employment in the environmental goods and services sector, accessed on 28 July 2025), UNEP 2019 (https://www.ilo.org/publications/green-jobs-towards-decent-work-sustainable-low-carbon-world-full-report), accessed on 28 July 2025). Despite these advancements, challenges remain, including gender disparities, skill mismatches, and the need for integrated policy frameworks to support just transitions. As such, green employment is increasingly recognized not only as a metric of environmental progress but also as a strategic lever to achieve multiple Sustainable Development Goals (SDGs), notably SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action).

The academic literature outlines several defining characteristics of green employment that distinguish it within the broader labor market. First, green jobs must contribute directly or indirectly to reducing environmental harm or enhancing sustainability, thereby aligning with ecological objectives. Second, they are expected to meet the standards of decent work, including fair wages, safe working conditions, and access to social protection, as emphasized by the International Labor Organization. Third, green employment is marked by sectoral diversity, covering a wide range of industries such as energy, transport, agriculture, financial services, and construction. Fourth, these roles often demand new competencies and continuous training, particularly in emerging technologies and sustainable practices, reflecting the dynamic nature of the green economy. Finally, green jobs have the potential to promote social inclusion by creating employment opportunities for marginalized and underrepresented groups, thereby contributing to equitable and inclusive economic growth. As ref. [2] indicates, "Green jobs are not only about environmental sustainability but also about economic and social sustainability."

Furthermore, beyond its role in shaping labor market dynamics and advancing social and environmental objectives, green employment intersects with broader corporate sustainability frameworks, particularly environmental, social, and governance (ESG) practices, which have been increasingly linked to firm-level financial performance. A substantial body of empirical research has examined the relationship between ESG practices and firm-level financial outcomes. Meta-analyses such as [3] have shown that approximately 90% of studies report a non-negative relationship between ESG and financial performance, with many indicating a positive correlation. In the work of [4], they found that firms with high sustainability profiles outperform their peers in both the stock market and accounting metrics over the long term. These findings suggest that ESG engagement can enhance firm value through improved operational efficiency, innovation, and stakeholder trust.

It is also widely argued that the results reported in the literature are highly dependent on the measurement of the ESG/CSR dimensions and firm performance metrics (see [5]). ESG/CSR captures hard-to-observe firm characteristics that translate into tangible financial outcomes. The analysis of the (ESG/CSR-CFP) nexus is highly challenged by divergence in ESG metrics and CSR considerations. Differences in ESG scores among data providers underscore the complexity of aligning sustainability measures with specific firm characteristics. Developing a unified framework to evaluate the impact of ESG/CSR on corporate performance is critical for advancing both theory and practice. Several studies, including [6–8], address the divergence of ESG scores, highlighting the difficulty in optimally representing the value of intangible ESG to reflect the specific characteristics of the firm. The dissimilar nature of each pillar (environmental, social, and governance) among data providers makes it unlikely to achieve uniform ESG-CFP effects within a company. Understanding the nature of each sustainability pillar and the various ESG/CSR issues is essential to build theoretical foundations that connect sustainability to the characteristics of firms with hard-to-observe short and long-term financial value.

The analysis of the ESG/CSR link is also challenged by the size factor. This arises from the possibility that inherently competitive and profitable firms are more likely to adopt these practices. The issue of reverse causality holds great importance in the discussion of ESG and financial performance, as seen in [9]. The work of [7] shows that large corporations have higher ESG ratings as companies with higher profitability are expected to have more discretionary funds to allocate to ESG initiatives. They also demonstrate in a portfolio analysis that firms with high ESG scores are less exposed to size risk.

Beyond performance, ESG practices have also been linked to risk mitigation. Research conducted by [10] and others has shown that firms with strong environmental performance tend to experience a lower idiosyncratic risk, measured by volatility of the stock return. ESG-aligned firms are often better positioned to anticipate and manage regulatory, reputational, and operational risks, which can reduce the variability of their cash flows and improve their risk-adjusted returns.

The transition toward sustainable economic models has placed increasing emphasis on the role of green employment, which includes jobs in the environmental goods and services sector in both market and non-market activities. As governments and industries respond to climate imperatives, understanding the economic value of green labor becomes essential for both policy design and corporate strategy. Although the environmental and social benefits of green employment are widely acknowledged, its direct economic contribution remains underexplored in the empirical literature.

According to Eurostat, green employment refers to jobs in the Environmental Goods and Services Sector (EGSS). These are measured in full-time equivalents (FTE) and include green employment in both market and non-market activities. It is classified by economic activity (NACE Rev. 2) and environmental purpose (e.g., waste management, renewable energy). Green employment represents a tangible and measurable dimension of the ESG strategy, particularly within the environmental pillar. It includes protection of the environment, prevention, reduction, and elimination of pollution or any other degradation of the environment, as well as resource management, preserving natural resources and safeguarding them against depletion. Green employment includes both market and non-market activities, and is classified by economic activity (NACE Rev. 2) (see definitions in https://ec.europa.eu/eurostat/statistics-explained, accessed on 27 July 2025) and for environmental purposes (e.g., waste management, renewable energy). Although much of the ESG literature focuses on governance structures at the firm level, fewer studies have quantified the macroeconomic implications of ESG-aligned labor practices.

This study addresses this gap by empirically estimating the contribution of green employment to macroeconomic output, thereby linking labor market sustainability with broader economic and financial outcomes. We aim to quantify the economic impact of green employment in three main sectors, construction, energy, and financial services, within European economies (France, Germany, Italy, and Spain), over the period 2008–2023. Specifically, we estimate the marginal effect of green jobs on Gross Value Added (GVA) and Gross Domestic Product (GDP), providing sectoral insight into how sustainable labor investments translate into economic output.

Our analysis contributes to the growing body of ESG-related economic research by (1) providing robust empirical estimates of the contribution of green employment to macroeconomic performance; (2) differentiating sectoral impacts to highlight where green labor produces the greatest economic returns; (3) offering a framework for linking macro-level sustainability metrics with firm-level financial performance; (4) complementing firm-level studies by relating ESG employment and macroeconomic impact analysis to corporate financial performance (CFP), which involves bridging the macro-level findings with firm-level outcomes. In the next section, we emphasize the implications of green employment for the UN Sustainable Development Goals.

1.1. Green Employment and Sectoral Analysis

The economic implications of green employment are increasingly evident in key sectors such as construction, energy and financial services, each playing a distinct role in the advancement of sustainable development. In the construction sector, the integration of energy efficient technologies and sustainable building practices has stimulated the demand for skilled labor, contributing to job creation and long-term cost savings. Green employment in this domain not only enhances productivity but also fosters innovation in materials and design, thereby improving sectoral competitiveness. In the energy sector, the transition to renewables has generated substantial employment opportunities, with solar and wind industries now employing more workers than traditional fossil fuel sectors in several EU member states (IRENA, 2022 (International Renewable Energy Agency (IRENA), (2022);

Renewable energy and jobs—Annual Review 2022; Abu Dhabi: IRENA), Eurostat, 2022 (Eurostat, (2022), employment in the environmental goods and services sector; retrieved from https://ec.europa.eu/eurostat, accessed on 26 July 2025)). These jobs are often more geographically dispersed and resilient to market volatility, supporting regional economic development. Meanwhile, the financial services sector has witnessed a surge in green finance roles, including ESG analysts and climate risk specialists, as institutions increasingly integrate sustainability into investment strategies (OECD, 2023 (Organisation for Economic Co-operation and Development (OECD), (2023); Green finance and sustainable investment: Trends and policy insights. Paris: OECD Publishing, [11])). These roles are instrumental in mobilizing capital toward low-carbon projects and enhancing financial system stability. Collectively, green employment across these sectors contributes to economic diversification, innovation, and inclusive growth, reinforcing its strategic relevance to achieving Sustainable Development Goals, particularly SDG 8, SDG 9, and SDG 13.

The construction sector has experienced a significant transformation due to the growing emphasis on sustainability and the transition toward a green economy. Increased demand for environmentally responsible buildings has led to the expansion of green employment, particularly in areas such as energy-efficient retrofitting and the use of sustainable building materials. Although green construction projects often involve higher upfront costs, these are frequently offset by long-term savings in energy consumption and maintenance, thus enhancing their economic viability and market appeal. In addition, the shift towards green construction practices fosters innovation in building techniques and materials, contributing to the sector's overall competitiveness. According to reports by the International Labor Organization (ILO) and the Organisation for Economic Co-operation and Development (OECD), green construction also supports local job creation due to its labor-intensive nature, especially in retrofitting existing structures. Key indicators of this transition include the growth in green building certifications, such as LEED and BREEAM, increased investment in energy-efficient infrastructure, and the expansion of vocational training programs aimed at equipping workers with green construction skills.

The energy sector is undergoing a profound transformation driven by the global shift toward renewable energy sources such as solar, wind, and bio-energy. This transition has generated substantial green employment opportunities, which in many cases have surpassed job creation rates in traditional fossil fuel industries. Green energy jobs are typically more stable and widely distributed across regions, thereby contributing to balanced regional economic development. Furthermore, the expansion of the renewable energy sector stimulates technological innovation and attracts both public and private investment, reinforcing its role as a key driver of sustainable economic growth. According to the United Nations Environment Programme (UNEP, 2019), renewable energy is among the fastest-growing sources of green employment worldwide. Key indicators reflecting this trend include increased employment in solar and wind energy industries, a decline in fossil fuel-related jobs offset by net employment gains in renewable, and rising expenditures in research and development (R&D) for clean energy technologies.

The financial services sector is playing an increasingly pivotal role in the transition to a green economy through the emergence and growth of green employment. This includes specialized roles in sustainable investing, environmental, social, and governance (ESG) analysis, and climate risk assessment. As financial institutions integrate green finance products such as green bonds and climate-focused investment funds, there is a growing demand for professionals with expertise in sustainable finance. The sector functions as a key enabler by directing capital flows toward environmentally sustainable projects, thereby influencing systemic economic transformation. According to the Organisation for Economic Co-operation and Development (OECD, 2020), green finance employment also enhances financial market stability by incorporating long-term environmental risks into investment and lending decisions. Key indicators of this shift include the rapid expansion of green financial instruments and ESG portfolios, the development of dedicated sustainability departments within banks and investment firms, and the increasing demand for climate-related financial disclosures.

1.2. Green Employment and SDG Alignment

Table 1 illustrates how the financial mechanisms identified in this study contribute directly to the achievement of specific UN Sustainable Development Goals (SDGs), highlighting the importance of ESG metrics not only in improving corporate financial performance, but also in advancing global sustainability agendas.

Table 1. Mapping ESG–DCF mechanisms to UN Sustainable Development Goals.

ESG–DCF Mechanism	Explanation	Linked SDG(s)	Relevant SDG Target(s)
Cash-flow Channel (Profitability via ESG)	ESG practices improve operational efficiency, stakeholder trust, and long-term value creation.	**SDG 8**—Decent Work and Economic Growth	
SDG 9—Industry, Innovation	Infrastructure	8.2—Promote higher levels of productivity through diversification and innovation	
9.4—Upgrade infrastructure for sustainability and efficiency			
Idiosyncratic Risk Reduction	Strong governance and ethical practices lower firm-specific risks, such as reputational and legal risks.	**SDG 12**—Responsible Consumption	Production
SDG 16—Peace, Justice	Strong Institutions	12.6—Encourage companies to adopt sustainable practices	
16.6—Develop effective, accountable, and transparent institutions			
Downside Risk Mitigation	ESG helps firms prepare for and absorb environmental, social, and regulatory shocks.	**SDG 12**—Responsible Consumption	Production
SDG 13—Climate Action	12.4—Environmentally sound management of chemicals and waste		
13.1—Strengthen resilience and adaptive capacity to climate-related hazards			
Cost of Capital Reduction (Systematic Risk Channel)	High ESG scores attract long-term investors and reduce perceived investment risk.	**SDG 8**—Decent Work and Economic Growth	
SDG 17—Partnerships for the Goals	8.10—Strengthen the capacity of domestic financial institutions		
17.3—Mobilize financial resources for sustainable development			

Specifically, the table outlines how various ESG–DCF (Environmental, Social, and Governance—Discounted Cash-Flow) mechanisms align with specific UN Sustainable Development Goals (SDGs) and their targets. It highlights four key mechanisms: cash-flow channel, which links ESG-driven profitability to SDGs 8 and 9 through innovation and infrastructure; Idiosyncratic Risk Reduction, which emphasizes ethical governance to reduce firm-specific risks, aligning with SDGs 12 and 16; Downside Risk Mitigation, which prepares firms for environmental and regulatory shocks, supporting SDGs 12 and 13; and Cost of Capital Reduction, where strong ESG performance attracts investors and lowers risk, contributing to SDGs 8 and 17. Every mechanism links to particular SDG goals, illustrating how financial and sustainability aims can support each other.

Green employment is closely linked to several SDGs, particularly the following: (1) SDGs 8 and 9: Decent Work and Economic Growth—Industry and Innovation. Green jobs contribute to sustainable economic growth by promoting employment in sectors that reduce environmental impact. (2) SDG 12: Responsible Consumption and Production—Green employment supports sustainable practices in industries, helping reduce waste and resource use. (3) SDG 13: Climate Action—Jobs in renewable energy, energy efficiency, and environmental protection directly support climate mitigation and adaptation. (4) SDG 7: Affordable and Clean Energy—Employment in renewable energy sectors is a key component of this goal.

1.3. Green Employment, ESG Metrics vs. CSR Criteria

Green employment, ESG, and CSR are interrelated constructs within the broader discourse on sustainable development and corporate sustainability. While they share common objectives, their interconnections manifest through distinct mechanisms and frameworks.

Green employment refers to jobs that contribute substantially to preserving or restoring environmental quality. These roles typically exist within sectors such as renewable energy, energy efficiency, waste management, environmental protection, and sustainable agriculture. Green employment is both a driver and an outcome of the transition toward a low-carbon, resource-efficient economy.

It is essential to clarify the terminology used in the academic literature. Environmental (E), social (S), and governance (G) investment refers to a framework for evaluating corporate behavior and guiding investment decisions. It integrates these three key factors into investment decisions, along with traditional financial metrics. The goal of investing in ESG is to support sustainable and ethical business practices while aiming at competitive financial returns. Within the ESG framework, green employment serves as a tangible indicator of a firm's commitment to environmental and social sustainability. Specifically, regarding the environmental dimension, green jobs reflect efforts to mitigate environmental degradation and promote sustainable resource use. With respect to the social dimension, the creation of green jobs can enhance social equity by fostering inclusive labor markets and supporting just transitions for workers affected by environmental policies. Finally, within the governance dimension, transparent reporting on green employment initiatives can enhance corporate accountability and stakeholder trust. Thus, green employment is a performance indicator, instrumental in operationalizing ESG criteria, particularly in demonstrating measurable progress in environmental and social performance.

Corporate social responsibility (CSR) is increasingly regarded as a key component of competitive strategies of companies. CSR is a voluntary business approach that contributes to sustainable development by delivering economic, social, and environmental benefits. CSR is broader in scope than ESG, and focused on corporate contributions to society, emphasizing ethical responsibility and goodwill (see https://www.hec.edu/en/institutes-and-centers-expertise/sustainability-organizations/think/executive-factsheets/what-corporate-social-responsability-csr#:~:text=Corporate, accessed on 26 July 2025). It reflects a company's proactive stance in addressing environmental challenges, contributing to community development, and enhancing corporate reputation. Unlike ESG, which is often driven by investor expectations and regulatory compliance, CSR initiatives are generally discretionary and value-driven. Green employment fits into CSR as (1) a strategic initiative to show commitment to environmental stewardship, (2) a way to engage communities and support local green economies, and (3) a method to enhance brand reputation through sustainable hiring practices. The perceived commitment of a company to CSR has become a significant factor in how the market assesses both its overall reputation and its corporate financial performance (CFP).

While both ESG and CSR frameworks support the advancement of green employment, they do so through different lenses: ESG positions green employment as a performance metric within a structured evaluation framework used by investors and regulators. CSR views green employment as a voluntary commitment aligned with ethical business conduct and stakeholder engagement. According to Eurostat, green employment refers to jobs in the Environmental Goods and Services Sector (EGSS). These are measured in full-time equivalents (FTE) and include employment in activities that serve one of two purposes: environmental protection—preventing, reducing, and eliminating pollution or any other degradation of the environment; resource management—preserving natural resources and safeguarding them against depletion. Green employment includes both market and non-market activities, and is classified by economic activity (NACE Rev. 2) and environmental purpose (e.g., waste management, renewable energy) (see ec.europa.eu).

A closer look at Table 2 shows how ESG factors translate CSR concerns into specific risk categories that influence financial performance and valuation. With regard to environmental issues, companies face risks from climate change, pollution, resource depletion, and unsustainable land use. These lead to higher costs, regulatory challenges, operational disruptions, reputational damage, legal liabilities, and limited market access. Social issues involve human rights violations, poor labor practices, and conflicts that impact supply chains and workforce productivity. This results in lost innovation opportunities, reduced market access, increased political and financial risks, brand damage, and potential legal actions. Finally, corporate governance issues include poor governance, such as tax avoidance, corruption, lack of transparency, and weak leadership processes, which undermine investor confidence. Consequences include difficulties in financing, increased costs, reputational harm, accounting fraud, loss of business opportunities, and diminished shareholder value.

Table 2. Green risk categories and company exposure.

Environmental Issues and Company Risks	
Climate change, industrial pollution, greenhouse effect, extreme weather conditions, natural disasters, increased atmospheric CO_2 gas.	1.1 Higher production costs 1.2 Policy and regulatory risks 1.3 Risks in social licence to operate at an industry level
Fracking policies, depletion of water usage, over-exploitation, methane emissions.	1.4 Operational and physical risks 1.5 Reputational risks 1.6 Community controversies, bans 1.7 Additional costs of the adverse climatic effect, low economic innovation
Sustainable land use, inefficient supply chains, tropical deforestation and degradation.	1.8 Direct or indirect costs: high reputational risks 1.9 Legal risk 1.10 Market access risks
Social Issues and Company Risks	
Human rights and labor, employee relations, conflict zones.	2.1 Loss of potential benefits from innovative suppliers, low access to market contracts, low motivation and productivity rates and commitment from employees. 2.2 Lack of responsible business, high political, economic and financial risks. 2.3 Lack of human rights in supply chains and increased risks in the production process. Lack of traceability and market-driven changes, supply chain disruption, reduced market share, brand damage, loss of sales, potential lawsuits and fines.

Table 2. *Cont.*

Corporate Governance Issues and Company Risks	
Tax avoidance, executive pay, unethical contracts design, corruption, conflict of interest and creation value for director nominations, cyber-security.	3.1 Lack of awareness within companies of investors concerns, low transparency of clear business goals and hence inability of promoting long term value creation. 3.2 Difficulty in ensuring favorable financing, increased operating costs, bad reputation, loss of clients loyalty, deterioration of the social and economic conditions in which the company operates. 3.3 Accounting frauds, large profit losses, exclusion from beneficial business opportunities, damage to brand and share price. 3.3 Direct loss of value for investors, lack of processes to review managerial performance, poor financial planning, lack of a robust process to place and select candidates that can best serve the company.

Our research is organized as follows. Section 2 provides a comprehensive literature review through the lens of the discounted cash-flow (DCF) model, highlighting the cash-flow (CF) transmission channel in relation to corporate financial performance (CFP) and idiosyncratic risk. Section 3 describes the data and methodology employed in the empirical analysis. Section 4 presents the empirical results. Section 5 compares and analyzes the characteristics of two representative companies from different economic systems. Section 6 discusses the implications of the findings for ESG, green employment, SDG alignment, and policy. Finally, Section 7 offers concluding remarks.

2. Literature Review

2.1. Current Research on ESG and Corporate Performance

We followed a structured multi-step literature review protocol to gather a comprehensive body of evidence on how environmental, social, and governance (ESG) factors affect corporate financial performance. First, we conducted keyword searches on Google Scholar using the terms 'ESG', 'corporate social responsibility (CSR)', 'discount rate', 'idiosyncratic risk', 'volatility', 'tail-risk' and 'financial performance', restricting results to peer-reviewed articles and academic journal articles published in English. Second, we screened titles, abstracts, and, when necessary, full texts. We retained only studies that contained explicit empirical tests linking ESG/CSR metrics with at least one dimension of financial performance (e.g., accounting returns or market-based measures); conceptual or purely descriptive papers were excluded. Third, we expanded our corpus by examining the reference lists of eligible studies and adding any additional articles cited that had an empirical component that met our inclusion criteria.

A total of 85 articles were initially retrieved. The primary inclusion criteria for further selection included the time frame, market conditions (comparing the US, EU, and emerging markets), and geographic diversity. We view the time frame as a crucial element for comprehending both the effects of ESG and its development, especially in light of the significant increase in sustainable and responsible investments.

We categorized studies into those conducted before the 2008 global financial crisis and those from 2008 through the recent post-COVID-19 period. We also sought to tackle the problem of reverse causality in the ESG–corporate financial performance (CFP) relationship to evaluate the effects of ESG initiatives from a holistic viewpoint. Every selected article was later reviewed in full.

In addition, the search was enriched by the use of two large-language-model-based academic discovery tools, Consensus and Elicit, which surfaced recent or less traditionally indexed work. All candidate papers retrieved through these platforms were subjected to the same screening and inclusion filters. This process yielded a focused yet representative set of studies that underpins the analysis reported in this paper.

2.2. The Cash-Flow Transmission Channel, CFP, and Idiosyncratic Risk

We employ the work of [12] and use the discounted cash-flow (DCF) model to decompose and review the financial and economic impact of ESG factors, focusing on their effects on performance through the lens of cash-flow, idiosyncratic, and systematic risk transmission. The framework is used to address the following issues: a) the channels through which ESG characteristics deliver financial performance, b) the key variables shaping corporate performance that should be examined to quantify the ESG impact.

We define the DCF model as

$$\text{Firm Value} = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} \quad (1)$$

CF_t is the predicted cash flow. r is the discount rate (e.g., required rate of return or cost of capital, which can be proxies for the Weighted Average Cost of Capital or WAcc). t is the time period (from 1 to n). n is the total number of periods in the projection.

The DCF framework, which defines a company's value as the sum of its future cash flows discounted by the cost of capital, is used to decompose the impact of a firm's ESG/CSR profile on equity valuation. It identifies three key mechanisms through which ESG/CSR characteristics influence corporate financial performance (CFP). These are structured around the two main components of the DCF model, the numerator (cash flows) and the denominator (discount rate or cost of capital).

The cash-flow channel of ESG practices refers to how a firm's ESG initiatives impact its financial performance through changes in the firm's cash flow (CF). The existing literature investigates multiple channels through which environmental, social, and governance practices influence firm-level financial performance, particularly in terms of revenues, costs, and overall cash-flow generation. A key mechanism by which ESG practices affect corporate cash flows is through revenue enhancement, facilitated by market differentiation and the strengthening of brand equity. ESG initiatives can boost a company's revenue by attracting consumers who prioritize sustainable and ethical products (see [13]). Companies with strong ESG commitments often achieve higher customer loyalty and brand value, leading to stable or increasing revenues (see [14]). Thus, companies investing in ESG can access new markets and benefit from premium pricing on sustainable products. The positive impact of ESG practices on future cash flows can also manifest through cost reductions and efficiency gains.

Specifically, ESG initiatives contribute to improved operational efficiency by lowering energy consumption and minimizing waste management expenses (see [12]). In addition, the adoption of sustainable supply chain practices has been shown to reduce procurement expenditures and optimize resource utilization. Lastly, companies with strong ESG policies tend to experience higher employee productivity and retention, reducing recruitment and training expenses (see [15]). The different mechanisms through which ESG practices improve revenues contribute to a firm's competitive advantage, resulting in improved abnormal returns, higher profitability, and higher dividends (see [16]). What follows is a summary of the literature that examines the relationship between ESG performance and firm outcomes through the cash-flow channel.

The integration of green employment metrics and macroeconomic ESG indicators into firm-level financial analysis represents a progressive shift in valuation methodology. By positioning green employment as a proxy for ESG commitment, firms can be evaluated not only on traditional financial metrics but also on their alignment with sustainability transitions. This approach recognizes that ESG-aligned firms may benefit from regulatory tailwinds, consumer preference shifts, and capital market advantages, all of which can materially affect future cash flows and risk profiles.

At the macro-level, the contribution of green employment to GDP and GVA in sectors such as energy, construction, and financial services provides a contextual backdrop for firm-level performance. Firms operating in these sectors are likely to experience sector-wide growth, driven by policy incentives, innovation, and labor market transformation. This sectoral momentum can be reflected in DCF models through adjusted growth rates, cost structures, and discount rates. Empirical literature supports the notion that ESG-aligned firms often exhibit higher profitability, lower cost of capital, and premium valuation multiples. These outcomes can be systematically incorporated into DCF frameworks, making them more responsive to sustainability dynamics. However, doing so requires careful calibration of assumptions and a willingness to move beyond purely financial inputs.

While the proposed framework offers a valuable conceptual bridge between macroeconomic indicators of green employment and firm-level financial performance through the DCF model, it is not without limitations. A primary concern lies in the quantification of ESG-related impacts, particularly those arising from green employment, which are often indirect, long-term, and difficult to translate into precise financial metrics. The temporal mismatch between the accrual of ESG benefits and the short- to medium-term focus of DCF projections may result in undervaluation of sustainability-driven initiatives. In addition, sectoral generalizations based on GDP and GVA contributions can obscure firm-specific heterogeneity in ESG strategies and results. The rigidity of traditional discount rate formulations further complicates the integration of ESG risks and opportunities, as WACC does not inherently account for climate transition risks or reputational factors. Moreover, the sensitivity of terminal value assumptions to long-term sectoral viability introduces volatility and speculative bias into valuations. Finally, the lack of standardized, high-quality ESG employment data limits the robustness and comparability of the framework, while the exclusion of environmental and social externalities from conventional DCF models constrains their ability to reflect the full spectrum of value creation in a sustainability-oriented economy.

2.3. The Link Between Performance, Value, and ESG Metrics

In this subsection, we review the relevant literature on the relationship between financial performance, value, and ESG ratings. The majority of the studies use ESG data from MSCI KLD (now part of MSCI ESG STATS), Thomson Reuters ASSET4 (now Refinitiv), and Bloomberg, while some recent or region-specific studies, particularly those focused on China, likely rely on local ESG providers such as Sino-Securities Index, CNRDS, or Wind, and one study (Lee & Faff, 2009 [17]) uses the Dow Jones Sustainability Index (DJSI). There are increasing numbers of studies from both academia and institutional asset management that have examined the potential financial benefits of investing in ESG. The analysis in the work of [3] provides an extensive review, reporting that over 90% of the literature reveals a non-negative relationship between ESG and financial performance, with the majority indicating positive results (see also [18]). The study reviews over 2000 empirical papers spanning the fields of management, accounting, finance, and economics. Within the finance literature, various methodological approaches are employed to examine the relationship between ESG commitment and firm performance. Performance and firm value are typically evaluated using metrics such as short- and long-term stock returns or Tobin's Q.

The work of [19] concludes that ESG can enhance CSR, highlighting that further standardizing efforts are needed given the differences between regions and sectors. ESG investment emerges as a strategy that companies use to differentiate. Thus, the cost of ESG investment represents an act of assuming social responsibility in pursuit of future economic benefits and higher long-term profitability. They argue that ESG and CSR are integral to the global financial system. However, they highlight the lack of adequate financial metrics to evaluate their impact and enforce sanctions for non-compliance. Therefore, their arguments are consistent with the use of the DCF model to disentangle the different transmission channels. This consequently creates economic pressure on firms to fulfill their ESG responsibilities. Finally, they emphasize the need for further research on ESG investment from a CSR perspective to deepen the understanding of its contribution to firm value.

The effect of ESG engagement policies can increase income as well as enhance operational efficiency. Higher ESG-rated companies leverage their competitive advantage to generate higher levels of profitability, which is reflected in the numerator of the DCF model, the cash-flow channel. The impact of higher ESG compliance enhances profitability through increased revenues or lower costs, thereby increasing firm value. The relationship between ESG policies and firm value has been studied with mixed conclusions.

Some theoretical studies, such as refs. [1,8], suggest that higher ESG performance can increase firm value but also argue that sometimes, CSR activities can create managerial agency problems. Corporate managers may pursue CSR-friendly activities that maximize personal utility at the expense of shareholder welfare, as analyzed in [8]. Academic research identifies various ways sustainability commitments can create firm-specific value. First, CSR activities can enhance shareholder wealth by increasing future profitability and, hence, cash flows (e.g., attracting investors, improving employee satisfaction and productivity). This literature also discusses the role of lower discount rates (e.g., lowering the cost of capital) in increasing firm value. This will be addressed in Section 4. Second, ESG activities may create value by maximizing shareholder utility. Beyond higher cash flows, shareholders might value the environmental and social benefits of ESG practices, deriving greater utility from responsible firms even if cash flows remain unchanged compared to irresponsible firms. In a seminal contribution, ref. [20] examines both the financial and real-world impacts of sustainable investment within a highly manageable equilibrium framework. In doing this, they discuss how agents obtain higher utility from holdings of green firms and inutility from investing in a brown firm.

Furthermore, ref. [21] uses panel data from Chinese-listed companies from 2017 to 2021, with Reuters as the source for stock prices and ESG scores. They find that ESG scores negatively correlate with Tobin's Q, indicating that Chinese stocks tend to be undervalued as their ESG ratings increase. While the social and governance pillars are insignificant, only the environmental score explains this correlation. Their results remain robust with fixed effects. When ROA is used as a dependent variable, none of the ESG factors are significant, implying that investment in ESG does not substantially improve ROA. Similar results are observed with ROE. They conclude that ESG practices are not fully reflected in financial performance as ESG remains a relatively new concept not yet integrated as a core corporate strategy in China.

The relationship between ESG and CFP can also work in the reverse direction: higher-value firms with strong financial performance may exhibit higher ESG scores, as larger companies are better equipped to allocate resources to ESG activities. The evidence supports this association, with higher CSR performance often observed in firms with greater resources and in developed countries. It is important to understand the complex reverse causality relationship in order to assess the true impact of ESG metrics on financial performance.

Several studies suggest that firms with high profitability or large market share are more likely to engage in ESG practices, for reasons like reputation management and resource availability. Profitable firms have more capital to allocate to long-term ESG initiatives, such as sustainability commitment programs, social work and community engagement, or employee welfare schemes (see [22]). In their work, they do not address the reverse causality explicitly, but they include control variables such as size, profitability, leverage, and growth opportunities, which helps mitigate the possibility that financially healthier firms are simply more likely to engage in CSR activities.

In addition, financially successful firms often face greater public and social scrutiny. Hence, they use ESG adoption as a tool for managing their reputation and reducing social and regulatory risks (see also [9]). In their work, they emphasize a holistic view of CSR, where both external and internal actions related to CSR influence the financial conditions of the firm. External actions refer to public-driven actions (e.g., implementing green technology, reducing carbon emissions, philanthropic actions, or public commitments). Internal actions involve employee satisfaction, corporate culture, and the integration of CSR principles to management decisions. They measure financial performance by assessing the ROA and Tobin's Q. They utilize both the stakeholder theory, focusing on both external and internal aspects to achieve long-term value, and the resource-based view, which suggests that firms with unique and valuable resources (employee engagement, strong reputation, strong ESG commitment) can gain an effective competitive advantage. Their key finding is that internal CSR, when accompanied by aligned corporate culture, becomes a stronger predictor of long-term financial returns. The greater gap between internal and external action is associated to 26.5 percent lower market value than the average. On the other hand, when the gap is equal to zero, the market value is 36.5 percent higher than the average. Synergistic effects can be key, as firms aligning their internal and external CSR efforts can build a more consistent and authentic CSR brand, potentially leading to higher stock market performance and improved financial returns, which in turn could foster higher levels of commitment.

This result is compatible with the bidirectional relationship ESG-CFP, which means that strong financial performance leads to better adoption of ESG, and strong ESG practices further improve financial outcomes. Finally, companies with strong financial performance and stability are adopting long-term strategic goals and, hence, ESG initiatives. They usually face greater pressure from their stakeholders, such as customers, investors, and regulators, and therefore focus on sustainability as a strategic issue rather than a short-term goal. Related contributions that address the issue of reverse causality in the ESG literature include [3,23–25].

The work of [26] examines the relationship between corporate social responsibility (CSR) and firm performance, considering the size of the firm as a key factor. It finds that larger firms tend to have more structured CSR activities and greater capacity to engage in socially responsible practices. Although this paper focuses primarily on CSR, the findings are relevant for ESG, as CSR is an essential component of the "S" (social) factor in ESG. Similarly, the analysis of [4] examines how companies that adopt sustainability practices (including factors of ESG) perform over time, focusing on large versus small companies. The authors found that firms with robust sustainability practices tend to perform better financially in the long-run and this effect is particularly strong for large companies due to their ability to invest more in sustainability.

Likewise, the study by ref. [27] investigates the relationship between company size, ESG performance, and financial performance. They find that larger firms tend to perform better in terms of ESG scores because they have more resources, governance structures, and transparency. However, the relationship between ESG performance and financial returns is more pronounced in larger companies. Higher-value firms and better financial performance can lead to higher ESG performance, as larger firms are better equipped to allocate resources to ESG activities. Both directions of causality predict a positive association between ESG performance and shareholder wealth. There is enough evidence to support this association, with higher CSR performance often seen in firms with greater resources and in developed countries. Identifying the direction of causality remains an important issue.

In contrast, some argue that CSR activities can create problems for the management agencies. Corporate managers may pursue activities that maximize personal utility at the expense of shareholder welfare, as analyzed in [8].

A related strand of research suggests that companies that offer high-quality environmental and social disclosures can reduce informational asymmetry. Effective corporate ESG reporting is recognized as a key tool for enhancing corporate reputation (see [28]). The overall conclusion is that there are two directions of causality within the ESG-CFP link and that both effects' relationships predict a positive association between ESG performance and shareholder wealth.

Regional trends show that in the Chinese economy, there are mostly positive results for the ESG/CSR link [21]. In the US, studies generally support a positive long-term impact of ESG [4,14], while some studies with a short-run focus find neutral or negative effects on ROA. In Europe, we find more mixed findings, likely due to stricter ESG norms and variation across countries. Cross-continental studies [9,29] generally show a positive long-run performance effect.

In many cases, a positive relationship is observed between ESG/CSR performance and financial performance metrics, particularly for firms in the USA, China, and Europe. This positive association is especially evident in metrics such as equity returns and firm valuation indicators (e.g., Tobin's Q). However, a negative relationship has been reported in a few instances, such as for Tobin's Q in the USA during 2007 [30], possibly reflecting market reactions to ESG in crisis periods or perceived inefficiencies.

The overall body of evidence supports the view that ESG/CSR is value-enhancing, particularly over the long term. This is most consistently demonstrated in studies using market-based measures such as stock returns or long-run performance.

Table 3 presents performance metrics and their relationship with environmental, social, and governance (ESG) scores or corporate social responsibility (CSR) data in various countries and time periods. Reported results show that there is a significant variation in terms of geographical scope and sample periods, as well as performance measures used in the analysis. Most importantly, the sign of the ESG/CSR-CFP nexus varies.

Table 3. Performance metrics, value, and ESG ratings.

Sample	Sample Period	Performance Metric	Ind/Dependent	Sign	Citation
China	2009–2021	Value Added of Assets	Independent	+	[31]
China	2017–2021	ROA, ROE, Tobin's Q	Dependent	+/−	[21]
Europe	2005–2019	Excess returns	Independent	+/−	[5]
USA	1991–2011	Stock returns	Dependent	+	[32]
USA	2003–2015	Tobin's Q	Dependent	+	[1]
China	2010–2017	Firm Value	Independent	−	[33]
USA	2007	Tobin's Q	Dependent	−	[30]
USA/Europe	2007–2015	Long-run returns	Dependent	+	[29]
USA/Europe	2002–2008	ROA, ROE, Tobin's Q	Dependent	+	[9]
USA	2001–2007	Short run returns	Dependent	+/−	[10]
USA	2002–2011	Portfolio returns	Dependent	+/−	[7]
USA	1993–2010	Stock portfolio returns	Dependent	+	[4]
USA	2003–2009	Revenue Growth	Dependent	0	[34]
USA	2003–2009	ROA	Dependent	−	[34]

Table 3. *Cont.*

Sample	Sample Period	Performance Metric	Ind/Dependent	Sign	Citation
USA	1991–1995/1996–2000/2001–2008	Financial Constraints	Independent	−	[35]
USA	1984–2009	Long-run returns	Dependent	+	[14]
USA	1998–2002	DJSI	Dependent	+	[17]

This table summarizes the results proposed to relate to ESG/CSR in the academic literature on firm-specific value and performance. For each paper cited, we report the variable of interest, whether it is an independent or dependent variable. The sign indicates the direction of the relationship between the ESG metric and the performance metric; 0 indicates that no significant relation was found. Both +/− means relationships in both directions have been found among different ESG metrics.

In contrast, short-term results and accounting-based indicators (e.g., ROA, ROE) may understate this relationship, likely due to implementation lags, reporting inconsistencies, or the delayed realization of ESG benefits.

When short-run returns or limited time frames are analyzed, as in event studies or single-year snapshots, the findings tend to be mixed or negative, highlighting the time-dependent nature of ESG impact. This aligns with the understanding that ESG initiatives are typically long-term strategic programs, often embedded within a broader corporate governance framework.

Several studies reported mixed results, with both positive and negative effects observed depending on the metric or time horizon (e.g., excess returns in Europe, short-term returns in the USA). Additionally, a null relationship was found in some contexts, such as revenue growth in the USA between 2003 and 2009 [34], further emphasizing the complexity and multidimensionality of ESG-financial performance linkages.

Studies such as [7] use three different sources of ESG ratings: Bloomberg, Asset4, Reuters, and KLD. They highlight that results can be biased depending on the underlying rating approach. In addition, they emphasize the limitations arising from the use of short periods in other studies, arguing that cross-sectional regressions provide better insight into ESG levels and their effect on stock returns. Using a sample period from 1990 to 2011, they combine and normalize ESG metrics from the three providers. They employ a time-series portfolio approach to evaluate the performance of the ESG ratings, applying the Carhart four-factor model [36]. To gain further insight, they conducted a cross-sectional regression analysis, following the panel-based strategy of [37], to analyze the direct impact of ESG values on returns. Their findings show no significant return differences between firms with high and low ESG ratings. Cross-sectional regressions reveal an ambiguous influence of ESG variables depending on the rating provider.

Interestingly, the authors of ref. [34] utilize KLD ratings at the firm level and find no evidence of companies recovering ESG expenditures through sales. They report a negative relationship between increases in ESG ratings and future stock returns, along with declines in firm ROA. This implies that the benefits of the commitment to sustainability are achieved at the expense of firm value. Their sample includes a panel of the Russell 3000 index from 2003 to 2009. They calculate KLD scores by summing up 56 categories for each firm-year observation and regressing stock returns on the prior year's levels of KLD strengths, concerns, and overall ratings. Their results indicate that KLD scores have no effect on stock returns. Firms with Democratic-leaning insiders that increase CSR scores experience a drop in future stock returns of about 1.8 percent per year. The effect is statistically significant, particularly for firms that already had high CSR scores. They conclude that expanding sustainability commitments leads to long-term declines in financial performance and ROA, interpreting stock declines as delayed market reactions to ESG policies due to the investors' learning processes.

Conversely, studies such as ref. [1] report a significantly positive relationship between ESG ratings and financial performance. They find that firms with high product differentiation benefit from favorable sustainability policies. They find that firms with higher CSR scores exhibit higher Tobin's Q values as a result of greater market valuation. A one-standard-deviation rise in CSR leads to a 0.087 increase in Tobin's Q, which is approximately a 5 percent increase relative to the average Tobin's Q of 1.885. These results are even more significant in firms with higher levels of product differentiation; they use advertising levels as a proxy of product differentiation. The rise in Tobin's Q is 0.356 higher due to CSR than companies without advertising expenditure.

On the other hand, ref. [32] takes an alternative approach by examining the relationship between firm cash holdings and CSR performance. Using KLD ratings for US corporations from 1991 to 2011, they regress firm cash holdings on CSR performance and estimate the effect on cash value. The positive link between CSR and cash holdings is solid and statistically significant at 1% level in firms whose sustainability commitments is related to internal actions as in [9]. They control for firm-specific factors such as size, profitability, and leverage. A one-standard-deviation increase in the CSR score is associated with a 0.7 to 1.3 percentage point increase in the cash-to-assets ratio. Their findings indicate that an additional dollar increase in cash has a more significant impact on firm value for higher ESG-rated companies, suggesting that sustainability commitments enhance firm value.

Additional studies support the positive effects of CSR/ESG on financial performance. The authors in [14] use a 14-year period from 1984 to 2009 and demonstrate a positive correlation between employee satisfaction and long-run returns, indicating that sustainability policies create firm value. More analytically, they report that companies listed in the "100 Best Companies to Work For in America" gain an annual alpha of 3.5 percent from 1984 up to 2009, outperforming industry benchmarks by 2.1 percentage points. Similarly, ref. [38] analyzes US banks and concludes that poor performance is positively related to the overall ESG index (using KLD ratings), suggesting that CSR activities are rewarded with improved financial performance.

Several studies focus on short-term market reactions to ESG events. The authors in ref. [10] analyze stock market reactions to more than 2000 positive and negative sustainability events for US companies using the KLD Socrates database. They find significant differences in market responses: investors respond strongly and negatively to adverse events and weakly and negatively to positive events. Adverse reactions are particularly pronounced for information about communities and the environment. The authors estimate a median cost of USD 76 million for adverse events, indicating substantial expenses associated with corporate irresponsibility. Their results also show that adverse events provide information about legal risks and economic contexts, aligning with the view that unsustainable behavior is costly to shareholders.

A different approach used by ref. [30] contributes to the ESG literature by showing that the effect of the CSR value varies with institutional ownership levels. Using Bloomberg ESG ratings as a proxy for CSR quality, they examine the impact of CSR on firm value changes during the financial crisis. They find that CSR participation can negatively affect the value of the firm, particularly during severe agency conflicts. High ESG/CSR investment costs are cited as the reason for more significant value declines among firms with strong sustainability commitments during the crisis. In normal market conditions before the 2008 financial crisis, more responsible firms show a Tobin's Q 5 or 7 percent higher than non-CSR firms, on average. In general, they find that CSR contributes to firm value in normal market conditions and decreases firm value during a crisis unless there is strong institutional oversight.

2.4. The Link Between ESG and Idiosyncratic Risk

ESG characteristics may also affect future cash flows through variations in idiosyncratic (as well as tail-downside-risk) risk exposures. Various studies have argued that ESG/CSR can influence a company's risk profile through several channels. These include idiosyncratic risks and, more specifically, reputational, product development and litigation risk.

Table 4 documents studies that use idiosyncratic risk as the main research variable. Data reported in column 1 show that the literature addressing the ESG-idiosyncratic risk nexus covers different geographic areas and time periods. Column 2 highlights the heterogeneity of sample periods used while column 3 reports the different measures of idiosyncratic risk applied. A large number of idiosyncratic risk measures are used, including Z-scores, implied volatility, residuals from asset pricing models (e.g., FF3, FF4, FF5, Carhart 4-factor), among others. Idiosyncratic risk refers to the pure firm-specific measures that the academic literature analyzes when examining the ESG-CFP nexus. Note that there are some instances in which the ESG measures have been used as a proxy for idiosyncratic risk. The third column explains how the variable of idiosyncratic risk is measured and defined in relation to ESG metrics. The studies primarily rely on ESG data from MSCI KLD, Refinitiv (ASSET4), and Bloomberg, while several region-specific studies—particularly in China, Taiwan, and Malaysia—use local ESG databases (such as CNRDS, Wind, or CSMAR), and some early or specialized works employ ESG indices (e.g., DJSI) or corporate reputation metrics as proxies for ESG performance. The reported results indicate that companies with high ESG ratings have historically shown lower idiosyncratic volatility and better management of company-specific risks.

A substantial number of studies identify a negative relationship between ESG performance and idiosyncratic risk, suggesting that firms with stronger ESG profiles tend to experience lower firm-specific risk or volatility. This negative association has been documented across various markets, including the US, China, Europe, and Australia, and is particularly robust in studies employing residual-based risk measures derived from models such as Fama-French (FF3, FF4, FF5) or the Carhart 4-factor model.

This evidence supports the hypothesis that ESG and CSR engagement functions as a risk mitigation mechanism, especially over longer time horizons. ESG-oriented firms may benefit from reduced exposure to operational disruptions, regulatory penalties, and reputational shocks, thereby lowering their idiosyncratic risk. These benefits appear to accrue over time, which aligns with the notion that ESG is a long-term strategic investment rather than a short-term performance lever.

Similar to the financial performance literature, findings based on short-term or event-based measures of risk (e.g., implied volatility or portfolio-based proxies) are more likely to produce mixed or inconsistent results. For example, studies using options data or short-term Z-score models occasionally report ambiguous or even positive relationships, potentially reflecting investor uncertainty or ESG over-investment concerns in the short term.

Table 4. The link between idiosyncratic risk and ESG metrics.

Sample	Sample Period	Idiosyncratic Risk	Ind/Dependent	Sign	Citation
Taiwan	2007–2022	Z-score elaboration	Dependent	+/−	[39]
USA	2005–2020	Options Implied Volatility	Dependent	+/−	[40]
USA	1991–2018	Residuals of 4-factor Carhart model	Dependent	−	[41]
China	2012–2022	FF3, FF4, FF5 residuals	Independent	−	[42]
USA	2006–2018	Vine-Risk measures	Independent	+	[43]
Europe	2002–2015	Excess Returns	Independent	+	[44]
World	2011–2020	ESG Indices	Independent	−	[45]
China	2006–2019	CSR	Dependent	−	[46]
USA	2002–2018	FF3 residuals	Dependent	−	[47]

Table 4. *Cont.*

Sample	Sample Period	Idiosyncratic Risk	Ind/Dependent	Sign	Citation
Australia (ASX)	2007–2017	Cost of capital/FF3 residuals	Dependent	−	[48]
USA IPOS	2002–2018	FF3 residuals	Dependent	−	[47]
Malaysia	2005–2018	Cost of capital/FF3 residuals	Dependent	−	[49]
China	2011–2017	FF3 residuals	Dependent	−	[50]
USA	2003–2015	Tobin's Q	Dependent	+	[1]
Spain	2006–2011	Corporate reputation	Dependent	+	[51]
Europe	2002–2014	Residuals 4-factor Carhart Model	Dependent	−	[52]
Poland	2012–2013	Portfolio approach	Dependent		[53]
USA	2003–2015	Tobins Q/Firm Value	Dependent	+	[1]
USA	1992–2005/2006–2010	Deterministic estimation	Dependent	−	[54]
USA	2007–2012	Portfolio approach	Portfolio approach	−	[55]
UK	2002–2011	Residuals of 4-factor Carhart model	Independent	0	[56]
World	1998–2002	CAPM/Residuals of 6- factor model	Dependent	−	[17]
Canada	1995–1999	Market Model/Campbell 2001	Portfolio approach	−	[57]

This table summarizes the results proposed to relate to ESG/CSR in the academic literature on firm-specific downside risk. For each paper cited, we report the variable of interest, whether it is an independent or dependent variable. The sign indicates the direction of the relationship between the ESG / CSR and the performance metric; 0 indicates that no significant relation was found. Both +/− means relationships in both directions have been found among different ESG metrics.

Some studies observed no significant relationship, especially when risk was treated as an independent variable or when measurement frameworks lacked consistency across firms and time (e.g., [55,56]). Nonetheless, the dominant trend through the literature is that ESG/CSR engagement is associated with reduced idiosyncratic risk, reinforcing the view that such practices contribute to corporate resilience and long-term stability.

Recent studies (post-2020) lean more strongly towards a negative ESG–risk link, likely due to better ESG data quality, higher investor sensitivity to sustainability (post-COVID period), or improved econometric modeling. The type of idiosyncratic measure that matters, that is, residual-based models (FF3, Carhart, etc.), are more consistent in showing negative relationships with ESG, indicating that ESG contributes to reduce firm-specific noise or volatility. Market-based measures (e.g., Tobin's Q, options implied volatility) produce mixed results, probably because they capture market expectations or strategic ESG signaling. Portfolio approaches also produce mixed results, often lacking statistical detail or consistency over time.

This positive correlation is seen in regions such as the USA (e.g., for Tobin's Q and firm value), Europe (excess returns), and Australia (cost of capital). In many cases, studies find a negative relationship between ESG/CSR and idiosyncratic risk. For example, residuals from asset pricing models (FF3, FF4, FF5) show negative correlations, particularly in regions such as China, the USA, and the rest of the world. Other research finds a mixed relationship (both positive and negative results depending on the specific ESG metric), such as in Taiwan (Z-score) and the USA (options-implied volatility). The study regarding the UK (2002–2011) finds no significant relationship between ESG and idiosyncratic risk using the Carhart model residuals. The table also indicates that while most research considers idiosyncratic risk as the dependent variable, examining its relationship with ESG/CSR factors, some analyses use ESG/CSR metrics as independent variables, assessing their impact on idiosyncratic risk.

The work of ref. [39] particularly focuses on the impact stemming from the additional costs and risks resulting from ESG investment. They investigate Taiwan's financial industry from 2007 to 2022 in order to shed light on the link between CSR, capital costs, and business risk. They construct a z-score to represent risk as the degree of bankruptcy and financial distress of the companies. They use accounting variables such as earnings, revenue, working capital, earnings before interest, and the market value of the company to construct the z-score, assigning multipliers that are firm-specific (that is, idiosyncratic). ESG scores for the 2017 to 2022 period are used as reference data. They find that for the full sample and for financial holding companies, the overall ESG score has a significant positive effect on the z-score at the 5% significance level with a low impact coefficient of −0.005, meaning that banks that have implemented ESG strategies exhibit a lower financial risk. The environmental sustainability and corporate commitment scores in CSR have a negative impact on the z-score at a 10% significance level, with negative coefficient of −0.575 and −0.498, respectively. The social pillar is not significant, and the environmental score is negatively significant at 5% level with a coefficient of −0.017. They interpret that an indirect risk banks face arises from clients who do not respond rapidly to changes in environmental policies, hence causing increased costs for banks and further risk. Additionally, they show that corporate governance has a significant impact at the 1% level and a positive 0.033 correlation with the z-score, which means that good corporate governance can improve business performance and reduce risks in the case of financial holdings.

Moreover, the research conducted by [44] analyzes risk premiums in 18 European countries using ESG ratings as a proxy for CSR. The monthly returns for European stocks from June 2002 to May 2015 are extracted from Thomson Reuters. Stocks are classified into three ESG groups (good, bad, neutral), and then linked to financial ratings which are used as the dependent variable. Risk premiums are determined by the excess return of lower-rated firms compared to higher-rated ones. This risk class is labeled as "footprint risk." Reported results reflect that poor ESG practices lead to lower ratings in the medium to long-term. They further conclude that companies with low ESG ratings yield higher expected returns to compensate for higher risks. This is consistent with the work of Bolton and Kacperczyk [53,58,59], which reports similar results in a multi-sector panel analysis of us equity based on carbon emissions and stock returns. This related literature also supports the existence of a carbon premium using carbon emissions firm-level data. It should be noted that this conjecture is challenged by the work of [60], which shows that green firms offer risk-hedging statistical properties and therefore lower returns. The authors in [20] discuss how the increased perception of climate risk is reflected in green expected and realized returns.

In particular, ref. [48] investigates the relationship between ESG criteria and idiosyncratic risk in Australian companies from 2007 to 2017 using Bloomberg data. Their panel regression analysis shows that higher ESG ratings correlate with lower financing costs and reduced idiosyncratic risk. Note that the effect on the cost of capital will be analyzed in Section 4. They emphasize that corporate ESG disclosures mitigate firm-specific risks, providing better access to financing. They suggest that future research should focus on non-listed small and medium-sized companies while controlling for diverse economic conditions and cultural environments.

Similarly, ref. [55] reports comparable results using USA sample of S&P 500 companies for the period from 2007 to 2012. They provide an in-depth analysis of the documented negative nexus between ESG and volatility. They conducted Chi-square frequency tests and demonstrated that higher CSR-rated companies tend to be in the low-volatility groups, while low ESG-rated firms tended to be in high-volatility groups in a statistically significant manner for all the time periods considered. Both high CSR companies and low volatility resulted in higher stock returns, but the ESG effect is documented to be an independent driver of greater returns. Hence, they argue that there was value creation in using sustainability criteria in investment decisions.

As explored by Lee and Faff [17], it is found that firms with high corporate social performance (CSP) exhibit lower idiosyncratic risk. They calculate idiosyncratic risk using the CAPM and the six-factor market model, showing that CSP differences explain return variations. High CSP firms achieve lower volatility, and their portfolios yield higher returns. They also emphasize the importance of using the Dow Jones Sustainability Index (DJSI) as a multidimensional sustainability measure. They calculate idiosyncratic risk in two ways. Firstly, they follow refs. [57,61] and use the CAPM to estimate the firm's idiosyncratic risk. They also use the six-factor market model. The idiosyncratic risk is then computed using annual time series regressions, repeating the same process on a five-year basis. Similar methods of computing idiosyncratic risk are also used in [17,47–49,61]. In their paper, the firm's idiosyncratic risk is taken as the square root of the residual variance captured in each of the models considered. They report that a significant part of the difference in returns between leading CSP and lagging CSP firms or portfolios is explained by differences in idiosyncratic risk.

Earlier studies on idiosyncratic risk and CSR performance include [57]. They analyze a relatively small sample of Canadian firms over the 1995–1999 period. They report evidence of significantly lower idiosyncratic risk for higher socially responsible firms when compared to lower socially responsible companies. In a related paper, ref. [62], we find evidence of lower risk in leading CSP firms. The authors in ref. [63] argue the relevance of idiosyncratic risk for equity prices. They believe that the size effect found by [64] could be a proxy for the varying idiosyncratic risks of small and large firms. Secondly, they imply that portfolio managers and investors may reasonably seek an additional risk premium for individual company issues perceived to have exceptionally high specific risk. The latter is consistent with the notion of market friction and imperfect capital market assumptions.

In a later paper, ref. [6], it is argued that ESG information is perceived to provide insights about risk rather than the competitive position of the firm (see also [16]). They use a survey approach to first pose the question of what motivates investors to use ESG data. They find that eighty-two percent of the respondents believe that ESG information is important for investment performance. A smaller percentage of the respondents state that such information is considered in the decision-making process because it allows accounting for ethical responsibility, with European investors being more likely to regard this as an ethical obligation. First, their findings strongly suggest that investors mainly utilize CSP information for financial performance rather than ethical considerations. Secondly, they explore why ESG information is relevant to investment decisions. The respondents suggested that this information is highly relevant for assessing the company's reputational, legal, and regulatory risks. The third reason is that better CSR performance serves as a proxy for management quality. In essence, sustainability reporting offers insight into a company's risks and serves as a corporate accountability tool. Finally, they pinpoint specific ESG issues that are financially significant for investment decisions. Respondents identify anti-corruption policies, board and leadership practices, climate change, and energy and fuel management as the most material ESG factors.

ESG awareness issues in estimating the risk premium for firm-specific climate change are analyzed in [40] among S&P 500 stocks from 2005 to 2020. They find positive risk premiums before the global financial crisis of 2008 and an increase afterward. The risk premium is calculated using the expected return proxy (MW) introduced by Martin and Wagner [65] and a different approach (GLB) by Chabi-Yo et al. [66], which incorporates higher-order moments of stock returns. All estimated parameters include the six-factor [37] model and various firm characteristics. Before 2008, they report a positive risk premium for climate change risk exposures of 1% annually. During the financial crisis, the risk premium decreased sharply and became negative. From 2011 to 2014, both premiums increased, ranging between 0.5% and 1% annually. Since 2015, the premiums have been reduced to zero. Since 2015, it has reverted to zero again. In addition, they find that the flows of ESG funds decrease the risk premium for exposure to climate change. This suggests that additional flow information raises stock prices, reducing the conditional risk premium. These findings align with the idiosyncratic risk channel mechanism described by Giese et al. [12], highlighting how better risk management reduces severe incidents and tail risks.

In the region of China, ref. [42] examines the effect of ESG performance on stock idiosyncratic volatility using data from listed firms (2012–2022). They find that ESG reduces idiosyncratic volatility by enhancing transparency and enabling better risk management, establishing a causal link between ESG performance and reduced firm-specific risks.

In contrast, ref. [54] notes that firm-specific factors influence idiosyncratic risk and can increase with ESG efforts due to additional restrictions on profit maximization. Although ESG initiatives can raise idiosyncratic volatility, they also help mitigate stakeholder conflicts, indicating that firms with high ESG performance are not inherently riskier.

In the literature, the relationship between ESG and idiosyncratic risk remains complex. Positive ESG performance is frequently associated with lower volatility and financing costs, but methodologies and data interpretation variations introduce nuances that warrant further investigation. The key takeaways of this section is that the idiosyncratic risk dimension of the cash-flow channel documents economically meaningful drivers of the ESG-CFP channel. Specifically, ESG disclosures are linked to lower capital constraints (see [22]) and decreased stock price variation due to enhanced ESG transparency. Moreover, industry-specific classifications of the financial materiality of ESG disclosures highlight their direct relationship with firm value and their predictive ability for future financial performance (see also [67]). ESG information is also associated with lower price synchronicity, as prices reflect more firm-specific information, thereby capturing idiosyncratic risks as in [68].

In general, a strong commitment to ESG generally reduces the risk of idiosyncratic events in various regions and sectors. This effect is particularly pronounced during periods of economic uncertainty, such as the COVID-19 pandemic and the 2008 global financial crisis. It is influenced by firm-specific factors such as CEO power and rating consistency. These findings emphasize the importance of integrating ESG principles into corporate strategies to enhance financial stability and resilience. In the following section, we conduct a brief analysis of two companies, each representative of their respective economies and operating within the same sector, with a focus on their cash flows and ESG practices.

2.5. The Valuation Channel, the Link Between ESG and Systematic Risk

The characteristics of ESG influence the systematic risk by affecting the discount factor. Systematic risk is the primary risk incorporated into the required cost of capital of an investor. Firms with strong ESG performance are often perceived as lower-risk investments due to improved governance, regulatory compliance, and stakeholder trust. This can lead to lower equity and debt risk premiums, reducing the firm’s cost of capital, as analyzed in the work of refs. [22,49].

To build a fundamental understanding of how ESG characteristics influence corporate financial profiles, it is important to perceive systematic risk as a risk associated with macroeconomic or market factors, changes in the regulatory framework, and technological expertise. Furthermore, companies focused on environmental sustainability may experience lower exposure to macroeconomic shocks, climate risks, and social instability, thus reducing their cost of capital. As a result, investors can apply a lower discount rate to future earnings, ultimately increasing firm valuation and long-term shareholder value. Thus, we explore relevant and recent academic literature to gain insights and rationale on the link between sustainability efforts and systemic risk.

For example, in the work of [8], we observe that firms with higher ESG ratings may have different exposures to systematic risk due to their resilience during crises and/or the presence of a specific ESG/CSR risk factor. Consistent with this argument, ref. [69] finds that during the global financial crisis of 2008–2009, companies with higher ESG ratings performed better than less socially responsible firms.

In their paper, the authors of [16] investigate the value derived from CSR, focusing on stock market measures that reflect future cash-flow expectations rather than accounting measures. They highlight that the "stickiness" of CSR measures' small or often nonexistent changes can lead to incorrect conclusions about the impact of CSR on risk or financial performance. To estimate the impact on systematic risk, they assess the cost of equity capital. They use this parameter as a proxy for the risk that determines the required rate of return. Higher systematic risk calls for higher expected returns to compensate investors. To explore this, they compare the cost of capital between "Green" and "Toxic" firms by forming portfolios of these stocks. Using the FF-3 model [70], they provide a richer analysis of systematic risk through size (SMB) and value (HML) factors compared to CAPM. Their key findings indicate that CSR strengths ("Greenness") are positively valued across all stakeholders, while CSR concerns ("Toxicity") negatively impact firm value. Notably, only the environmental dimension directly contributes to sustainability performance. They also demonstrate that "Green" firms exhibit greater long-term growth in abnormal earnings across most CSR dimensions, except the employee dimension. Their research concludes that high CSR commitment delivers a competitive advantage, allowing firms to achieve long-term abnormal earning growth. While the reduction in the cost of equity is statistically significant, the authors note that its economic magnitude is relatively modest compared to the impact of CSR on long-term growth prospects.

The analysis of [1] confirms empirically the link between CSR, systematic risk, and firm values. Their main message is that higher CSR leads to lower beta and higher Tobin's Q. In their analysis they estimate individual betas using the CAPM and regress these betas on CSR scores, controlling for industry and size effects, time effects, and leverage. Specifically, the authors find that a one-standard-deviation increase in a firm´s CSR score is associated with a 1 percent reduction in its beta, the measure of systematic risk. This implies that firms with greater sustainability engagement tend on average to have less exposure to market risk.

The results reported in Table 5 show that numerous studies indicate a correlation between better ESG/CSR performance and lower systematic risk. This includes various measures of systematic risk, such as the CAPM beta, Value at Risk (VaR), or the probability of default. However, several studies find a positive relationship, primarily using CAPM betas and stock returns.

The impact of ESG integration in a DCF model is detailed in the work of [12], which understands ESG as a tool for improving portfolio risk–return profiles. They attribute inconclusive results to differences in underlying ESG data and the lack of standardized methodologies for controlling common factors. Their analysis focuses on three transmission channels: the idiosyncratic risk channel, the discounted cash-flow (DCF) channel, and the valuation channel. As is the case in the current analysis, systematic risk is captured by the cost of capital, while firm-specific risks are reflected in the present value of future cash flows. A strong ESG profile contributes to competitive advantages and profitability, resulting in higher future cash flows and dividends. Lower idiosyncratic risk arises from better risk management, which reduces severe incidents and tail risks. Systematic risk is minimized through lower capital costs, leading to higher valuations. For instance, energy-efficient companies are less vulnerable to shocks, translating to lower beta and required returns under a CAPM framework. The study of [35] highlights two additional factors: socially responsible investors who avoid low-ESG companies and reduced information asymmetry in high-ESG firms due to greater transparency.

Table 5. Systematic risk and ESG/CSR.

Sample	Sample Period	Performance Metric	Ind/Dependent	Sign	Citation
USA	2005–2021	CAPM Beta	Dependent	+/−	[71]
CHINA	2015–2021	CAPM Beta	Dependent	−	[72]
World	2002–2021	Ebitda	Dependent	−	[73]
World	2010–2021	Probability of default	Dependent	+/−	[74]
Indonesia	2018–2020	Market Beta	Dependent	+/−	[75]
World	2007–2020	Value At Risk	Dependent	−	[76]
USA	2016–2020	PCA	Dependent	−	[77]
Europe	2016–2018	Market Value Model	Dependent	+/−	[78]
USA	2003–2015	Tobin's Q	Dependent	+	[1]
World	2007–2017	DCF Model	Dependent	−	[12]
USA	2007	Tobin's Q	Dependent	−	[30]
USA	2001–2007	Short run returns	Dependent	+/−	[10]
USA	1992–2009	Firm Value	Dependent	+	[16]
USA	1993–2010	Stock portfolio returns	Dependent	+	[4]
USA	1991–1995/1996–2000/2001–2008	Financial Constraints	Independent	−	[79]
USA	1980–2003	Stock portfolio returns	Dependent	+	[35]

This table summarizes the results proposed to relate to ESG/CSR in the academic literature on firm-specific downside risk. For each paper cited, we report the variable of interest, whether it is an independent or dependent variable. The sign indicates the direction of the relationship between the ESG/CSR and the performance metric; 0 indicates that no significant relation was found. Both +/− means relationships in both directions have been found among different ESG metrics.

Analyzing US-data, ref. [71] analyzes the relationship between systematic risk and ESG factors for 791 NYSE-listed companies over 17 years (2005–2021). They find a non-linear, inverted U-shaped relationship between ESG expenditure and systematic risk. Low ESG spending provides flexibility and reduces risk, but higher ESG investments lead to lower systematic risk beyond a certain threshold. When they consider the quadratic term in their regression model, a statistical significance at the 1% level is confirmed. They calculate the level of each independent variable that maximizes systematic risk. For example, in the case of the overall ESG score, the maximum point is 0.477. Shifting from zero up to this point increases systematic risk due to the relevant risks associated to sustainability commitments of the firms. Investing resources in ESG efforts means they have fewer resources to allocate to other, more profitable activities. As a result, companies become more rigid and, consequently, more perilous. Conversely, surpassing the upper limit, systematic risk diminishes as ESG-focused investors support ESG-dedicated companies not due to their financial results but for their CSR achievements.

This dynamic reflects investor preferences and persistent demand for ESG stocks, as identified by Pástor et al. [20] and Cheung [80]. Their analysis demonstrates that, similar to the DCF model, companies with strong ESG profiles are less susceptible to market shocks, as indicated by a lower market beta factor. They help quantify a specific threshold beyond which companies can gain competitive advantage over peers by lowering their cost of capital and leading to higher valuations.

Overall, strong ESG performance generally leads to a reduction in systematic risk, especially during periods of economic uncertainty such as the COVID-19 pandemic. These mitigating effects are particularly significant in the environmental and governance pillars, underscoring the role of ESG metrics in promoting financial stability within the global economy. ESG practices are especially pronounced under conditions of economic uncertainty, such as the COVID-19 period and the financial crisis of 2008 (see [12,16,71]), and are influenced by specific firm conditions, such as CEO power and rating consistency. These findings highlight the importance of integrating ESG principles into corporate strategic plans as tools to enhance financial stability and resilience.

2.6. ESG/CSR Performance and Downside Risk

The cash-flow channel that identifies the ESG-CFP link also addresses the effect of downside risk as a firm-specific idiosyncratic mechanism when ESG (environmental, social, and governance) factors play a crucial role in mitigating downside risk, which refers to the potential for significant financial losses due to adverse events. Firms with strong ESG performance tend to exhibit lower downside risk through several mechanisms that can be embedded under the cash-flow channel as well as the discount rate or systematic channel. These include (i) reputational resilience: strong ESG practices enhance brand reputation and stakeholder trust, making firms less vulnerable to consumer backlash, boycotts, or social controversies that could harm financial performance. (ii) Operational stability: Sustainable supply chain management, ethical labor practices, and environmental risk mitigation enable companies to prevent disruptions that could result in expensive operational setbacks. (iii) Market perception and investor confidence: firms with strong ESG credentials are often viewed as lower-risk investments by institutional investors, which can reduce stock price volatility and downside risk during market downturns. (iv) Regulatory and legal protection: companies that proactively address ESG concerns are less likely to face fines, lawsuits, or regulatory penalties, reducing unexpected financial shocks. (v) Crisis resilience: ESG-focused firms tend to demonstrate stronger financial and strategic resilience during economic crises, as they are better prepared to manage long-term risks related to climate change, social unrest, and governance failures.

The literature that specifically investigates the relationship between ESG/CSR performance and downside risk is noteworthy. Important contributions include [1,69,81–83].

The study of [84] introduces an innovative approach to studying tail risk by examining downside, extreme systemic, and spillover risks in ESG factors within the health and financial sectors in the USA, China, Europe, and the UK using ETFs. They use global daily data spanning from 1999 up to 2022, and from 2007 to June 2022 for the ESG metrics. Motivated by the climate change crisis, they focus on the health and financial sectors due to their unique role during the COVID-19 pandemic and their interconnection with ESG investments. Using daily ESG-ETF data from Bloomberg, they identify the top 10 ESG healthcare and financial ETFs by net asset value. Applying extreme value theory, they assess equity tail risk, finding that ESG sectors exhibit high tail risk during shocks of ETF drops of 25% or 50%. The ESG sector remains the riskiest for extreme systemic risk, especially during shocks originating in China. The financial sector shows the highest risk, while the healthcare sector demonstrates the lowest tail quartile risk. The study also shows that the healthcare and ESG sectors have lower spillover risks than the financial sector. As an example of the spillover risk, if one ESG ETF goes into financial distress, there is a 17.71% probability that all 10 ESG ETFs will also go into distress. The equivalent effect is 16.40% for the healthcare sector and 20.57% for the financial sector.

A similar analysis is conducted by ref. [85]. They analyze ESG indices' risk-adjusted performance in developed and emerging markets, such as India, Brazil, and China, using data from the MSCI database for 2017–2022. ARCH and GARCH models are applied to model conditional variance, and the Sortino ratio is calculated to measure downside risk. Findings reveal that ESG returns are highest in the USA (13.69%) and India (13.04%), with lower volatility than diversified markets in most regions, except China. ESG indices generally yield positive rolling returns, with India achieving the highest alpha (4.82%) and China the second highest (1.49%). The Sortino ratio exceeds the Sharpe ratio for all ESG indices, indicating limited downside risk relative to overall volatility. This is attractive for risk-averse rational investors seeking minimal downside exposure.

Furthermore, Lins et al. [69] found that firms with high environmental and social ratings achieved significantly higher returns during the 2008–2009 financial crisis. Using

MSCI ESG statistics, they observe that socially responsible firms had returns 4–7 percentage points higher than less responsible firms, attributing this to more outstanding social capital. Regression analyses reveal that social capital is at least half as important as liquidity and leverage. Idiosyncratic risk is defined as residual variance from a market model, included as a control variable and the results show a significant negative relationship to returns when a positive relationship is present between crisis-period returns and CSR. Their research suggests that CSR activities, and social capital in general, yield higher returns, particularly during periods when trust becomes more crucial, especially due to significant downside risks, as seen during the 2008–2009 global financial crisis.

They also find that excess returns are higher for companies based in regions where people have higher levels of trust. They do not find noticeable differences in stock return performance between high- and low-CSR firms during the recovery period after the crisis. In general, these findings imply that, in periods of greater lack of transparency and information asymmetry, the social capital gained through CSR activities is particularly valuable during times when trust in corporations has diminished. In contrast, during more stable periods, the benefits of social capital are already reflected in the stock price of a company. The absence of a reversal in returns after the crisis suggests that trustworthiness has remained important, which aligns with the cash-flow mechanism, reputational resilience, and operational stability.

Accordingly, ref. [82] indicates that the involvement of ESG contributes to a reduction in downside risks, although the extent of this impact varies depending on the nature of the involvement. In particular, the most substantial risk mitigation is observed in environmental areas such as climate change, whereas engagements deemed unsuccessful exhibit no statistically significant effects. Using the FTSE All-World Index, they find that downside risk decreases significantly after successful ESG engagements, providing evidence that ESG initiatives can create long-term value.

The work of [86] investigates the risk reduction and window dressing hypotheses using a sample of US firms in controversial industries from 1991 to 2010. They find that CSR commitment inversely relates to firm risk, with higher CSR scores associated with lower long-term risk. The study emphasizes that CSR involvement can improve a company's image and corporate reputation while reducing downside risk.

Table 6 reports a summary of recent specific studies that address ESG performance and downside risks. The studies cover diverse geographical regions, including the USA, Europe, China, Korea, and heterogeneous samples and measures of downside risk.

The table above compiles key findings from various academic studies that examine the relationship between environmental, social, and governance (ESG) or corporate social responsibility (CSR) performance and downside risk. Most studies indicate a negative relationship between ESG/CSR and downside risk. This suggests that firms with stronger ESG/CSR performance generally experience a lower downside risk.

For example, in the USA (2008–2009), idiosyncratic downside risk decreases with better ESG performance, according to [69]. In the USA (2009–2020), the ESG risk rating has a negative impact on downside risk [87]. In China (2015–2020), companies with strong ESG/CSR practices experience lower volatility in stock returns, as reported by [88].

In some cases, ESG/CSR improvements are associated with lower downside risk. For example, a global study (2018–2020) found that the impact of ESG scores was more evident in the year 2020 during the pandemic crisis. In particular, they report that ESG is more significant as a long-term variable than a short-term effect. A one unit improvement in ESG metrics results in a 2.5 basic point reduction in downside risk as a short-term effect and 7 basis points as a long-term effect significant at 1% level. Hence, the Value at Risk (VaR) decreases with the involvement of ESG/CSR, as reported by [89].

Table 6. ESG/CSR perfomance and downside risk.

Sample	Sample Period	Downside Risk Metric	Ind/Dependent	Sign	Citation
USA, UK, China, Europe	1999–2022	EVA Tail-Risk	Dependent	+	[84]
USA, Germany, Japan, India, Brasil China	2017–2022	Sortino Ratio	Independent	−	[85]
USA, Canada, Mexico	2011–2020	Ohlson O-score	Dependent	−	[90]
China	2010–2020	Lower order returns	Dependent	−	[46]
World	2018–2020	VaR	Dependent	+	[89]
Korea	2011–2019	Credit Risk	Dependent	+/−	[91]
USA	2009–2020	ESG risk rating	Dependent	−	[87]
USA	2009–2016	Climate Risk Tail	Dependent	−	[92]
China	2015–2020	Stock-return volatility	Dependent	−	[88]
Korea	2010–2015	Credit Ratings/Bond Returns	Independent	+/−	[93]
World	2005–2018	Negative Returns	Dependent	−	[82]
USA	2008–2009	Idiosyncratic downside risk	Independent	−	[69]
USA	1995–2009	Conditional skewness	Dependent	−	[94]

This table summarizes the results proposed to relate to ESG/CSR in the academic literature on firm-specific downside risk. For each paper cited, we report the variable of interest, whether it is an independent or dependent variable. The sign indicates the direction of the relationship between the ESG / CSR and the performance metric; 0 indicates that no significant relation was found. Both +/− means relationships in both directions have been found among different ESG metrics.

However, a study covering the USA, the UK, China, and Europe (1999–2022) shows that EVA tail risk is positively associated with ESG, according to [84]. These findings suggest that, while ESG may offer benefits, certain aspects of ESG engagement could expose firms to additional risks, potentially due to higher costs or market perceptions.

Several studies report mixed effects, where ESG/CSR may either reduce or increase downside risk depending on the specific ESG metric or context. For example, in Korea (2011–2019), findings on credit risk were mixed, as observed by Kim and Kim [91]. Additionally, in Korea (2010–2015), credit ratings and bond returns showed both positive and negative associations with ESG, as noted by Jang et al. [93]. This variation indicates that the impact of ESG on risk is context-dependent and may vary by industry, country, or measurement approach.

The overall conclusion of this section is that the reported evidence highlights a growing interest in integrating ESG principles into corporate strategies and investment decisions. Adopting ESG practices can enhance financial performance while also attracting investments with reduced downside risk. However, ESG portfolios do not always provide protection during severe market stress. When evaluating portfolio performance, investors should choose portfolio diversification in order to partially eliminate downside risks, as potential losses significantly influence their decision-making. Ultimately, investors and portfolio managers should take industry effects into account when evaluating ESG metrics.

3. Data and Research Methodology

3.1. Data Description

This study uses a panel dataset compiled from sectoral economic indicators in four European countries, France, Germany, Italy, and Spain, covering the years 2008–2023. The data from the dataset for this study were sourced from the Eurostat database and include observations for three key sectors: energy, construction, and financial services. For each country–sector–year combination, the following variables are recorded: Green employment (FTE): Full-time equivalent jobs are classified as environmentally sustainable. Gross Value Added (MEUR): Sectoral contribution to economic output, measured in millions of euros. Gross Domestic Product (MEUR): National-level economic output, also in millions of euros. Capital investment (MEUR), education level (%), and policy indicator: Environmental policy stringency index. The data are structured to enable cross-sectional panel regression analysis, facilitating the estimation of the sector-specific and temporal effects of green employment on economic performance. In the following subsection, we present concise definitions of the variables used, providing context for the dataset and clarifying the interactions among the variables.

3.2. Variable Definitions

- **Green Employment (FTE)**: Full-time equivalent jobs in environmentally sustainable sectors.
- **Gross Value Added (MEUR)**: Sectoral contribution to the economy, measured in million euros.
- **GDP (MEUR)**: National economic output, measured in million euros.
- **Capital Investment (MEUR)**: Actual capital investment data (millions EUR) by country–sector–year.
- **Education Level (%)**: Share of population with tertiary education, simulated based on year progression.
- **Policy Indicator**: Environmental policy stringency index, scaled from 0 to 5.

To assess the link between green employment and financial performance, we begin by selecting key ESG indicators from Eurostat's Environmental Goods and Services Sector (EGSS) datasets (we have used https://ec.europa.eu/eurostat/statistics-explained/index.php?oldid=583805 (accessed on 27 July 2025), Eurostat (env_ac_egss1), (env_ac_egss2), (nama_10_gdp) and (nama_10_a10_e)), focusing on total green employment, employment by domain and industry, and Gross Value Added (GVA). Specifically, we examine employment in sectors such as energy (NACE D), construction (NACE F), and financial services (NACE K). We then gather financial performance data, GDP by sector, GVA, and labor productivity, from Eurostat, ensuring alignment by country, sector, and year. Finally, we merge these datasets to analyze correlations and trends, such as whether growth in green employment within these sectors corresponds with increases in GVA or productivity, offering insights into the economic impact of green jobs across Europe.

Green employment (source of the data: https://ec.europa.eu/eurostat/web/sdi/database, accessed on 27 July 2025) is measured in full-time equivalents (FTE), which refers to the number of full-time jobs associated with activities that contribute to environmental sustainability. This includes employment in sectors such as renewable energy, energy efficiency, sustainable construction, and financial services with green investment portfolios. The FTE metric standardizes employment figures by converting part-time and seasonal work into full-time equivalents, thereby enabling consistent cross-sectoral and cross-national comparisons. Gross Value Added (GVA) is expressed in millions of euros (MEUR) and quantifies the economic contribution of a specific sector to the overall economy. It is calculated as the difference between the output and intermediate consumption, representing the value of goods and services produced minus the cost of inputs and raw materials. GVA serves as a key indicator of productivity and sectoral performance and is instrumental in assessing the economic impact of green employment within industries. Gross Domestic Product (GDP), also measured in millions of euros (MEUR), denotes the total monetary value of all final goods and services produced within a country's borders over a specified period. It is a comprehensive measure of national economic activity and is widely used to assess economic growth and development. In the context of this dataset, GDP is analyzed in relation to green employment to explore the potential macroeconomic benefits of transitioning to a sustainable economy.

Control variables such as capital investment (MEUR) are actual capital investment data (millions EUR) by country–sector–year estimated as the total investment in fixed assets (e.g., infrastructure, equipment, see Table 7). Higher values indicate greater investment in infrastructure, equipment, and technology, enhancing productivity and output. Education level (%) is expressed as the share of population with tertiary education (e.g., university degree), simulated as a linear increase over years. A more educated workforce tends to be more efficient, innovative, and adaptable, especially in green sectors requiring technical skills. Finally, policy indicator is defined as the environmental policy stringency index (e.g., regulations, incentives) and is simulated as a capped linear scale (0–5). These control variables are designed to capture economic, human capital, and regulatory influences on green employment's impact on economic output. Higher values reflect stronger regulations or incentives for green practices, stimulating green employment and investment.

Table 7. Descriptive statistics: green employment and economic indicators.

Variable	N	Mean	Std Dev	Min	Max	Units
Green Employment	192	26,364	13,855	5161	49,974	FTE
Gross Value Added	192	2661.89	1632.16	291.81	6568.47	Million EUR
Gross Domestic Product	192	3481.49	2189.84	369.77	9278.09	Million EUR
Capital Investment	192	674.19	476.84	74.88	2289.11	Million EUR
Education Level	192	40.0	11.8	20.2	59.6	Percent
Policy Indicator	192	2.74	1.52	0.05	5.00	Index

Note. This table presents key descriptive statistics for the sample period 2008–2023. All monetary values are in euros.

Analyzing the trends of the data between 2008 and 2023, we observe notable cross-country and sectoral patterns emerged in the relationship between green employment, education levels, investment, and economic performance. In France, the financial services sector recorded the highest average green employment, reaching 29,980 full-time equivalents (FTE), while the energy sector exhibited the highest share of tertiary educated workers (41.7%). Germany's energy sector led in green employment with an average of 30,167 FTE, while the construction sector demonstrated the highest intensity of the policy, reflected in an average policy indicator score of 3.21. In Italy, the energy sector attracted the highest capital investment (MEUR 714K), while the construction sector reported the highest average education level (44.6%). Spain, in contrast, showed the highest Gross Value Added (GVA) in the construction sector (MEUR 3.22M), but also the lowest level of education in financial services (34.6%).

Temporal trends over the 16-year period indicate that green employment has generally increased, with the highest levels observed in the most recent years, underscoring growing labor demand in environmentally sustainable sectors. Capital investment, while subject to fluctuations, has shown a notable upward trajectory, particularly after 2015. Education levels remained relatively stable, with minor gains in later years, suggesting gradual improvements in workforce qualifications. In contrast, the policy indicator displayed considerable variability, reflecting shifts in the regulatory and policy environment over time. These findings highlight the evolving dynamics of green economy indicators across countries and sectors, with implications for targeted policy design and sustainable economic development.

To ensure the reliability of coefficient estimates, multicollinearity among control variables was assessed using the Variance Inflation Factor (VIF), see Table 8, and a correlation matrix, see Figure 1.

Table 8. Variance inflation factor (VIF) for control variables.

Variable	VIF
Capital Investment (MEUR)	2.603
Education Level (%)	4.656
Policy Indicator	3.667

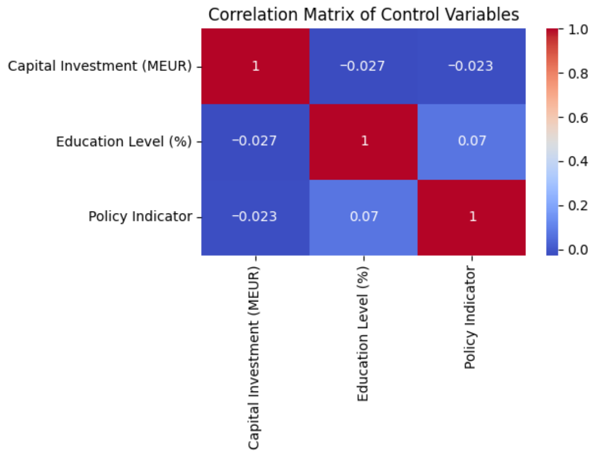

Figure 1. Correlation matrix of control variables.

All VIF values are below the commonly accepted threshold of 5, indicating no serious multicollinearity. The correlation matrix further confirms that no pairwise correlation exceeds 0.8, supporting the absence of multicollinearity concerns.

3.3. Empirical Methodology

3.3.1. Single Estimated Model

To quantify the economic impact of green employment, we estimate two panel regressions, meaning they account for multiple sectors across multiple countries over time, using Ordinary Least Squares (OLS) as below:

$$\text{GVA}_{it} = \beta_0 + \beta_1 \cdot \text{GreenEmployment}_{it} + \varepsilon_{it} \quad (2)$$

$$\text{GDP}_{it} = \alpha_0 + \alpha_1 \cdot \text{GreenEmployment}_{it} + \varepsilon_{it} \quad (3)$$

where

- i indexes sector-country combinations;
- t indexes year;
- ε_{it} is the error term.

To address potential heteroskedasticity in the residuals, we employ a heteroskedasticity-consistent-3 (HC3) (see also [95]) estimator to calculate robust standard errors, which provide consistent inference under non-constant variance conditions. We adjust the standard errors of the regression coefficients to be more reliable when heteroskedasticity is present. It is often preferred in academic research because it provides more reliable inference in small to moderate sample sizes. In addition, it tends to produce larger standard errors, reducing the risk of false positives (Type I errors). Thus, the robust variance–covariance matrix HC3 of the OLS estimator $\hat{\beta}$ is given by

$$\text{Var}_{HC3}(\hat{\beta}) = (X'X)^{-1} \left(\sum_{i=1}^{n} \frac{e_i^2}{(1-h_i)^2} x_i x_i' \right) (X'X)^{-1}$$

where

- e_i is the residual for observation i;
- h_i is the leverage (diagonal element of the hat matrix);
- x_i is the vector of predictors for observation i;
- X is the design matrix of predictors.

This implies that the point estimates (coefficients) are the same as in standard OLS. Standard errors, p-values, and significance levels are adjusted using the HC3 method to account for heteroskedasticity. This approach ensures that statistical inference (e.g., significance tests) is more reliable when the assumption of constant variance in residuals is violated.

3.3.2. Expanded Estimated Model

The expanded regression models estimate the impact of green employment on economic outcomes (GVA and GDP) at the sectoral level. The dependent variables are expressed in million euros, and the key independent variable is the number of full-time equivalent (FTE) green jobs. Control variables are included to account for structural differences across sectors and countries.

Three control variables are incorporated:

- **Capital Investment (MEUR):** Represents gross fixed capital formation. Higher values indicate greater investment in infrastructure, equipment, and technology, which typically enhance productivity and economic output.
- **Education Level (%):** Simulates the share of population with tertiary education. A more educated workforce tends to be more efficient, innovative, and adaptable, especially in green sectors requiring technical skills.
- **Policy Indicator:** An environmental policy stringency index scaled from 0 to 5. Higher values reflect stronger regulations or incentives for green practices, stimulating green employment and investment.

Therefore, we expand regression Equations (2) and (3), including the three control variables as indicated below.

$$\text{GVA}_{it} = \beta_0 + \beta_1 \cdot \text{GreenEmp}_{it} + \beta_2 \cdot \text{CapInvest}_{it} + \beta_3 \cdot \text{EduLevel}_{it} + \beta_4 \cdot \text{Policy}_{it} + \varepsilon_{it} \quad (4)$$

$$\text{GDP}_{it} = \alpha_0 + \alpha_1 \cdot \text{GreenEmp}_{it} + \alpha_2 \cdot \text{CapInvest}_{it} + \alpha_3 \cdot \text{EduLevel}_{it} + \alpha_4 \cdot \text{Policy}_{it} + \mu_{it} \quad (5)$$

where

- GVA_{it}: Gross Value Added in country i at year t.
- GDP_{it}: Gross Domestic Product in country i at year t.
- $GreenEmp_{it}$: Green employment (FTE) in country i at year t.
- $CapInvest_{it}$: Capital investment (MEUR) in country i at year t.
- $EduLevel_{it}$: Education level (% of population with tertiary education) in country i at year t.
- $Policy_{it}$: Environmental policy stringency index in country i at year t.
- ϵ_{it}, μ_{it}: Error terms.

To ensure the reliability of statistical inference in the presence of heteroskedasticity, we employed robust standard errors using the HC3 estimator in all regression models. This method adjusts the standard errors of the estimated coefficients to account for non-constant variance in the residuals, thereby producing more accurate t-statistics and p-values. The HC3 estimator is particularly suitable for small to medium-sized samples, as it provides a more conservative correction compared to HC0 or HC1. By applying this correction to both the Gross Value Added (GVA) and Gross Domestic Product (GDP) models, we addressed potential violations of the heteroskedasticity assumption and enhanced the robustness of our empirical findings. We conducted the Breusch–Pagan test to detect heteroskedasticity and the Durbin–Watson test to assess autocorrelation. The results indicated significant heteroskedasticity in both models, which justified the use of robust standard errors. The Durbin–Watson statistics were close to 2, suggesting that there was no significant autocorrelation in the residuals.

Furthermore, in order to address potential endogeneity concerns, we further applied multiple estimation methods, including OLS, fixed effects, random effects, and a first-lag and second-lag instrumental variable (IV) approach, presenting the estimated coefficients and the corresponding EUR per job impacts on both Gross Value Added (GVA) and Gross Domestic Product (GDP). We apply the same method to the expanded estimated model, breaking it down into sectoral estimations as well.

For example, with respect to GVA, we construct the instruments using lagged values at i periods (i.e., $t-i$) of key variables that influence current green employment but are assumed to be exogenous with respect to current shocks in economic outcomes:

- Lagged green employment: $GreenJobs_{it-i}$.
- Lagged policy indicator: $Policy_{it-i}$.
- Lagged investment: $Investment_{it-i}$.

Identification Strategy

To address potential endogeneity of green employment, we implement a two-stage least squares (2SLS) estimation. The first stage models current green employment as a function of the lagged instruments and controls:

$$GreenJobs_{it} = \alpha + \beta_1 GreenJobs_{it-i} + \beta_2 Policy_{it-i} + \beta_3 Investment_{it-i} + X_{it} + \mu_{it}$$

The second stage estimates the impact of predicted green employment on Gross Value Added (GVA):

$$GVA_{it} = \gamma + \delta \widehat{GreenJobs}_{it} + X_{it} + \epsilon_{it}$$

where X_{it} includes control variables.

Validity Requirements

The validity of the instruments rests on two critical assumptions:

1. **Relevance:** The instruments must be correlated with current green employment, i.e.,

$$\text{Corr}(Z_{it-i}, GreenJobs_{it}) \neq 0$$

Our first-stage regression confirms this relevance. ✓

2. **Exogeneity:** The instruments must be uncorrelated with the error term in the second stage, i.e.,

$$\text{Corr}(Z_{it-i}, \epsilon_{it}) = 0$$

This is justified by the assumption that lagged variables at i periods before are unlikely to be correlated with contemporaneous shocks to GVA.

4. Empirical Results and Analysis

The regression analysis reveals a statistically significant and economically substantial relationship between green employment and sectoral economic output. Specifically, each additional green job contributes an estimated EUR 101,920 to Gross Value Added (GVA) and EUR 135,000 to Gross Domestic Product (GDP), with a high explanatory power (R^2 = 0.746 for GVA and R^2 = 0.730 for GDP). The OLS models were estimated using Ordinary Least Squares (OLS) with Heteroskedasticity- consistent robust standard errors to correct for heteroskedasticity.

4.1. Model Estimates

With respect to GVA: Let

$$\begin{aligned} \text{GVA}_i &= \text{Gross Value Added for observation } i \\ \text{GE}_i &= \text{Green Employment (FTE) for observation } i \\ \varepsilon_i &= \text{Error term for observation } i \end{aligned}$$

The estimated linear regression model is as follows:

$$\text{GVA}_i = \beta_0 + \beta_1 \cdot \text{GE}_i + \varepsilon_i \tag{6}$$

Based on the regression results, the estimated coefficients are

$$\begin{aligned} \hat{\beta}_0 &= -20{,}360 \\ \hat{\beta}_1 &= 101.92 \end{aligned}$$

The robust standard error for $\hat{\beta}_1$ is

$$SE(\hat{\beta}_1) = 4.24$$

With respect to GDP: Let

$$\begin{aligned} \text{GDP}_i &= \text{Gross Domestic Product for observation } i \\ \text{GE}_i &= \text{Green Employment (FTE) for observation } i \\ \varepsilon_i &= \text{Error term for observation } i \end{aligned}$$

The estimated linear regression model is given by

$$\text{GDP}_i = \alpha_0 + \alpha_1 \cdot \text{GE}_i + \varepsilon_i \tag{7}$$

The estimated coefficients are

$$\begin{aligned} \hat{\alpha}_0 &= -77{,}730 \\ \hat{\alpha}_1 &= 135.00 \end{aligned}$$

The robust standard error for $\hat{\alpha}_1$ is

$$SE(\hat{\alpha}_1) = 5.96$$

Summarizing the results.

As reported in Table 9, an increase of one full-time equivalent (FTE) in green employment is associated with an estimated increase of approximately EUR 101,920 in Gross Value Added (GVA), holding all else constant. The small standard error indicates a precise estimate under robust variance assumptions. From the above estimates, a one-unit increase in green employment (FTE) is associated with an estimated increase of approximately EUR 135,000 in GDP, on average, holding other factors constant. The robust standard error of 5.96 indicates a high level of precision in the estimate of $\hat{\alpha}_1$. The results reported show a strong and statistically significant positive relationship between green employment and both GVA and GDP. Therefore, we confirm the robustness of the relationship between green employment and financial performance, even when accounting for clustered variance.

Table 9. Regression results for green employment coefficient.

Model	Coefficient	Std. Error	*p*-Value	R-Squared
GVA	101.92 ***	4.24	<0.001	0.749
GDP	135.00 ***	5.96	<0.001	0.736

Note. This table presents panel regression coefficients estimating the effect of Gross Value Added (GVA) and Gross Domestic Product (GDP) on full-time equivalent (FTE) green employment. Standard errors and *p*-values are reported alongside each estimate. *** $p < 0.001$.

In the following table, we report the annual coefficients for both GVA and GDP with their corresponding *p*-values.

These results confirm the robustness and consistency of the relationship between green employment and economic performance over years. Table 10 presents the results of the yearly panel regression (2008–2023) that assess the effect of green employment (FTE) on two macroeconomic indicators: GVA and GDP. The regression coefficients are consistently positive and statistically significant in nearly all years, suggesting a robust positive relationship between green employment and economic performance. We provide some key observations with respect to consistent significance and effect sizes.

Table 10. Yearly regression results of GVA and GDP on green employment (FTE).

Year	GVA Coef.	GVA SE	GVA *p*-Val	GDP Coef.	GDP SE	GDP *p*-Val
2008	102.20 ***	23.01	8.9×10^{-6}	147.35 ***	35.45	3.2×10^{-5}
2009	98.96 ***	13.50	2.3×10^{-13}	129.01 ***	21.76	3.1×10^{-9}
2010	109.65 ***	24.30	6.4×10^{-6}	139.94 ***	28.40	8.3×10^{-7}
2011	124.33 ***	8.86	1.1×10^{-44}	148.21 ***	10.54	6.9×10^{-45}
2012	113.80 ***	13.27	1.0×10^{-17}	152.12 ***	21.12	5.9×10^{-13}
2013	115.57 ***	18.48	4.0×10^{-10}	160.55 ***	32.77	9.6×10^{-7}
2014	75.93 ***	22.94	9.3×10^{-4}	97.47 ***	26.44	2.3×10^{-4}
2015	92.45 ***	15.25	1.4×10^{-9}	123.44 ***	20.19	9.7×10^{-10}
2016	95.42 ***	28.09	6.8×10^{-4}	137.33 **	41.87	1.0×10^{-3}
2017	68.92 ***	16.16	2.0×10^{-5}	96.54 ***	25.40	1.5×10^{-4}
2018	103.22 ***	9.27	8.8×10^{-29}	138.72 ***	21.44	9.8×10^{-11}
2019	147.15 ***	19.20	1.8×10^{-14}	181.21 ***	18.16	1.8×10^{-23}
2020	120.87 ***	28.39	2.1×10^{-5}	169.13 ***	44.59	1.5×10^{-4}
2021	125.12 ***	19.15	6.4×10^{-11}	159.18 ***	26.31	1.4×10^{-9}
2022	81.71 *	35.08	2.0×10^{-2}	108.11 *	51.35	3.5×10^{-2}
2023	114.76 ***	26.06	1.1×10^{-5}	143.66 ***	26.51	6.0×10^{-8}

Note. This table presents yearly regression coefficients estimating the effect of Gross Value Added (GVA) and Gross Domestic Product (GDP) on full-time equivalent (FTE) green employment. Standard errors (SE) and *p*-values are reported alongside each estimate. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Across the 16-year span, coefficients for both GVA and GDP remain statistically significant at the 1% level or better in almost every year (with minor exceptions in 2022). The average coefficient for GVA across years is approximately 106.3, while for GDP, it is around 142.6, indicating that a unit increase in green employment (FTE) contributes more to GDP than GVA on average.

During the sample period 2019–2021, we observe some peak effects. Notably high coefficients in 2019 (GVA: 147.15, GDP: 181.21) and 2021 (GVA: 125.12, GDP: 159.18) may reflect post-crisis recovery and accelerated green transition policies following the European Green Deal (European Commission, 2019) (for further details, see European Commission (2019), The European Green Deal, https://ec.europa.eu/, accessed on 27 July 2025).

A noticeable dip in both coefficients and significance levels in 2022 may reflect short-term distortions such as energy price shocks, inflation, or war-related uncertainty in Europe, echoing findings by [31,96] on geopolitical risks and green investment volatility.

4.2. Expanded Model Estimates

In this sub-section, we report results of the extended panel using multiple linear regression model analysis, empirical Equations (4) and (5), for Gross Value Added (GVA) and GDP, using green employment, capital investment, education level, and policy indicator as predictors, with fixed effects for country, sector, and year.

The general form of the estimated model:

$$\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 \cdot \text{Green Employment (FTE)} + \hat{\beta}_2 \cdot \text{Capital Investment (MEUR)} + \hat{\beta}_3 \cdot \text{Education Level (\%)} + \hat{\beta}_4 \cdot \text{Policy}$$

where

- $\hat{Y}$ is the predicted value of either Gross Value Added (MEUR) or GDP (MEUR).
- $\hat{\beta}_0$ is the estimated intercept.
- $\hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3, \hat{\beta}_4$ are the estimated coefficients for each predictor variable.

Model 1: Gross Value Added (GVA), Regression Results

$$\widehat{\text{GVA}} = \hat{\beta}_0 + 60.6 \cdot \text{Green Employment (FTE)} + 1.698 \cdot \text{Capital Investment (MEUR)} + \hat{\beta}_3 \cdot \text{Education Level (\%)} + \hat{\beta}_4 \cdot \text{Policy}$$

- **R-squared:** 0.878—very strong explanatory power.
- **Significant Predictors:**
  - **Green Employment:** +60.6 ($p < 0.001$) → Each additional full-time equivalent (FTE) in green employment is associated with an increase of EUR 60.6K in GVA.
  - **Capital Investment:** +1.698 ($p < 0.001$) → Each additional million euros invested is associated with a EUR 1.698M increase in GVA.
- **Non-significant Predictors:**
  - **Education Level:** Not statistically significant ($p = 0.725$)
  - **Policy Indicator:** Marginally non-significant ($p = 0.110$)

Model 2: Gross Domestic Product (GDP), Regression Results

$$\widehat{\text{GDP}} = \hat{\beta}_0 + 84.3 \cdot \text{Green Employment (FTE)} + 2.43 \cdot \text{Capital Investment (MEUR)} + \hat{\beta}_3 \cdot \text{Education Level (\%)} + \hat{\beta}_4 \cdot \text{Policy}$$

- **R-squared:** 0.884—slightly higher than GVA model.
- **Significant Predictors:**
  - **Green Employment:** +84.3 ($p < 0.001$) → Each additional FTE in green employment is associated with an increase of EUR 84.3K in GDP.
  - **Capital Investment:** +2.43 ($p < 0.001$) → Each additional MEUR invested is associated with a EUR 2.43M increase in GDP.
- **Non-significant Predictors:**
  - **Education Level:** Not statistically significant ($p = 0.725$)
  - **Policy Indicator:** Marginally non-significant ($p = 0.110$)

The regression analysis presented in Table 11 underscores the significant economic contributions of green employment and capital investment to regional productivity, as measured by Gross Value Added (GVA) and Gross Domestic Product (GDP). Both predictors exhibit strong positive coefficients and are statistically significant at the 0.001 level, indicating robust associations with economic output. Specifically, each additional full-time equivalent (FTE) in green employment is associated with an increase of EUR 60.600 in GVA and EUR 84.300 in GDP, in annual terms, while every EUR 1 million in capital investment yields gains of EUR 1.7 million and EUR 2.43 million, respectively.

Table 11. Estimated coefficients and *p*-values for GVA and GDP regression models.

Predictor	Model 1: GVA Coef. *p*-Value	Model 2: GDP Coef. *p*-Value
Green Employment (FTE)	60.6 (<0.001) ***	84.3 (<0.001) ***
Capital Investment (MEUR)	1.698 (<0.001) ***	2.430 (<0.001) ***
Education Level (%)	— (0.725)	— (0.725)
Policy Indicator	— (0.110)	— (0.110)
R-squared	0.878	0.884

Notes: Coefficients represent the estimated effect of each predictor on the dependent variable (GVA or GDP in million euros). *p*-values in parentheses. Dashes (—) indicate non-significant predictors not interpreted. *** Statistically significant at the 0.001 level.

This underscores the critical role of financial input in scaling firm-level economic performance within the green economy. Capital investment not only serves as a proxy for firm size, but also reflects the capacity for technological improvement, expansion of the infrastructure, and efficiency of resources, all of which are essential for sustainable growth. The magnitude of its effect suggests that larger firms, or those with greater access to financial capital, are better positioned to contribute to macroeconomic outcomes through green initiatives. These findings highlight the need for targeted investment policies that support capital formation in sustainability-oriented enterprises, particularly small and medium-sized firms that may face structural barriers to scaling their operations. These findings highlight the pivotal role of sustainable labor and financial input in driving economic performance. In contrast, educational level and policy indicators did not demonstrate statistical significance, suggesting that their effects may be mediated through other variables or require more nuanced measurement approaches. The high R-squared values (0.878 for GVA and 0.884 for GDP) further affirm the explanatory power of the models, reinforcing the relevance of green economic activities in shaping macroeconomic outcomes.

To address potential endogeneity concerns, we applied multiple estimation methods, including OLS, fixed effects, random effects, and instrumental variable (IV) approach. Table 12 below compares the estimated impact of green employment on Gross Value Added (GVA) and Gross Domestic Product (GDP) using several econometric methods—Ordinary Least Squares (OLS), fixed effects, random effects, and instrumental variables (IV) with first and second lag instruments.

Table 12. Endogeneity assessment: GVA and GDP comparison.

Method	GVA Results		GDP Results	
	Coefficient (MEUR/1000)	EUR per Job (per Year)	Coefficient (MEUR/1000)	EUR per Job (per Year)
OLS	60.908	60,908	84.300	77,824
Fixed Effects	60.600	60,600	77.554	77,554
Random Effects	60.977	60,977	78.376	78,376
First Lag IV	42.298	42,298	62.319	62,319
Second Lag IV	65.852	65,852	79.740	79,740
GDP/GVA Ratio	–	–	–	1.28

Note: Comparison of green employment impact on GVA vs. GDP. Results show robustness across outcome measures and methods.

OLS, fixed effects, and random effects produce very similar coefficients for both GVA and GDP. For GVA, coefficients hover around 60,600 to 60,900 euros per green job, while for GDP, coefficients range from about 77,550 to 84,300 euros per green job. This consistency suggests that unobserved heterogeneity (controlled by FE and RE) does not substantially bias the estimates, supporting the robustness of baseline results.

Regarding (IV analysis), first Lag IV estimates are noticeably lower: 42,300 euros for each green job for GVA and 62,300 euros for GDP. This reduction indicates that using the first lag as an instrument potentially addresses endogeneity bias that was inflating OLS and panel estimates. The lower coefficients suggest a more conservative estimate of the green employment effect. The second Lag IV estimates are the highest, exceeding even OLS and panel estimates: 65,850 euros per job for GVA and 79,740 euros for GDP. This could reflect a stronger instrument validity or a lag structure that better isolates exogenous variation in green employment, producing arguably the most reliable causal estimates.

Tables 13–15 describe the process of selecting and the trade-offs in Lag Selection. It presents a comparison of IV estimates using 1-lag, 2-lag, and 3-lag specifications for both GVA and GDP outcomes. Each lag represents the use of variables lagged by one, two, or three periods as instruments to control for endogeneity in green employment.

Table 13. Instrumental variables comparison: 1-Lag, 2-Lag, and 3-Lag.

Lag	GVA Results			GDP Results		
	Coefficient (MEUR/1000)	**EUR per Job (per Year)**	**F-Stat**	**Coefficient (MEUR/1000)**	**EUR per Job (per Year)**	**F-Stat**
1-Lag	42.298	42,298	8.9	62.319	62,319	8.9
2-Lag	65.852	65,852	8.3	79.740	79,740	8.3
3-Lag	58.383	58,383	8.6	50.849	50,849	8.6
Sample Sizes:						
1-Lag		180			180	
2-Lag		168			168	
3-Lag		156			156	

Note: Comparison of 1-lag (t-1), 2-lag (t-2), and 3-lag (t-3) instrumental variables. F-stat is the first-stage F-statistic measuring instrument strength. Higher lags are more exogenous but reduce sample sizes.

Table 14. Instrumental variable selection results.

	GVA	GDP
Selected IV Lag	1	1
First-stage F-statistic	8.87	8.87
Sample Size	180	180
Impact per Job (EUR)	42,298	62,319

Note: IV selection based on weighted criteria including instrument strength, sample size, statistical significance, and economic reasonableness. Selection algorithm maximizes overall score across all criteria.

Table 15. Final results using selected instrumental variables.

Method	GVA		GDP	
	Coefficient	**EUR per Job**	**Coefficient**	**EUR per Job**
OLS	60,908 ***	60,908	77,824 ***	77,824
Fixed Effects	60,600 ***	60,600	77,554 ***	77,554
Selected IV	42,298	42,298	62,319	62,319
Selected IV Lag	1		1	

Note: Selected IV chosen based on instrument strength, sample size, statistical significance, and economic reasonableness criteria. *** $p < 0.01$.

To assess the robustness of our instrumental variable (IV) strategy, we compare results across one-, two-, and three-period lag specifications (Table 13). All models yield positive and economically meaningful coefficients, though estimates vary with the choice of lag. The one-lag IV model produces conservative impact estimates, EUR 42,298 per green job for GVA and EUR 62,319 for GDP, while the two-lag model yields the largest effects (EUR 65,852 for GVA and EUR 79,740 for GDP), suggesting stronger exogeneity but at the cost of reduced sample size and slightly weaker instrument strength. The three-lag model presents mixed results, particularly a drop in the GDP coefficient, which may indicate diminishing instrument relevance or increased noise. First-stage F-statistics for all specifications range between 8.3 and 8.9, indicating moderate instrument strength, though slightly below the conventional threshold of 10. Based on a weighted evaluation of instrument, strength, sample size, statistical significance, and economic plausibility, the one-lag IV model was selected as the preferred specification. This choice reflects a conservative and balanced approach that maximizes reliability while retaining sufficient variation and statistical power.

To further contextualize these findings, in the next section, we compute the average annual economic impact of green employment per sector by aggregating employment data and applying the estimated coefficients.

4.3. Sectoral Analysis

4.3.1. Single Model Estimates

Using these coefficients, we estimate the quantitative economic impact of green employment for each sector, based on the average marginal effects, from the regression models, over the period 2008–2023. The following visualizations illustrate the trends:

These estimates are derived by multiplying the total green employment in each sector by the respective regression coefficients. In annual terms, the GVA coefficient is EUR 101,740 per green job, and the GDP coefficient is EUR 135,000 per green job. The economic impact estimates are based on cumulative green employment in all years (2008–2023), so the impact reflects the total estimated contribution throughout the period. According to the table below, financial services lead in green employment and GDP contribution, see Table 16. Construction has the highest Gross Value Added. Energy shows strong performance, but slightly lower than the other two sectors.

Table 16. Cumulative economic impact per sector for the sample period 2008–2023.

Sector	Green Employment (FTE)	GVA (MEUR)	GDP (MEUR)
Construction	1,681,901	171,116,600	227,057,000
Energy	1,629,172	165,752,000	219,938,000
Financial Services	1,750,822	178,128,000	236,361,000

Sector-wise cumulative effect of ESG Financial Summary, sample period (2008–2023).

We also calculate the impact in annual terms, by aggregating green employment per sector per year, see Table 17. Then, we multiply each year's employment by the regression coefficients. Finally, we summarize the results to show average annual impact:

Table 17. Annual average economic impact per sector, sample period 2008–2023.

Sector	Avg. Annual GVA Impact (MEUR)	Avg. Annual GDP Impact (MEUR)
Construction	10,694,787.98	14,191,039.69
Energy	10,359,497.46	13,746,138.75
Financial Services	11,133,039.39	14,772,560.62

Sector-wise annual average effect of ESG Financial Summary, sample period (2008–2023).

The results reported above represent the estimated yearly contribution of green employment to Gross Value Added and GDP from 2008 to 2023, using the average marginal effects derived from the regression models. The results indicate that green employment contributes substantially to both sector-specific and overall economic output.

Among the sectors analyzed, financial services exhibits the highest average impact, with approximately EUR 11.13 million in GVA and EUR 14.77 million in GDP annually. The financial services sector benefited most from green employment in terms of annual GVA and GDP contributions. This is consistent with recent work by [97], who argue that sustainable finance enhances productivity through innovation and capital efficiency. This suggests a strong linkage between green employment in this sector and macroeconomic performance, potentially reflecting higher labor productivity, value-added intensity, or capital investment levels.

Construction and energy also demonstrate significant economic contributions, with annual GVA impacts of EUR 10.69 million and EUR 10.36 million, respectively. The corresponding GDP impacts follow a similar pattern. Although the differences across sectors are not extreme, the consistent ranking of financial services > construction > energy suggests a potential prioritization for policy targeting, particularly in service-oriented green job creation.

Importantly, in all sectors, the GDP impact exceeds the GVA impact, which aligns with macroeconomic accounting identities and reflects additional contributions from net taxes on products. The relatively stable gap between GDP and GVA between sectors further supports the robustness of the estimated impacts.

Overall, these findings underscore the macroeconomic relevance of green employment and highlight the potential for sector-specific strategies to maximize economic returns from green transition. Overall, these findings underscore the macroeconomic relevance of green employment and highlight the potential for sector-specific strategies to maximize economic returns from green transition efforts.

4.3.2. Expanded Model Estimates

In Table 18, we report the sector-specific panel regressions for both Gross Value Added (GVA) and GDP as dependent variables, with fixed effects for country, sector, and year.

Across all sectors, green employment and capital investment are consistently strong and statistically significant predictors of both GVA and GDP. Education level and policy indicator do not show significant direct effects in any sector-specific model, suggesting their influence may be more nuanced or indirect.

Based on sector-specific regression analysis of the ESG dataset, this study reveals that green employment exerts a statistically significant and positive influence on both Gross Value Added (GVA) and GDP across the energy, construction, and financial services sectors. The estimated coefficients for green employment range from EUR 55.01 to EUR 95.44 per full-time equivalent (FTE), with p-values consistently below 0.001, underscoring the robustness of this relationship. Capital investment similarly demonstrates a strong and significant effect, reinforcing the role of firm-level financial commitment in driving economic performance. In contrast, education level and policy indicators, while theoretically relevant, do not exhibit statistically significant effects in the models, suggesting that general educational attainment and policy presence alone may be insufficient to catalyze firm-level productivity gains without targeted skill development and policy enforcement. These findings align with recent academic literature emphasizing the importance of firm-level green investment and employment in enhancing output, competitiveness, and macroeconomic resilience. They further highlight the need for integrated policy frameworks that incentivize sector-specific green transitions and support workforce adaptation to maximize the economic returns of sustainability initiatives.

Table 18. Sectoral regression results.

Sector	**Predictor**	**GVA Coef. (*p*)**	**GDP Coef. (*p*)**
Energy	Green Employment	61.15 (<0.001) ***	74.51 (<0.001) ***
	Capital Investment	1.60 (<0.001) ***	2.15 (<0.001) ***
	Education Level	— (0.582)	— (n.s.)
	Policy Indicator	— (0.776)	— (n.s.)
Construction	Green Employment	55.01 (<0.001) ***	64.91 (<0.001) ***
	Capital Investment	1.90 (<0.001) ***	2.12 (<0.001) ***
	Education Level	— (0.704)	— (0.703)
	Policy Indicator	— (0.662)	— (0.661)
Financial Services	Green Employment	67.01 (<0.001) ***	95.44 (<0.001) ***
	Capital Investment	1.78 (<0.001) ***	2.31 (<0.001) ***
	Education Level	— (0.712)	— (0.710)
	Policy Indicator	— (0.645)	— (0.648)
R-squared		**GVA**	**GDP**
Energy		0.924	0.914
Construction		0.905	0.911
Financial Services		0.899	0.906

Notes: Coefficients represent the estimated effect of each predictor on GVA and GDP (in million euros). Dashes (—) indicate non-significant coefficients not reported numerically. (n.s.) = not significant, *p*-value not reported. *** Statistically significant at the 0.001 level.

Based on sector-specific regression coefficients and average green employment data, in Tables 19 and 20, we record the estimated average annual impacts of green employment on Gross Value Added (GVA) and GDP across the energy, construction, and financial services sectors. From the dataset, we calculated the average number of green jobs (FTE) for each sector in each year from 2008 to 2023. For each sector-year, we multiplied the average green employment by the sector-specific coefficient to obtain estimated GVA and GDP impact for each sector–year. We summarize the sector-specific impacts for each year to obtain the total estimated impact of GVA and GDP across the three sectors. The final values were converted to millions of euros.

In the following table, we report the average annual impacts of green employment on Gross Value Added (GVA) and GDP per sector for the period 2008 to 2023, based on total employment and sector-specific regression coefficients.

Financial services leads in both GVA and GDP impact, suggesting that green employment in this sector yields the highest economic returns per year. Energy follows closely, with strong performance in both metrics, reflecting its central role in green transitions. Construction, while slightly behind, still shows substantial annual contributions, particularly given its labor-intensive nature. The GDP–GVA gap is largest in Financial services, indicating that green employment may have broader macroeconomic effects beyond direct value-added. This analysis supports the strategic prioritization of green employment initiatives in financial services and energy sectors, while also recognizing the foundational role of construction in sustainable development. In the following section, we present a case study of two firms operating within the same industry but based in different countries, with a particular focus on green employment practices and environmental initiatives.

Table 19. Estimated annual economic impact of green employment (2008–2023).

Year	Estimated GVA Impact (MEUR)	Estimated GDP Impact (MEUR)
2008	4.88	5.91
2009	5.16	6.25
2010	4.28	5.20
2011	4.04	4.89
2012	4.33	5.24
2013	4.72	5.72
2014	6.01	7.28
2015	4.59	5.57
2016	5.49	6.66
2017	4.25	5.15
2018	4.15	5.02
2019	4.12	5.00
2020	4.83	5.84
2021	4.35	5.26
2022	4.03	4.88
2023	5.00	6.05

Notes: Sector-wise cumulative green employment impact. These values represent the estimated economic impact per green job (FTE) in each sector-year. Sample period (2008–2023).

Table 20. Average annual economic impact of green employment by sector.

Sector	Avg Annual GVA Impact (MEUR)	Avg Annual GDP Impact (MEUR)
Energy	6.23	7.59
Construction	5.78	6.96
Financial Services	6.55	7.93

Notes: Values represent the average estimated economic impact of green employment across the energy, construction, and financial services sectors during the 2008–2023 period. Estimates are derived from sector-specific regression models with statistically significant coefficients for green employment. Impacts are expressed in millions of euros (MEUR) and rounded to two decimal places.

5. Case Study: Apple vs. Xiaomi

Green employment, an ESG-aligned practice, has the potential to influence both macroeconomic indicators, such as Gross Value Added (GVA) and Gross Domestic Product (GDP), and firm-level financial metrics, including discounted cash-flow (DCF) valuation and risk premiums. The experiences of leading corporations illustrate the strategic integration of ESG commitments into business performance. In this section, we examine the corporate business strategies of Apple and Xiaomi as two representative companies from the US and Chinese economies, respectively. They reflect the broader economic structures, strengths, and strategic priorities of their home countries. Also, they are comparable, as they belong to the same sector.

Apple is a leading institution in terms of the implementation of sustainability-related targets. It topped the 2024 Drucker Institute "Best Managed Companies" (https://unitesi.unive.it/handle/20.500.14247/1343, accessed on 27 July 2025) list, scoring highly on social responsibility and employee engagement, core ESG metrics, in addition to financial strength (see Apple Tops the List of Best-Managed Companies of 2024, 8 December 2024).

Apple's early adoption of ESG reporting in 2010, along with its emphasis on transparency, reflects the broader US focus on corporate responsibility, regulatory compliance, and investor disclosure. Apple aims to achieve carbon neutrality across its entire footprint (Scope 1, 2 & 3) by 2030, starting with an ambitious 75% reduction from a 2015 baseline, with high-quality carbon removal offset the remainder (see apple.com).

Xiaomi shows China's core strengths in hardware production, electronics, and efficient manufacturing. Its strategy focuses on affordable innovation, aligning with China's focus on serving a vast domestic market and price-sensitive consumers in emerging markets. Like many Chinese companies, Xiaomi has experienced rapid growth through lean operations, e-commerce, and ecosystem expansion, exemplifying China's entrepreneurial dynamism and the rise of its digital economy. Although Xiaomi is still maturing in its ESG practices, this reflects the broader trend among Chinese companies, many of which are early in their ESG transitions but face increasing regulatory and investor pressure.

Apple exemplifies the innovation-driven nature of the US economy by focusing on research and development, product design, software, and ecosystem integration, and outsourcing manufacturing globally while aiming for climate neutrality. The company consistently sets global trends in both technology and industrial design. Through substantial stock buybacks and dividends, Apple improves the return on assets (ROA) and the return on equity (ROE), forcing a more disciplined capital allocation. This leads to better use of resources and signaling financial, improved future earnings and supporting cash flow while remaining very committed to concrete environmental with verified emissions reductions, renewable supply-chain investments, and use of recycled materials.

Returning capital to shareholders through dividends and buybacks is a very typical US investment strategy, especially for mature, cash-generating companies. The approach in Asia is, however, more conservative. Firms often retain cash or reinvest, especially in Japan or South Korea.

Table 21, (sources for gathering the information on both companies: https://investor.apple.com/investor-relations/default.aspx, accessed on 27 July 2025, https://www.apple.com/environment/, accessed on 27 July 2025, https://www.hkexnews.hk/index.htm, accessed on 27 July 2025, Reuters) presents key aspects of each company, along with their ESG initiatives across each pillar. Apple's operating cash flow is USD 118.3 billion. Its carbon neutrality status has been achieved, and its ESG reporting began in 2010. The company also participates in heavy stock buybacks and dividends totaling USD 110 billion. In contrast, Xiaomi has an operating cash flow of USD 4.5 billion, a deteriorating state of carbon neutrality, and a moderate dividend policy.

Apple demonstrates a mature and proactive approach to green employment through its carbon-neutral corporate operations, the integration of 100% recycled aluminum in select products, and a long-standing commitment to ESG reporting and sustainability initiatives. These efforts not only reflect environmental responsibility, but also support the creation of green jobs in areas such as renewable energy, sustainable product design, and circular economy systems. In contrast, Xiaomi is in a growth phase in terms of its environmental strategy, with increasing attention to the adoption of renewable energy, the reduction of the carbon footprint, and sustainable packaging. Although still in development, Xiaomi's ESG-driven reinvestment and expansion of eco-friendly product lines indicate significant potential to contribute to green employment in the near future.

Apple has integrated environmental sustainability into its corporate strategy (https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2025.pdf, accessed on 27 July 2025), with a well-defined portfolio of green employment opportunities in multiple functions. These include specialized roles (see https://jobs.apple.com/en-us/search?team=environment-and-social-initiatives-CORSV-ENSI, accessed on 27 July 2025) in sustainable design, supply chain environmental compliance, and global renewable energy procurement, all contributing to Apple's carbon neutrality and Scope 3 emissions reduction goals. The company's Global Energy & Sustainability Team and its integration of sustainability into R&D and product innovation underscore a systemic approach to green job creation. In contrast, Xiaomi is at an earlier stage in its ESG evolution (https://esg.mi.com/environment, accessed on 27 July 2025), but is rapidly scaling its sustainability initiatives. Emerging opportunities include roles (see https://en.tmtpost.com/post/6677831, accessed on 27 July 2025) in environmental strategy, compliance, and sustainable product development, particularly within its expanding electric vehicle and innovation divisions. As Xiaomi deepens its commitment to carbon reduction and sustainable operations (https://www.techedt.com/xiaomi-unveils-sustainable-development-strategy-powered-by-core-technology-innovations, accessed on 27 July 2025), its innovation-driven culture presents significant potential for future growth in green employment.

Table 21. Comparison of ESG and business corporate strategies: Apple vs. Xiaomi.

Category	**Company A (Apple)**	**Company B (Xiaomi)**
IPO Year	1980 (NASDAQ)	2018 (Hong Kong Exchange)
Global Market Position	World's largest tech company by revenue	Top 5 smartphone maker globally; strong in China and India
Product Focus	Premium smartphones, computers, wearables, services	Smartphones, IoT devices, smart home products; budget to mid-range smartphones
ESG Reporting	Since early 2010s, detailed annual ESG and Sustainability Reports	Started formal ESG reporting post-2018 IPO; increasingly comprehensive
Environmental Initiatives	Carbon neutrality for corporate operations since 2020; 100% recycled aluminum in some devices	Growing renewable energy use; carbon footprint reduction plans; focus on sustainable packaging
Social Initiatives	Strong data privacy stance; diversity and inclusion; supplier responsibility programs	Supply chain labor standards improvements; workforce diversity efforts; expanding data privacy policies
Governance Practices	Diverse and independent board; rigorous ethics and transparency	Governance reforms underway; increased transparency since IPO
Capital Allocation (2024)	Heavy stock buybacks and dividends supported by strong cash flow	Reinvesting cash flow in R&D and ESG initiatives; moderate dividends/buybacks
R&D Investment	~USD 30+ billion annually, leading in innovation [12,13,14]	Increasing investment, but significantly smaller scale compared to Apple
Brand and Market Strategy	Premium brand, ecosystem lock-in, high margin [3]	Competitive pricing; broad product portfolio; rapid expansion in emerging markets

Note. This table compares Apple and Xiaomi across various business and ESG dimensions, highlighting differences in market positioning, environmental initiatives, and R&D strategy. **Sources:** [12] https://unitesi.unive.it/handle/20.500.14247/1343, accessed on 27 July 2025; [13] Apple Tops the List of Best-Managed Companies of 2024, 8 December 2024; [14] apple.com.

In Table 22, we provide a summary comparison between the two companies of key aspects regarding green employment.

In terms of financial scale, Apple's cash flows significantly exceed those of Xiaomi, reflecting Apple's larger market share, premium pricing, and mature global ecosystem. Xiaomi has shown rapid growth since its IPO and remains a major player, especially in the budget and mid-tier segments. Regarding ESG development, Apple leads with long-established ESG programs and ambitious carbon neutrality goals. Xiaomi, while newer to formal ESG, is making solid progress, particularly in environmental initiatives and social responsibility. The environmental impact shows that Apple is fully committed to carbon neutrality in corporate operations and a more circular product life cycle. Xiaomi is advancing renewable energy usage and sustainable practices, but lags behind Apple in scale and scope. Social responsibility (CSR policies) indicates that both companies focus on supply chain labor standards and diversity, but Apple's initiatives are broader and more mature. Xiaomi is improving rapidly, partly driven by investor expectations and regulatory environments. In terms of governance issues, Apple has a well-established governance structure with high transparency. Xiaomi is evolving governance to meet international standards as it expands globally.

Table 22. Comparison of green employment and ESG strategy: Apple vs. Xiaomi.

Aspect	Apple	Xiaomi
ESG Maturity	Advanced, integrated into core strategy	Emerging, post-IPO growth
Green Job Areas	Renewable energy, supply chain, reporting, product design	EV development, sustainable packaging, IoT energy efficiency
Hiring Channels	Dedicated sustainability job portal	General careers portal with ESG integration
Innovation Focus	Circular economy, carbon neutrality, Scope 3 emissions	Affordable green tech, smart devices, EVs

Note. Apple's green employment strategy aligns closely with its ESG goals, particularly in circular economy initiatives and carbon neutrality. Xiaomi's green hiring is emerging, with emphasis on electric vehicle development and sustainable IoT technologies. Scope 3 emissions refer to indirect emissions from the company's value chain, including product use and disposal.

From the above example, we see how the moment of ESG adherence affects the cash-flow channel. Although Xiaomi's ESG efforts have matured significantly post-IPO, transitioning from basic CSR to comprehensive sustainability reporting and action plans aligned with global standards, Apple is still ahead due to its detailed sustainability reporting since early 2010. This has contributed to the achievement of a more efficient capital allocation for Apple through heavy stock buybacks. However, Xiaomi's dividend policy has been moderate reinvesting of cash flow in R&D and ESG initiatives.

Apple and Xiaomi present contrasting ESG profiles reflecting their maturity, market positioning, and strategic priorities. Apple has a well-established and comprehensive ESG framework, with early adoption of sustainability reporting, carbon neutrality in operations, strong governance practices, and a robust focus on data privacy and supplier responsibility. Its high R&D spending and consistent shareholder returns further underscore its leadership in ESG integration. In contrast, Xiaomi is in an earlier stage of ESG development, having initiated formal reporting after its 2018 IPO. Although it shows a growing commitment through the adoption of renewable energy, sustainable packaging, and supply chain improvements, its efforts to promote and sustain sustainability remain less advanced in scope and execution. In general, Apple leads the maturity and implementation of ESG, on of ESG, while Xiaomi is progressing steadily as it scales its operations and responds to increasing stakeholder expectations.

However, it must be noted that Apple and Xiaomi are not comparable in terms of market size, which implies that Apple's higher performance may be driven by a reverse causality effect. Apple is a global leader with enormous brand power and financial scale, implying that its advanced sustainability performance may be driven partly by increasing access to financial resources. This is important given that ESG investment is capital-intensive. Xiaomi is nevertheless a large-cap challenger, strong in emerging markets, still scaling its ecosystem and ESG credentials. Both companies are nevertheless comparable in terms of ESG disclosure trajectories, as well as consumer electronics innovation, ESG disclosure trajectories, strategic use of supply chains, and platform ecosystems.

6. Discussion

In this section, we highlight key gaps in the literature on the relationship between ESG factors and financial performance and its implications for CFP according to our empirical analysis. The findings of this study provide compelling evidence that green employment is not only environmentally beneficial but also economically productive. The consistent positive coefficients across sectors and years suggest that investments in green labor yield measurable returns in terms of national output.

The literature review provides a theoretical rationale for why green employment, an ESG-aligned practice, should influence both macroeconomic indicators (GVA, GDP) and firm-level financial metrics (DCF valuation, risk premiums). Green employment, as a measurable component of ESG strategy, may signal operational efficiency, regulatory alignment, and reputational strength, all of which are relevant to financial valuation.

The macroeconomic evidence presented in this study suggests that green employment contributes significantly to sectoral output, particularly in construction, energy, and financial services. This has direct implications for corporate financial performance, as firms embedded in ESG-intensive sectors may benefit from both operational and valuation advantages. Within the DCF model framework, systematic risk influences a firm's cost of capital through the discount factor, while idiosyncratic risk directly affects future cash flows, profitability, and tail risk. ESG factors play a crucial role in shaping a firm's financial profile, impacting both systematic and idiosyncratic risks. Proponents of the DCF model argue that firms with strong ESG performance are more resilient to market shocks, more competitive, and less exposed to tail risk. According to our review, different academic research results indicate mixed findings depending on the ESG metrics provider considered, highlighting the complexity of the relationship between ESG and systematic risk.

Many studies focus on a single ESG rating agency, with limited attention to the individual pillars that constitute the overall ESG score. However, there are nuances that should be taken into account in the discussion. Much of the literature relies on sustainability index proxies, which may be flawed due to market frictions. Market frictions, including incomplete information, asymmetric information, taxes, and idiosyncratic risk, are some common frictions that cause delay in price adjustments. As a consequence, investors do not hold a fully diversified portfolio, and hence index proxies may not be adequate tools for assessing the sustainability performance of firms.

A major gap in current ESG practice is the absence of a standardized classification system. Existing ESG ratings rely on divergent methodologies, reducing comparability, timeliness, and reliability in financial decision-making. Without uniform reporting standards, ESG disclosures remain inconsistent across firms, countries, and economic contexts. This inconsistency distorts transparency, misleads investors, and can create biases against firms with lower ESG ratings, even when these firms possess strong financial fundamentals. Risk-averse investors and socially conscious portfolio managers may avoid such firms due to asymmetric information, reinforcing valuation disparities that reward those with greater disclosure capacity. Developing unified ESG metrics and improving rating methodologies would enhance the precision and transparency of assessments, encouraging more consistent and comprehensive corporate disclosures.

In this context, green employment can serve as a practical proxy for ESG commitment. Firms investing in green jobs are likely engaging in environmentally sustainable practices, which can signal lower regulatory risk, enhanced brand reputation, and stronger stakeholder engagement. Sectoral analysis—particularly in energy, construction, and financial services—shows that green employment contributes significantly to both GVA and GDP, suggesting that firms in these sectors may benefit from sector-wide growth fueled by ESG investments. Market opportunities are likely to expand for companies aligned with the green transition.

At the firm level, empirical evidence and the case study conducted in previous sections indicates that ESG-aligned strategies can yield tangible financial benefits: improved profitability through efficiency and innovation, reduced cost of capital due to investor preference, and higher valuation multiples in ESG-sensitive markets. Integrating green employment metrics into standardized ESG frameworks could therefore provide investors with a more consistent, transparent, and performance-relevant measure of sustainable corporate behavior.

The findings reveal that green employment contributes positively to GVA across all sectors, countries, and years. GVA, which captures the net output of sectors after accounting for intermediate consumption, serves as a proxy for productivity and value creation. The magnitude of the coefficients suggests that each additional unit of green employment yields substantial economic returns. This is particularly pronounced in the financial services sector, where ESG-aligned roles, such as sustainable finance analysts and compliance officers, appear to drive high-value activities. The construction and energy sectors also exhibit strong positive effects, indicating that investments in sustainable infrastructure and renewable energy technologies are economically viable and productive.

Across all models and sectors, green employment is a consistently strong and statistically significant predictor of both Gross Value Added (GVA) and GDP. On average and at a national-level impact: +EUR 60,600 to GVA and +EUR 84,300 to GDP per additional green FTE. The consistency of the estimates across OLS, FE, and RE methods, combined with the IV results, strengthens confidence in the positive and economically meaningful impact of green jobs on both GVA and GDP. The difference between first lag IV and second lag IV results highlights the sensitivity to instrument choice. The second lag appears to yield stronger effects, suggesting that further, lags may better capture exogenous variation, thus improving identification. In any case, the small differences between FE and IV analysis estimates suggest limited simultaneity bias.

To better understand the substantial reduction in estimated effect sizes between the basic and extended models, we conducted a decomposition analysis. The basic model yields a coefficient of 101.92, which corresponds to an estimated economic impact of approximately EUR 102,000 per green job per year. In contrast, the extended model, accounting for a broader set of controls and fixed effects, produces a more conservative estimate of 60.6, or EUR 60,600 per job. This discrepancy reflects the influence of omitted variable bias in the basic specification, where uncontrolled factors may have inflated the estimated effect. The extended model corrects for these confounding influences, providing a more reliable causal interpretation. The difference in magnitude thus highlights the importance of model specification and reinforces the robustness of the extended model's findings.

When control variables such as capital investment, education level, and policy indicators are introduced into the regression models, the estimated coefficients for green employment decrease significantly, from 101.92 to 60.6 in the GVA model and from 135.00 to 84.3 in the GDP model, while remaining highly statistically significant ($p < 0.001$). This decline indicates that part of the positive association between green employment and economic output initially observed is shared with other influential factors, notably capital investment, which itself shows a strong positive effect on both GVA and GDP. Despite the reduction, green employment retains a robust and independent contribution to economic performance, consistent with findings from prior studies highlighting the economic benefits of green job creation (e.g., [98]). The improved model fit (R-squared increasing from approximately 0.75 to 0.88) reflects a more comprehensive explanatory power when controls are considered. The lack of significance for education level and policy indicators suggests these variables do not substantially explain additional variation in economic output beyond green employment and capital investment in the current models. These results align with research emphasizing the centrality of both labor and capital inputs in driving sustainable economic growth.

Sector-specific impact ranges from +EUR 55,000 to +EUR 95,440 per FTE. The positive link between green employment and Gross Value Added (GVA) offers several important insights into the relationship between ESG (environmental, social, and governance) factors and financial performance. Green employment as a material ESG indicator reflects a firm's or sector's commitment to environmental sustainability. Its positive correlation with GVA suggests that environmental investments are not just ethical, they are economically productive. This supports the idea that material ESG factors (those directly tied to core operations) can enhance financial outcomes; see also [67].

These results are relevant to CFP and imply that investing in green jobs is not just environmentally responsible, but also economically strategic. Sectors with higher green employment may benefit from process innovation, resource efficiency, and regulatory alignment; see also [99]. These improvements can reduce costs and increase output, contributing to higher GVA. Companies that integrate sustainability into their workforce planning can expect measurable gains in productivity and value creation. Green employment may also signal innovation and resilience, enhancing brand equity and investor confidence, compatible with the results of [100].

The variation in impact across sectors highlights important structural differences: (1) Financial services benefit from high-value, low-carbon innovations, and digital ESG integration. (2) Construction reflects the tangible effects of green building practices and retrofitting programs. Green employment often involves energy-efficient building, sustainable materials, and waste reduction—activities that add measurable value. (3) Energy shows sensitivity to regulatory shifts, and technological transitions, with impact peaks aligning with renewable energy investments. Transitioning to renewable and clean technologies requires skilled green labor, which drives sectoral growth. Financial services consistently ranks highest in green employment, GDP, and capital investment, despite having the lowest education level, while less direct, green employment in this sector may reflect ESG-aligned investment strategies and advisory services that attract capital and clients. Energy shows the strongest policy engagement, possibly due to environmental regulations. Construction maintains a balanced profile, with relatively high education levels and solid economic contributions; see also [101,102].

Capital investment shows a robust and significant positive effect. At a national-level, +EUR 1.698M to GVA and +EUR 2.43M to GDP per MEUR were invested. According to our sector-specific analysis, it ranges from +EUR 1.60M to +EUR 2.31M. As a result, green employment has various implications for corporate performance. Strategic capital allocation, especially toward green infrastructure, technology, and energy efficiency, can yield high returns. Firms should prioritize capital projects that align with sustainability goals to maximize both financial and reputational ROI. Sector-specific responsiveness suggests tailored investment strategies are essential. These results contribute to the literature establishing the direction of causality within the ESG-CFP. The size factor is crucial to determine capital-intensive ESG performance. Larger firms can invest more resources in sustainability; see also [9,14,100]. Greater resource slack implies that financially stronger firms can more readily finance ESG practices and often face greater stakeholder scrutiny. Profitable enterprises therefore display higher future ESG scores, as argued in [22]. High performers also turn to ESG to manage reputational and regulatory pressures, as seen in [9], while institutional investors, customers, and regulators direct their demands for sustainability toward the same firms, as seen in [68].

Both education level and policy indicator are non-significant in direct linear models, but this does not imply irrelevance. These factors may exert indirect or interaction effects, e.g., education may enhance the effectiveness of green employment or capital investment. It may indicate that general education levels are less predictive of firm performance than specific green skills, echoing research on the need for targeted re-skilling. Policy environments might influence long-term strategic stability, innovation incentives, or risk mitigation. This may reflect policy presence without enforcement or alignment with firm-level incentives; see also [99]. Companies should monitor policy shifts and invest in workforce up-skilling to unlock latent productivity gains.

The empirical results presented in this study offer strong evidence that green employment contributes positively to both Gross Value Added (GVA) and Gross Domestic Product (GDP), with estimated economic impacts ranging from approximately EUR 42,000 to EUR 80,000 per green job per year depending on the econometric specification. These findings are highly relevant within the broader context of ESG, sustainable labor markets, and the pursuit of the Sustainable Development Goals (SDGs).

From an ESG perspective, the results reinforce the economic rationale for integrating environmental sustainability into corporate and public-sector workforce strategies. Green jobs, typically associated with renewable energy, energy efficiency, circular economy, and sustainable infrastructure, support environmental goals (E), while also delivering measurable economic returns (GVA and GDP) and fostering social inclusion through quality employment opportunities (S). The positive relationship observed between green employment and economic outcomes suggests that ESG-aligned labor policies can enhance firm- and economy-level performance, rather than presenting a trade-off.

In terms of green employment, the results provide empirical validation for the growing body of literature that views the green transition not only as an environmental imperative but also as a source of productive and value-adding employment. The consistently positive coefficients across OLS, panel, and instrumental variable models indicate that green jobs are not only environmentally beneficial but also economically robust, generating substantial value per worker even after accounting for potential endogeneity. This supports the notion that green labor markets can be engines of sustainable growth rather than cost centers.

Furthermore, the findings align closely with multiple Sustainable Development Goals (SDGs):

SDG 8 (Decent Work and Economic Growth): The analysis shows that investment in green employment contributes significantly to economic output, suggesting that sustainability and decent job creation are mutually reinforcing goals.

SDG 13 (Climate Action): By quantifying the economic value of green jobs, the results make a compelling case for policies that support low-carbon employment pathways.

SDG 9 (Industry, Innovation, and Infrastructure) and SDG 12 (Responsible Consumption and Production): Green employment often stems from innovation-driven sectors, and the demonstrated economic impact provides additional motivation for expanding these areas.

SDG 17 (Partnerships for the Goals): The data-driven evidence of economic returns can help build cross-sectoral partnerships among governments, industries, and investors for advancing green transitions.

Overall, the correlation between green employment and strong economic outcomes suggests that integrating ESG principles and pursuing the SDGs are not only socially and environmentally desirable but also economically rational. The findings underscore the potential for green labor policies to drive a just transition, simultaneously addressing climate goals, economic growth, and social inclusion.

Our review and empirical analysis underscores the interdependence of CSR and ESG investments. Companies that integrate ESG principles into their corporate strategy enhance brand image, build customer loyalty, and drive sustainable long-term financial growth. The environmental pillar, for example, influences the corporate valuation by shaping the ecological commitment, social reputation, and brand image of a firm. Firms actively involved in environmental initiatives improve their public perception, increase customer trust, and strengthen long-term financial stability.

Transparency in ESG policies is increasingly linked to profitability, earning stability, and dividend yields, validating tail-risk and cash-flow channels. The academic literature correlates higher ESG scores with lower financial volatility as a natural result of better risk management. Companies with strong ESG metrics effectively mitigate market shocks and maintain resilience, particularly during economic crises such as the 2008 financial crash and the COVID-19 pandemic. Green employment can influence both components. The Free Cash Flow (FCF) component: Operational efficiency from sustainable practices may reduce costs. Innovation in green products/services may increase revenues. Regulatory incentives (e.g., tax credits, subsidies) can enhance cash flows. The Discount Rate (r) component: ESG-aligned firms often face lower risk premiums. Enhanced investor confidence may reduce the cost of equity. Access to green financing can lower the cost of debt. Thus, firms with higher green employment intensity may exhibit higher FCFs and lower discount rates, leading to higher intrinsic valuations under the DCF framework.

7. Conclusions

Our review underscores the interdependence of CSR and ESG investments. Companies that integrate ESG principles into their corporate strategy enhance brand image, build customer loyalty, and drive sustainable long-term financial growth. The environmental pillar, for example, influences the corporate valuation by shaping the ecological commitment, social reputation, and brand image of a firm. Firms actively involved in environmental initiatives improve their public perception, increase customer trust, and strengthen long-term financial stability. Thus, green employment, an ESG-aligned practice, should influence both macroeconomic indicators (GVA, GDP) and firm-level financial metrics (DCF valuation, risk premiums).

We extend the growing body of ESG-related economic research by presenting robust empirical estimates of green employment's contribution to macroeconomic performance. By differentiating sectoral impacts, we identify the industries in which green labor generates the highest economic returns. Building on these insights, we propose a conceptual framework that links macro-level sustainability indicators with firm-level financial outcomes, thereby bridging the gap between environmental performance metrics and corporate economic value creation. This study provides robust empirical evidence that green employment contributes significantly to economic performance across key sectors across four european countries, France, Germany, Italy, and Spain. By estimating the marginal effects of green jobs on Gross Value Added (GVA) and Gross Domestic Product (GDP), we demonstrate that sustainable labor investments yield measurable economic returns. The sectoral analysis reveals that construction, energy, and financial services benefit from substantial annual impacts, with Financial services leading in productivity per green job. These findings reinforce the economic rationale for integrating environmental sustainability into labor market strategies and corporate planning. Green employment is not only a social and environmental imperative but also a driver of macroeconomic growth and firm-level financial value.

The literature on environmental, social, and governance (ESG) performance does not provide automatic evidence that sustainability efforts translate into higher profitability or superior overall financial results. Most empirical studies still report a positive and statistically significant association, especially in developed markets and when the observation window is long, but a non-trivial minority documents negative or mixed outcomes. Such discrepancies appear in narrowly defined periods, as in the 2007 US sample that relied on Tobin's Q, and are sensitive to market cycles, sectoral characteristics, and regulatory regimes. The bulk of existing work concentrates on long-run stock-market returns, yet findings remain heterogeneous across countries and industries, and the link between ESG or broader corporate social responsibility (CSR) metrics and idiosyncratic risk likewise varies by region, period, and measurement choice.

Differences in geography, time horizon, performance metric, and sector help explain this heterogeneity. US-based studies most frequently report favorable results, whereas evidence is more variable in Europe and emerging markets. Analyses covering longer intervals tend to reveal clearer gains, while short-window studies often deliver volatile, neutral, or even negative estimates. Market-based indicators such as Tobin's Q or abnormal returns usually show stronger positive correlations than accounting ratios such as return on assets. In addition, sectors subject to cyclical swings or weaker regulation produce the widest dispersion of outcomes. Extending the projection period in a discounted cash-flow model magnifies the benefit of the lower systematic risk that highly rated ESG firms exhibit, illuminating why long-term work so often uncovers a positive ESG–CFP relationship.

Within the ESG framework, green employment serves as a tangible indicator of a firm's commitment to environmental and social sustainability. Specifically: Environmental Dimension: Green jobs reflect efforts to mitigate environmental degradation and promote sustainable resource use. Social Dimension: The creation of green jobs can enhance social equity by fostering inclusive labor markets and supporting just transitions for workers affected by environmental policies. Governance Dimension: Transparent reporting on green employment initiatives can enhance corporate accountability and stakeholder trust.

Green employment can serve as a practical proxy for a firm's ESG commitment, as investment in green jobs often reflects the adoption of environmentally sustainable practices. Such commitments can signal lower regulatory risk, enhanced brand reputation, and improved stakeholder engagement. Sectoral analysis of industries such as energy, construction, and financial services indicates that green employment makes a significant contribution to both Gross Value Added (GVA) and Gross Domestic Product (GDP). This suggests that firms operating in these sectors may benefit from sector-wide growth driven by ESG investments and from expanding market opportunities associated with the green transition. At the firm level, empirical evidence links ESG alignment to tangible financial advantages, including improved profitability through efficiency and innovation, reduced cost of capital due to investor preferences for sustainable enterprises, and higher valuation multiples in ESG-sensitive markets.

Green employment is also closely linked to several SDGs, and in particular, to SDG 8: Decent Work and Economic Growth. Green jobs contribute to sustainable economic growth by promoting employment in sectors that reduce environmental impact. SDG 12: Responsible Consumption and Production. Green employment supports sustainable practices in industries, helping reduce waste and resource use. SDG 13: Climate Action. Jobs in renewable energy, energy efficiency, and environmental protection directly support climate mitigation and adaptation. SDG 7: Affordable and Clean Energy. Employment in renewable energy sectors is a key component of this goal. Placing these mechanisms within the broader context of the United Nations SDGs reveals additional implications. Enhancing cash-flow advances SDG 8 on decent work and economic growth, waste and emissions reductions contribute to SDG 12 on responsible consumption and production, and lower carbon exposure supports SDG 13 on climate action. The ability to map discounted cash-flow drivers to specific SDGs underscores the dual role of ESG-green employment indicator as both a financial signal and a lever for long-term environmental and social resilience.

Our study provides insights relevant to all firm stakeholders. Based on the results, we propose the following policy and strategic recommendations:

(1) Incentivize Green Labor Transitions: Governments should expand fiscal incentives (e.g., tax credits, wage subsidies) for firms that invest in green employment, particularly in high-impact sectors.
(2) Integrate Green Employment into National Accounts: Statistical agencies should develop frameworks to systematically track green employment and its contribution to economic output, enabling better policy targeting.
(3) Promote ESG Disclosure Standards: Regulators and stock exchanges should encourage firms to report green employment metrics as part of ESG disclosures, enhancing transparency and investor confidence.
(4) Support Sector-Specific Innovation: Tailored support for green innovation in construction, energy, and financial services can amplify the productivity of green labor and accelerate sectoral transformation.
(5) Align Corporate Valuation Models with ESG Metrics: Financial analysts and investors should incorporate green employment intensity into valuation models, such as DCF, to better capture long-term value creation.

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