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Alliance Portfolio Diversity as a Driver of Corporate Environmental Performance: Evidence from Sustainability-Oriented Alliances

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Summary

Abstract

This thesis investigates how the composition and diversity of corporate alliance portfolios influence firms' environmental performance, with a particular focus on the Electrical and Electronic Equipment (EEE) sector. As sustainability has evolved into a central strategic objective for companies worldwide, profitability alone is no longer sufficient to define competitiveness. Firms are now evaluated not only on financial metrics but also on their environmental and social impact, as growing regulatory pressures and stakeholder expectations demand measurable commitments toward sustainable development. Addressing complex challenges such as decarbonization, circular economy, and eco-innovation increasingly requires collaboration rather than isolated corporate action. In this context, managing sustainability-oriented alliance portfolios has become a crucial means of accessing complementary knowledge, technologies, and resources that foster innovation. Previous research has shown that certain types of alliance diversity can improve environmental outcomes, yet empirical evidence remains limited regarding how other forms of heterogeneity relate to sustainability performance. To fill this gap, the study employs a longitudinal panel dataset covering 164 firms and 618 sustainability-oriented alliances between 2002 and 2023. Using regression models, it explores how technological, industrial, functional, geographical, and operational diversity of an alliance portfolio are related to firms' environmental performance, measured through standardized ESG indicators. The results of functional, technological, and industrial diversity confirm positive association of previous researches. Geographical diversity also has a generally positive relationship, suggesting that international collaborations expose firms to broader environmental standards and best practices that stimulate sustainability adoption. In contrast, excessive operational diversity tends to have neutral or negative effects, as high heterogeneity may increase coordination costs and strategic complexity. Overall, the findings indicate that alliance portfolio diversity is a key enabler of sustainable innovation, but its effectiveness depends on balancing variety and coherence within collaborative networks. While the models are robust, some limitations must be acknowledged. The use of secondary ESG data may introduce measurement bias or reflect greenwashing tendencies, and certain unobservable factors - such as managerial culture or leadership priorities - could influence both sustainability strategies and alliance decisions. Despite these constraints, the research provides a valuable empirical contribution, extending empirical studies on alliance portfolio diversity and offering practical insights for firms seeking to design partnerships that enhance environmental performance.

1 Introduction

In recent years, the growing global emphasis on sustainability has profoundly transformed corporate strategy. Environmental performance is no longer viewed merely as a matter of compliance or reputation, but as a new dimension of competitiveness alongside profitability and efficiency. Within this context, firms in the Electrical and Electronic Equipment (EEE) sector face both exceptional opportunities and significant challenges. As a resource-intensive industry with high exposure to environmental regulation, it plays a pivotal role in enabling the green and digital transition. However, achieving substantial progress toward sustainability often exceeds the capabilities of individual firms. Addressing complex issues such as decarbonization, circular economy, and eco-innovation requires access to diverse resources, technologies, and knowledge bases - objectives that can rarely be attained in isolation.

Strategic partnerships therefore emerge as essential tools for pursuing sustainable growth. Yet, the competitive advantage derived from collaboration depends not only on individual alliances but also on how they are collectively managed as an alliance portfolio. The configuration and diversity of this portfolio determine a firm's ability to integrate heterogeneous resources and transform them into innovative and environmentally sustainable outcomes. Whereas traditional studies have largely examined bilateral partnerships, recent research highlights that a portfolio-level approach provides a more comprehensive view of inter-organizational learning, resource complementarity, and strategic coherence.

Building on these theoretical insights, this thesis continues the line of research developed in *The Role of Alliance Portfolio Diversity for Corporate Decarbonization, Circular Economy and Eco-Innovation*, which examined how three classical dimensions of alliance diversity - Functional, Industrial, and Environmental Technological - affect firms' environmental outcomes. Expanding upon that framework, the present study introduces two additional dimensions of diversity: Geographical Diversity, referring to the variety of countries in which alliance partners are based, and Operational Activity Diversity, which captures the heterogeneity of partners' business activities. These extensions allow for a more comprehensive understanding of how firms' strategic collaboration networks influence sustainability-related performance. Accordingly, the research addresses the following questions:

- Is a firm's corporate environmental performance positively associated with the Geographical Diversity of its alliance portfolio?
- Is a firm's corporate environmental performance positively associated with the Operational Activity Diversity of its alliance portfolio?

To answer these questions, the research first develops a comprehensive theoretical background exploring the evolution of sustainability and its integration into business strategies. The discussion begins with the conceptual shift from Corporate Social Responsibility (CSR) to Environmental, Social, and Governance (ESG) frameworks, examines the European and international regulatory landscape, and explores the strategic role of alliances for sustainable innovation. The analysis then extends from individual alliances to portfolio management, identifying the advantages and challenges of maintaining a diversified network of alliances.

The empirical component of the study builds upon a panel dataset constructed through the integration of two main data sources. The first includes 280 international companies engaged in 1,539 environmental alliances between 1993 and 2014, with information drawn from three primary databases: the Thomson SDC Platinum Database (for alliance data), Refinitiv ESG Database (for environmental performance scores), and Bureau van Dijk Orbis (for financial and firm-level variables). These data were then merged with an extended dataset comprising 1,225 additional strategic alliances, resulting in a final balanced panel covering the period 2002–2023. The merged dataset provides longitudinal information for each company - such as environmental scores, number of employees, and portfolio size - and details on alliance characteristics, including number of partnerships, partner profiles, and diversity measures across multiple dimensions.

As a preliminary step, the characteristics of the final dataset were analysed to provide an overview of the firms and alliance portfolios under examination. The final sample includes 164 companies engaged in 618 sustainability-oriented alliances, with a specific focus on the EEE sector. As already mentioned, this industry plays a crucial role in electrification and digitalization, acting as an enabler of sustainability while facing increasing pressure to reduce its environmental footprint. Geographically, the firms are primarily located in Europe, followed by North America and Asia, reflecting the concentration of sustainability leaders in technologically advanced regions. The sample is composed mainly of medium-to-large companies founded between 1990 and 2010, suggesting a balance between innovative drive and organizational maturity. Most firms manage relatively small portfolios of one to three alliances, typically bilateral in nature, as these are easier to coordinate and more effective for knowledge exchange. The majority of alliances target renewable energy, sustainable mobility, and energy management - sectors central to the global green transition. Overall, the dataset offers a representative overview of firms at the forefront of sustainability-oriented collaboration.

The analysis proceeds through a series of correlation tests and regressions, examining how the five dimensions of alliance portfolio diversity are associated with multiple environmental performance scores. The results confirm that Functional, Technological, and Industrial Diversity are positively associated with corporate environmental outcomes, supporting the view that diversified portfolios promote inter-firm learning and the diffusion of clean technologies. The findings also highlight more complex dynamics for the new dimensions of diversity introduced. Geographical Diversity generally exerts a positive and significant relationship, suggesting that international alliances expose firms to a wider range of environmental standards, best practices, and regulatory pressures that stimulate sustainable innovation. However, Operational Activity Diversity displays a negative relationship with environmental performance, implying that excessive heterogeneity in partners' core activities can increase coordination complexity and dilute strategic focus. These results point to the existence of a trade-off between learning opportunities and managerial efficiency in managing diverse partnerships.

To conclude, this research underscores the strategic importance of managing diverse alliance portfolios as an integral component of corporate sustainability strategies. By extending empirical evidence beyond the classical dimensions of diversity, the study contributes to bridging the gap between theoretical reasoning and measurable environmental outcomes, offering new insights into how firms can structure their collaborative networks to achieve both competitive and sustainability objectives.

2 Theoretical Background and Key Concepts

2.1 The Role of Sustainability in Modern Business

Traditionally, the primary role of businesses was limited to generating profit, creating jobs, and providing goods and services. This view, while long predominant, proved insufficient to address the complex and interconnected challenges of the contemporary era, such as climate change, resource depletion, social inequalities, and global health crises. As companies expanded within a globalized economy, their environmental and social impact became more pronounced, increasing the expectation that they actively contribute to solving these problems rather than being part of them. In this context, sustainability has assumed a crucial role, transforming from a marginal initiative into a strategic imperative for the long-term survival and success of businesses.

2.1.1 The Evolution of the Concept of Sustainability: from CSR to ESG

The evolution of the corporate role towards sustainability can be traced through several historical phases, which have progressively broadened its scope and importance. The roots of the concept of sustainability can be found in the 1972 United Nations Conference on the Human Environment in Stockholm. This event marked a turning point in global environmental policy, recognizing the need for shared principles for environmental protection and highlighting the interconnectedness between development and ecology (United Nations, 1972).

In the same year, the Club of Rome's report, *The Limits to Growth*, was the first to model the consequences of exponential population growth and resource consumption, highlighting the urgent need for long-term planning to avoid ecological collapse.

A subsequent fundamental stage, resulting from a growing awareness of new social and environmental challenges, was the formal definition of sustainable development in the 1987 document *Our Common Future*, also known as the Brundtland Report. This report defined it as the ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs." This definition, for the first time, emphasized the need to reconcile human development with the planet's carrying capacity, overcoming the historical dichotomy between economic growth and environmental protection.

In the 21st century, the Brundtland Report found a practical application in the corporate world through Corporate Social Responsibility (CSR). Defined by the European Commission in 2001, CSR is a concept whereby companies voluntarily integrate social and environmental concerns into their business operations and interactions with stakeholders. Its distinctive elements are voluntarism, cooperation with stakeholders, and the Triple Bottom Line (TBL) approach, based on three fundamental pillars: people, which involves attention to worker health and safety, equal opportunities and training; profit, which consists of adopting ethical codes, transparency, and fighting corruption; and planet, which translates into energy efficiency, conscious use of resources, and waste reduction (European Commission, 2001).

Subsequently, the paradigm evolved into the concept of ESG (Environmental, Social, Governance). The term originated from the 2004 United Nations report, *Who Cares Wins*, with the goal of demonstrating the financial benefits of integrating environmental, social, and governance considerations into long-term investment strategies. Unlike CSR, which largely focused on managing relationships with society, ESG shifted the focus to the quantitative evaluation and measurement of corporate performance by investors, solidifying the idea that sustainability factors are a fundamental component of risk management and long-term value creation (United Nations et al., 2004).

This ESG vision was further reinforced by the 2030 Agenda for Sustainable Development, providing a global framework for integrating these topics into all spheres of human and corporate activity. The 2030 Agenda is a global action plan that offers a shared structure for addressing the most urgent challenges of our time. Adopted by 193 member countries of the United Nations, the Agenda is based on 17 Sustainable Development Goals (SDGs), which cover a wide range of interconnected topics, from ending poverty to protecting marine ecosystems.

For companies, the 2030 Agenda has become an essential reference framework for guiding their sustainability strategies and for clearly communicating their impact. Instead of focusing solely on financial performance, companies are now called upon to demonstrate how their activities contribute to achieving the SDGs, thereby transforming sustainability commitments into measurable strategic objectives.

2.1.2 The Materiality of ESG Factors for Corporate Performance

The integration of ESG factors has thus emerged as a central paradigm in portfolio management, overcoming the perception that it was a simple ethical initiative. From a financial perspective, ESG is a sophisticated risk management tool that aims to identify and mitigate systemic risks often overlooked by traditional metrics, offering investors a more complete and forward-looking view of a company's prospects (Ma et al., 2023).

ESG data are increasingly used in investment strategies to improve risk-adjusted returns. Firms like Morgan Stanley Capital International (MSCI) provide ESG ratings that allow investors to assess a company's vulnerability to idiosyncratic risks, such as regulatory penalties for high carbon emissions or operational disruptions due to poor labor practices. Incorporating these ratings can influence a fund's exposure, favoring sectors with lower environmental and social risks (e.g., renewable energy) and reducing exposure to riskier sectors (e.g, fossil fuels) (MSCI, 2025).

The factors in question therefore have a direct impact on company valuation, particularly in discounted cash flow (DCF) models. This is a consequence of analysts adjusting assumptions about the cost of capital (WACC) based on a company's ESG profile: firms with low ESG scores may be subject to higher borrowing costs or equity risk premiums due to potential liabilities or reputational damage; conversely, companies with solid ESG practices can benefit from a lower cost of capital, attracted by growing demand from institutional investors seeking sustainable assets.

ESG integration also has a significant impact on asset allocation. A growing number of institutional investors, including pension funds and sovereign wealth funds, use negative screening or "best-in-class" strategies to align their portfolios with ESG principles. This also happens as a direct consequence of directives like the European Union's Sustainable Finance Disclosure Regulation (SFDR), which at a regulatory level requires asset managers to disclose the degree of ESG integration, influencing capital flows (Becker et al., 2022).

Finally, these factors are now considered necessary for a company's long-term financial performance: failure to consider ESG risks can be seen as a violation of the fiduciary duty to maximize shareholder value, as it implies ignoring the company's complete risk profile.

In this landscape where social and environmental responsibilities acquire a measurable dimension, a crucial period was the Covid-19 crisis. This acted as a catalyst, a "stress test" that validated the hypothesis that companies with solid ESG practices are more resilient and able to navigate uncertain scenarios. This resilience translates into greater investor confidence, which has been reflected in capital flows directed towards sustainable portfolios, also thanks to regulations like the aforementioned SFDR (Kozimov, 2024).

Looking ahead, ESG integration will continue to evolve, with a greater emphasis on the measurability and transparency of data. It will no longer be enough to declare a commitment to sustainability; it will be necessary to demonstrate it with concrete data and impact metrics. ESG integration is thus solidifying as an indispensable pillar of modern finance, redefining the concept of fiduciary duty and offering investors the opportunity to pursue not only profit maximization but also the creation of a positive impact, where financial success is intrinsically linked to sustainability.

2.2 The International and European Regulatory Context

The growing awareness of the importance of sustainability has led to the creation of a vast and complex framework of regulations and standards at the international and European levels. These regulatory instruments are fundamental to guiding companies toward more responsible practices, ensuring transparency, fairness, and effective management of environmental and social risks. The evolution of this legislative framework reflects the urgency of addressing global challenges, pushing companies to integrate sustainability into their strategies and operations.

2.2.1 Foundational Principles and Binding Directives of the European Union

Environmental law and, more generally, corporate sustainability governance are based on a foundation of legal and philosophical principles that have guided regulatory evolution over recent decades. These principles, recognized internationally and deeply integrated into European Union law, are not mere declarations of intent, but the conceptual bases that inform the creation and application of every directive and regulation. Understanding their origin and meaning is essential to framing the legislative context in which businesses are called to operate (European Commission, 2000).

The precautionary principle is a concept that has been consolidated in international and EU law in response to the growing awareness of environmental and human health risks whose consequences are uncertain or difficult to predict scientifically. Its roots can be traced back to the *Vorsorgeprinzip* (principle of foresight) of German environmental policy in the 1970s. Subsequently, it gained international relevance, being included in important declarations, such as the Rio Declaration of 1992, and in the Treaty on the Functioning of the European Union (TFEU) (de Smedt & Vos, 2022).

Its essence can be summarized as the idea that a lack of full scientific certainty should not be used as a pretext to postpone the adoption of effective and proportionate measures to prevent serious and irreversible harm. In other words, when a potential risk is suspected, even in the absence of conclusive scientific evidence, it is necessary to act with caution. This principle shifts the burden of proof: it is no longer up to the public authority to prove that an activity is harmful, but it is up to the operator to demonstrate that it is safe.

The implications for the corporate sector are profound. The precautionary principle requires companies to adopt proactive rather than reactive risk management. Before introducing a new product, process, or technology to the market, companies are required to conduct thorough impact assessments and explore less risky alternatives. For example, in the chemical sector, this has led to rigid testing and authorization protocols for new substances (as in the REACH Regulation). In the context of sustainability, this principle guides investments in clean and safe technologies from the early stages of research and development, encouraging responsible innovation and preventing environmental damage before it occurs. Despite its crucial role, the principle is subject to debate, with critics sometimes labelling it as an obstacle to technological progress and innovation, while supporters defend it as an indispensable pillar for the long-term protection of the planet and human health.

Parallel to the precautionary principle, the "polluter pays" principle provides the economic foundation of environmental regulations for internalizing negative externalities. Also formalized in international and EU law, it establishes that the costs arising from the prevention, control, and repair of environmental damage must be borne by the polluter. This principle is crucial for its ability to correct a market failure: pollution, or any environmental damage, is a so-called "negative externality," a cost that society bears but which is not reflected in the market price of the good or service that generates it (European Court of Auditors, 2021).

By applying this principle, legislation requires companies to internalize these externalities, including environmental costs in their balance sheets and, consequently, in the final price of their products. For example, a regulation that establishes a carbon tax or an Emissions Trading Scheme (ETS) forces the company to account for the cost of pollution, creating a powerful economic incentive. Faced with this additional expense, the company has two options: continue to pollute and bear the cost, which will make it less competitive in the market; or invest in cleaner technologies and more efficient processes to reduce its emissions and, consequently, the cost to be paid.

The second option translates into an opportunity for innovation and long-term competitive advantage. The principle not only aims to restore environmental justice, but also acts as a driver for the green transition, orienting business decisions toward more sustainable solutions. Its application is manifested in various instruments, including environmental taxes, tradable permit systems, such as the ETS, and Extended Producer Responsibility (EPR), which requires companies to take charge of the management of their products at the end of their life (e.g., packaging or electronic equipment), promoting a circular economy (Regebro, 2010).

In summary, the precautionary and "polluter pays" principles represent two sides of the same coin: the first urges caution and prevention in uncertain contexts, while the second provides the economic mechanism to internalize the costs of damage, pushing companies to integrate sustainability not as an optional, but as an inescapable component of their strategy and business model.

2.2.2 European Directives for Sustainability

The European Union has translated the fundamental principles of environmental law into an ambitious and articulated legislative plan, the European Green Deal. This plan, launched in 2019, is not simply an environmental policy, but the EU's long-term growth strategy, with the goal of making Europe the first climate-neutral continent by 2050. This strategy has been made legally binding by the European Climate Law, which formalized the cutting of net greenhouse gas emissions by at least 55% by 2030, laying the groundwork for a systemic transformation of the economy (European Commission, 2019).

The Green Deal is a holistic plan that covers every aspect of economic policy, from energy to industry, from transport to agriculture. Specific initiatives are planned for each sector: an action plan for the circular economy, a "Farm to Fork" strategy for sustainable agriculture, and a series of measures to accelerate the spread of renewable energy. A crucial and distinctive element is its focus on the social dimension of the transition. The Just Transition Mechanism was created to mobilize investments in favour of the regions and sectors most vulnerable to change, such as mining areas or those with high fossil fuel intensity, ensuring that the transition is fair and inclusive.

To translate the goals of the Green Deal into concrete legislative actions, the Commission presented the "Fit for 55" package in 2021, a set of legislative proposals that aims to review and update existing regulations to achieve the 55% reduction target. The pillars of this package are: Strengthening the EU Emissions Trading Scheme (ETS), Introduction of the Carbon Border Adjustment Mechanism (CBAM) and new targets for renewable energy and energy efficiency (European Commission, 2021).

Firstly, the ETS is the EU's main instrument for reducing industrial emissions. The "Fit for 55" package has significantly expanded its scope, for the first time including emissions from maritime transport and launching a separate system for the road transport and building sectors. The ETS operates according to the cap-and-trade principle: it sets a maximum cap on total emissions that can be produced, and companies can trade emission allowances. This increasingly restrictive mechanism makes it economically advantageous for companies to invest in low-emission technologies and pushes markets to move toward green innovation.

On the other hand, the CBAM aims to prevent so-called carbon leakage, the risk of companies relocating production outside the EU to escape stricter climate standards. The CBAM is an innovative tool that imposes a cost on imports of carbon-intensive goods. This mechanism applies to products such as cement, iron, steel, aluminium, fertilizers, and electricity. In practice, European importers will have to purchase carbon certificates to offset the emissions embedded in imported products, equivalent to what European companies pay with the ETS. The CBAM not only protects the competitiveness of European companies but also encourages non-EU countries to increase their climate ambition (European Commission, 2023).

Finally, new targets for renewable energy and energy efficiency consist in a package that has raised the binding targets for renewable energy, aiming for a share of at least 42.5% in final energy consumption by 2030, and has imposed more stringent requirements for energy efficiency, promoting energy saving and building renovation.

Another milestone in European policy is the Corporate Sustainability Reporting Directive (CSRD). This directive, which replaced the less stringent NFRD, extends the sustainability reporting obligation to over 50,000 companies throughout the EU, including all large companies and listed SMEs. The goal of the CSRD is to elevate sustainability reporting to the same level of reliability and importance as financial reporting. Its most innovative element is the principle of double materiality, which requires companies to report not only on the impact of ESG factors on their financial performance (financial materiality) but also on the impact of their activities on society and the environment (impact materiality). This pushes companies to consider sustainability not only as a risk to be managed for investors but as an intrinsic responsibility toward the community and the environment. The information must be published according to the European Sustainability Reporting Standards (ESRS), developed by EFRAG, which offer a standardized and comparable reference framework for all sectors. A further guarantee of reliability is the obligation to have the reporting verified by an external auditor, making the CSRD a powerful tool to combat greenwashing and provide stakeholders with credible data to assess companies' true sustainability commitment (European Commission, 2022).

2.2.3 Difference Between "Carbon Neutrality" and "Net-Zero"

In the corporate sustainability debate and the definition of climate goals, the terms "Carbon Neutrality" and "Net-Zero" are often used interchangeably, leading to ambiguity and potential confusion. However, they represent two profoundly different approaches and levels of ambition. A clear distinction between the two concepts is fundamental to assessing the credibility and effectiveness of a company's climate strategies (World Resources Institute et al., 2010).

To fully understand this difference, it is first necessary to frame the method for measuring emissions. The measurement of greenhouse gases (GHG) is standardized internationally by the GHG Protocol (Greenhouse Gas Protocol), which classifies emissions into three main categories, known as "Scope". This distinction is crucial: Scope 1 includes direct emissions, which are those generated from sources owned or controlled by the company; Scope 2 covers indirect emissions from purchased and consumed energy; Scope 3, often the most complex and vast, includes all other indirect emissions that occur in the company's value chain, both upstream (e.g., suppliers) and downstream (e.g., use and disposal of products). For many companies, particularly in the consumer goods sector, Scope 3 emissions represent the vast majority of their total impact (Greenhouse Gas Protocol, 2001).

In this context, the concept of Carbon Neutrality focuses specifically on achieving a balance between the carbon dioxide (CO_2) emitted and that absorbed or offset. Its focus is limited to CO_2 emissions, often ignoring other greenhouse gases. A company declares Carbon Neutrality when it balances its emissions with the removal of an equivalent amount of CO_2 from the atmosphere. This balancing is often achieved through the purchase of carbon credits (or offsetting), which finance environmental projects such as reforestation or the construction of wind farms in other parts of the world. Consequently, a company can achieve

Carbon Neutrality without having necessarily implemented a deep strategy to reduce its direct emissions or those of its value chain. Although offsetting can finance valid environmental projects, this approach has often been criticized, as it can be perceived as a form of greenwashing if it is not accompanied by a substantial commitment to internal reduction.

In contrast, the Net-Zero goal represents a much more ambitious and comprehensive strategy, whose scope extends to all greenhouse gases (GHG), not just CO_2. The fundamental difference lies in the methodology: Net-Zero requires, first and foremost, a binding commitment to a deep and substantial reduction of emissions throughout the entire value chain, including Scope 1, 2, and 3. The primary goal is not offsetting, but decarbonization. Only after having exhausted all possibilities for reduction and having reached a minimal level of residual emissions, considered technically unavoidable (such as, for example, those from the most complex industrial processes), can the company resort to permanent removal mechanisms, such as CO_2 capture technologies. Offsetting through carbon credits is not the main tool, but a last resort option.

In summary, adopting a Net-Zero target implies a radical and systemic transformation of a company's business model and its entire supply chain. It represents a long-term commitment to align with a low-emission future and to contribute significantly to achieving the goals of the Paris Agreement. Organizations like the Science Based Targets initiative (SBTi) provide a scientifically validated framework to help companies set credible Net-Zero goals consistent with the recommendations of the scientific community.

2.2.4 Voluntary Sustainability Standards (VSS) and Certifications (B Corp)

The growing interest in sustainability has also led companies to seek tools to measure, communicate, and validate their environmental and social performance, beyond regulatory obligations. In this context, Voluntary Sustainability Standards (VSS) and independent certifications have become strategic tools for demonstrating commitment, managing reputational risks, and gaining a competitive advantage. Adopting these standards allows businesses to go beyond mere regulatory compliance, offering stakeholders (consumers, investors, suppliers) a signal of credibility and seriousness (B Corp, 2024).

VSS can be classified based on their subject: those that apply to individual products and those that concern the entire organization. At the product level, ISO standards offer a robust reference framework. For example, ISO Type I standards - like the EU Ecolabel - are based on multiple environmental criteria and a product life cycle analysis, with verification by an independent third party. This type of certification ensures that the product meets strict sustainability parameters in all its phases, from production to disposal. ISO Type II standards, on the other hand, are the producer's environmental self-declarations, although they must comply with precise guidelines. Finally, ISO Type III standards, such as the Environmental Product Declaration (EPD), are based on a rigorous Life Cycle Assessment (LCA) methodology, providing quantitative and verified data on a product's environmental impact, making them particularly useful for B2B markets and sustainable procurement (EPD Italy, 2024).

Similarly, at the organizational level, there are standards that guide the management and reporting of performance. The ISO 14001 standard is one of the most widespread in the world: it provides a framework for implementing an effective environmental management system (EMS), helping companies control and improve their environmental performance in a systematic and continuous manner. In parallel, the guidelines of the Global Reporting Initiative (GRI) offer the most widely used sustainability reporting framework globally. The GRI Guidelines allow companies to measure and disclose their performance across a wide range of ESG indicators, ensuring greater transparency and comparability for investors and other stakeholders.

Among the certifications that offer a particularly strong signal of commitment, B Corp certification has gained considerable international resonance. Unlike other standards or the legal form of Benefit Corporation, B Corp is a certification issued by the non-profit organization B Lab, which assesses a company's overall impact on five key areas: governance, workers, community, environment, and customers. To obtain the certification, the company must pass a rigorous evaluation process, known as the B Impact Assessment, and achieve a minimum score of 80 points. B Corps are not only evaluated based on their products or processes but on their entire business model, which must be an "engine for positive impact." This certification not only verifies performance but also requires periodic updates and a legal commitment to consider the interests of all stakeholders, not just shareholders. B Corp certification is therefore a powerful tool to combat greenwashing and to distinguish companies that integrate sustainability at the heart of their mission and identity (B Corp, 2024).

2.3 Strategic Alliances for Sustainability

In an increasingly competitive and complex environment, where sustainability represents both a necessity and a duty, businesses are forced to evolve their business models to remain relevant. This scenario has made it increasingly clear that to address global challenges like sustainability, no company can act alone. The practice of corporate partnership emerges as a fundamental strategic solution, allowing companies to fill internal gaps, access complementary resources, and achieve goals that would otherwise be unattainable. Although many companies still harbour a certain reluctance to enter into collaborative paths, fearing a loss of control over projects or the exposure of their key competencies to potential competitors, the creation of strategic alliances has become an imperative to maintain a lasting competitive advantage in a constantly evolving market.

2.3.1 Definition and Types of Alliances

Strategic alliances, while they can take on different names such as joint ventures, partnerships, networks, or collaborations, share a common nature: they are a voluntary collaborative relationship established between two or more companies with the goal of obtaining mutual benefits. Such benefits can vary from the exchange of information and knowledge to the sharing of resources, up to the joint development of products, technologies, and services.

There are, however, fundamental distinctions that delineate the nature and structure of these collaborations. The most integrated form of alliance is the Joint Venture, which is the only case in which a completely new legal entity is created. In a Joint Venture, the founding partners own capital shares and share governance, reflecting an extremely high degree of collaboration, coordination, and communication (Yoshino & Rangan, 1995).

The other alliances, on the other hand, fall into the category of equity or non-equity alliances. The former occurs when partner companies hold different ownership shares in the common entity created for the collaboration, while not giving rise to a new company. Conversely, non-equity alliances are purely contractual in nature: the companies collaborate and combine their resources and skills, but maintain their full autonomy and legal separation. Common examples of non-equity alliances include licensing agreements, supply contracts, or distribution agreements.

In addition to the distinction based on legal nature, alliances can be classified based on the degree of competitiveness and the objectives that guide them. This particular aspect will be taken into account through analysis, to understand which level of similar industries and activities can benefit. A first model is that of pro-competitive alliances, a classic form of partnership that occurs between companies that are not direct competitors, often operating in different phases of the same value chain. A typical example is an alliance between a component supplier and a finished product manufacturer. The main goal is to maximize the efficiency and stability of the supply chain, ensuring a constant flow of high-quality raw materials or components. In these collaborations, companies seek to integrate their processes to reduce costs, optimize logistics, and improve overall quality. Although the level of competition is low, the alliance is still strategic because it allows for the preservation of each partner's key competencies, consolidating their position in the market. The main challenges in this type of partnership involve the management of operational risks and the need to ensure complete trust and transparency to avoid interruptions or quality problems.

A second model is represented by competitive alliances, which are formed between companies that are direct competitors in the same sector and in the same market. The basic idea is that, despite the competition, there are areas of common interest where collaboration can lead to a greater benefit for all partners compared to individual action. A classic example is the collaboration between two car manufacturers for the development of a common platform for electric vehicles, in order to reduce research and development costs, while maintaining competition on the design and marketing of the final product. These alliances are inherently complex and high-risk. A company that allies with a competitor must carefully balance the openness necessary for collaboration with the protection of its strategic skills and technologies so as not to lose its competitive advantage. The risk of failure is high, as the partnership can be easily undermined by a lack of trust, divergent objectives, or inefficient communication. However, if managed successfully, competitive alliances can lead to significant advantages, such as accelerating innovation and creating new industry standards (Jiang, Tao & Santoro, 2010; Riegler et al., 2023).

Finally, pre-competitive alliances involve partners who operate in completely different sectors and are not in direct competition. The main goal of these collaborations is the acquisition of unique knowledge and skills that would otherwise not be available to any single partner. This type of alliance is particularly relevant for solving complex problems that require an interdisciplinary approach and for the development of disruptive innovations. For example, a partnership between a technology company and a textile company to develop sustainable and biodegradable materials falls into this category. Pre-competitive alliances are fundamental in the context of sustainability, where solving complex challenges such as pollution, waste, or the energy transition requires the collaboration of actors with specialized knowledge in very different fields. The main challenges concern the management of cultural and organizational diversity, the ability to integrate disparate knowledge, and the need for a strong shared vision to overcome potential friction (Riegler et al., 2023).

2.3.2 Advantages and Risks of Alliances

Entering strategic alliances, although it represents an opportunity for growth and a necessary action to face the challenges of sustainability, does not guarantee a positive outcome. As already mentioned, partnerships are, by their nature, complex and have a dual profile: they offer a wide range of benefits, but also entail significant risks and unexpected challenges – indeed results show a positive relationship with Geographical Diversity, but negative relationship from Operational Activity Diversity. A company's ability to successfully navigate this scenario depends on its careful management of the advantages and its preparation to face the critical issues (Yoshino & Rangan, 1995). On the other hand, the objective of this thesis will be to empirically verify whether the overall final effect of these partnerships and the various degrees of variety they present represent a benefit or a difficulty.

One of the main advantages of alliances lies in the possibility of accessing resources and skills that would otherwise not be available. Collaboration allows companies to benefit from the tangible assets - such as machinery or advanced technologies - and intangible assets - such as experience, specialized knowledge, or a brand's reputation - of their partners. This synergy increases the company's flexibility and strengthens its overall competitiveness (Riegler et al., 2023; Chu, 2019).

In parallel, partnerships act as an accelerator for expansion into new markets or sectors. This is a particularly advantageous aspect for companies that intend to enter emerging geographical areas, as they can take advantage of the partner's already consolidated presence and local knowledge. In the context of sustainability, entering "green" markets allows for gaining a broader market share, attracting increasingly ethical and environmentally conscious consumers. This creates a virtuous cycle that strengthens brand reputation and customer loyalty.

Another crucial benefit is the possibility of becoming a market leader through innovation. Partnerships allow companies to rethink their products, processes, and services in a more radical way than they would on their own. Collaborating with partners who have complementary skills can lead to the creation of unique and disruptive solutions, which differentiate the company in a crowded market and give it a significant competitive advantage.

On the financial level, alliances offer significant opportunities for cost reduction and risk mitigation. Sharing resources and skills allows for better foresight and management of problems, distributing the financial burden and reducing the impact of potential losses. Furthermore, sustainability-oriented alliances make companies more attractive to investors and financial institutions specializing in ESG projects, which can translate into a lower cost of capital and more favourable growth conditions. For small and medium-sized enterprises (SMEs) and companies in developing countries, partnerships with global players are an extraordinary lever to align with international sustainability standards, expand their network, acquire resources, and access innovative technologies, improving their reputation and competitiveness on the global stage (Falcke et al., 2024; Riegler et al., 2023).

However, these opportunities are not without risks. Contractual problems represent one of the most common causes of failure: a vague agreement or one without defined boundaries can generate misunderstandings and conflicts that undermine the partnership. Another significant risk is related to reputation. While transparency is fundamental on the one hand, on the other it exposes the company to the failures of its partners. An unethical action or a scandal involving an ally can damage the image of all parties, compromising not only the ongoing partnership but also future collaborations (Wassmer et al., 2014).

The most complex challenges often emerge in international partnerships, due to profound socio-cultural differences. Language barriers can go beyond simple translation, leading to misunderstandings of technical concepts or industry-specific terms such as "materiality assessment" or "ESG reporting". Furthermore, the social context and cultural norms can differ substantially. For example, while child labour is strictly prohibited in an industrialized country, in some developing nations it could be a cultural norm or an economic necessity for family survival. Such disparities require careful supervision to ensure compliance with agreed standards, even with an adequate understanding of the local context – however, the results of this thesis show that these risks are well balanced by advantages, so the overall relationship between Environmental Score and Geographical Diversity is still positive.

Finally, labour rights standards can vary drastically. A Western partner might expect high health and safety standards, while a partner in a country with high unemployment rates and economic inequality might operate in a context where these rights have a different perceived relevance than international standards. Managing these divergences requires open communication, a strong alignment on values, and the ability to find a balance between respecting global norms and understanding cultural specificities.

2.3.3 SDG 17: The Global Partnership for Sustainable Development

Given the variety of socio-cultural contexts and local norms, solving global sustainability challenges like climate change, poverty, and inequalities requires concerted action that transcends the boundaries of individual states and economic sectors. Recognizing this reality, the United Nations 2030 Agenda for Sustainable Development, with its 17 goals (SDGs), has outlined a universal strategy. Within this roadmap, *SDG 17: Global Partnership for Sustainable Development* occupies a unique and crucial position. Unlike the other 16 goals which focus on specific topics (such as climate action or ending hunger), SDG 17 is an implementation goal, meaning it is how the other goals can be achieved. It emphasizes that the success of the entire 2030 Agenda depends on the ability to build effective and inclusive alliances globally, involving governments, the private sector, civil society, and all other actors.

The essence of SDG 17 lies in the recognition that no single entity, no matter how powerful, has the resources, skills, and authority needed to solve global-scale problems. This goal promotes a philosophy of multi-stakeholder collaboration that aims to mobilize and share financial resources, technologies, and knowledge. The partnerships envisioned by SDG 17 are not simple commercial agreements but long-term strategic alliances, based on a shared vision and mutual commitment to the common good. Such partnerships are fundamental for increasing the effectiveness of development aid, for facilitating the transfer of clean technologies to less developed countries, and for promoting greater coherence between public policies and sustainability goals (Falcke et al., 2024; Riegler et al., 2023).

Corporate strategic alliances, the central theme of this thesis, are a direct manifestation of the principles of SDG 17. Companies are, in fact, no longer limited to passively supporting development goals but are actively creating targeted partnerships that generate measurable impact. For example, an alliance between a large technology corporation and a non-governmental organization can lead to the development of digital solutions for sustainable agriculture in developing countries, thus contributing to several SDGs simultaneously. Similarly, a partnership between a multinational company and local suppliers can facilitate the transfer of environmental and social best practices, strengthening the value chain and improving working conditions. Alliances, in this context, become the vehicle through which the private sector can actively contribute to development goals, not only for reasons of social responsibility but also because a more stable, equitable, and sustainable world represents a more prosperous and resilient market for everyone.

However, realizing the ambitions of SDG 17 is not without challenges. Partnerships require complex management and a culture of trust, transparency, and mutual respect. It is essential to overcome the historical mindset focused exclusively on profit and embrace a broader role as a "global citizen." Companies that succeed in building solid alliances, aligned with the principles of SDG 17, not only contribute to a sustainable future but also gain a significant competitive advantage. They ultimately demonstrate that collaboration and economic growth can and must go hand in hand with the creation of shared value for society and the environment.

2.3.4 Innovation for Sustainability through Alliances

Consistent with the SDGs, innovation is universally recognized as the engine of economic growth and progress, but in the context of sustainability, it takes on an even more critical connotation. The transition to a low-carbon and circular economy cannot happen through marginal improvements but requires radical and disruptive innovation, which cannot be sustained by individual independent companies, as SDG 17 emphasizes. However, the complexity of environmental and social challenges, which are often interconnected, exceeds the capabilities and resources of a single company. Strategic partnerships thus become an indispensable vehicle for sustainable innovation, allowing companies to combine diverse resources, knowledge, and skills to develop solutions that would otherwise not be possible (Falcke et al., 2024; Riegler et al., 2023).

Alliances for sustainable innovation are driven by the need to overcome the limits of internal innovation. Companies can use partnerships to access cutting-edge technologies they do not possess, such as a consumer goods company collaborating with a biotechnology startup to develop biodegradable packaging. This type of collaboration helps to accelerate the research and development process, reducing associated costs and risks.

Furthermore, as already mentioned, alliances offer the possibility of accessing specialized skills that do not fall within the company's core business, such as knowledge of emerging markets, an understanding of complex regulations, or expertise in social impact. The combination of different skills creates fertile ground for disruptive innovation, which often occurs at the intersection of seemingly unrelated sectors.

Another fundamental role of alliances is the ability to generate systemic innovation, which means solutions that are not limited to a single product or process but that transform the entire value chain or even the business model. The transition to a circular economy, for example, cannot be achieved by a single company. It requires collaboration between producers, suppliers, distributors, and recycling companies to create ecosystems in which materials are constantly reused. An alliance between an electronics company and a logistics services company, for example, can lead to the development of a system for collecting and recovering end-of-life products, an innovation that would not be possible without collaboration between the two actors.

In addition, alliances for sustainability are a crucial tool for the co-creation of shared value. The innovation that results from them is not limited to generating profits for the partners but also creates benefits for society and the environment. For example, a partnership between a food company and an NGO specializing in sustainable agriculture can lead to the development of new farming practices that improve soil health, reduce pesticide use, and increase the income of local farmers. This type of innovation creates economic value for the company, strengthens its supply chain, and generates a positive social impact, demonstrating that sustainability can be a factor for growth and not just a cost.

In summary, strategic partnerships for sustainability act as true "catalysts" of innovation. They overcome organizational barriers, combine diverse skills, and allow for addressing complex challenges at a systemic level. For companies, the ability to form and manage effective alliances is not just a strategic choice but a prerequisite for innovation that is at the same time economically advantageous, socially equitable, and environmentally sustainable.

2.4 The Alliance Portfolio for Sustainability

In today's corporate landscape, sustainability is no longer an isolated problem to be solved with a single initiative or an ad-hoc partnership. The challenges related to the ecological transition, value chain management, and social responsibility are complex and require an integrated strategic response. In this context, the traditional concept of a single partnership, however useful, proves insufficient. The most mature and strategic companies are now embracing a broader perspective: that of the alliance portfolio, an approach that considers the set of collaborations as a single strategic asset, managed consistently to achieve long-term sustainability goals.

2.4.1 From Single Alliances to Portfolio Management

The transition from an approach based on single partnerships to managing an alliance portfolio represents a fundamental evolution in business strategy. A single alliance, while it can solve a specific and circumscribed problem, such as the supply of a recycled material or access to a clean technology, is often not enough to address the systemic challenges of sustainability that extend along the entire value chain (Le et al, 2021).

Managing an alliance portfolio, on the other hand, introduces a holistic and proactive perspective. Companies no longer evaluate collaborations in isolation but consider them as an interconnected set of relationships. The goal is to create a network of alliances that, by working in synergy, amplify the positive impact and reduce risks. This strategic approach requires continuous evaluation and optimization of the entire portfolio, like how a financial manager evaluates an investment portfolio. Decisions are not only about starting a new alliance but also about its positioning within a broader strategy: each partnership must have a well-defined role, whether it is to fill a technological gap, ensure access to a market, or address a specific environmental or social issue.

In this model, management shifts from a purely operational to a strategic level: the company must ensure that its alliances are aligned with its overall sustainability strategy. An alliance for emission reduction, for example, should be complementary to another for promoting the circular economy. Portfolio management also requires intelligent diversification of alliances: having a mix of partnerships with startups, universities, suppliers, and NGOs can mitigate risks and stimulate innovation from various sources. Finally, a well-managed alliance portfolio is characterized by synergy, where the combined effect of the partnerships is greater than the sum of the individual contributions. This approach is a testament to a company that has understood that sustainability is not a cost to be minimized but a strategic opportunity to be maximized through collaboration and integrated management (Jiang et al, 2010).

2.4.2 Advantages and Challenges of Alliance Portfolio Management

The management of a portfolio of strategic alliances, in contrast to the approach based on single partnerships, offers a set of advantages and introduces a new order of challenges that require more sophisticated management. A company that elevates collaboration to the portfolio level demonstrates strategic maturity but must be aware of the complexities that such a choice entail (Le et al, 2021).

As already mentioned, the main advantage of portfolio management is risk diversification: similar to a financial portfolio, a diversified set of alliances offers greater stability and resilience. If an alliance does not produce the expected results, or if a partner faces difficulties that compromise its effectiveness, the company's entire sustainability strategy is not at risk. The other partnerships can compensate for the shortcomings, ensuring that the company continues to progress toward its goals. This diversification also extends to multiple objectives: a company can have an alliance for technological innovation, another for ethical sourcing, and a third for waste management, creating a support network that covers the entire range of ESG challenges simultaneously and effectively (Wuyts et al, 2014; Lee et al, 2017; Jiang et al, 2010).

Another crucial benefit is the creation of synergies and the acceleration of systemic innovation. Alliances are not managed in silos but with an interconnected perspective. This allows for the discovery and exploitation of synergies between different partners. For example, an alliance with a company that develops recycled materials can be integrated with another partnership that manages reverse logistics and recycling, creating a virtuous cycle that would not be possible with a single collaboration. This interconnectedness promotes systemic innovation, meaning the creation of solutions that transform not just a single product or process, but the entire value chain.

Finally, portfolio management offers greater strategic flexibility. The company is not tied to a single long-term relationship but can periodically review the portfolio's performance, deciding to renew, terminate, or start new alliances based on market evolution, new technologies, or changing sustainability regulations (Stadtler et Al, 2017).

However, managing an alliance portfolio also presents significant challenges. The first, and perhaps largest, is management and coordination complexity. Administering multiple alliances, each with its own contract, goals, relational dynamics, and cultural specificities, requires dedicated resources and superior managerial skills. Without robust governance and a clear coordination strategy, the portfolio can become unmanageable, with the risk of redundancy, where multiple alliances work toward the same goal without creating additional value, or, even worse, of conflict, where the goals of two or more allies are at odds with each other (Wuyts et al, 2014; Jiang et al, 2010).

Another challenge is the difficulty in measuring the overall impact. While it is possible to quantify the results of a single partnership, aggregating and evaluating the ESG performance and financial returns of an entire portfolio of alliances, which often use different metrics and reporting standards, is an extremely difficult task. This complexity can make it difficult for management to justify the strategic investment in the portfolio (Lavie, 2007).

Finally, there is the risk of diluting resources. Managing too many alliances can disperse attention and human capital, preventing any single partnership from receiving the necessary support to reach its full potential, with the result that the overall impact of the portfolio is less than the sum of its parts (Wuyts et al, 2014).

2.4.3 Portfolio Characteristics and Their Influence on Sustainability

The management of an alliance portfolio goes beyond the simple sum of individual alliances. The intrinsic characteristics of this portfolio, such as its composition and structure, are crucial factors that determine its effectiveness and impact on achieving sustainability goals and the benefits already listed of diversification and synergy. An in-depth analysis of the dynamics that govern a company's portfolio allows for understanding how strategic choices can influence not only financial performance but also the company's ability to generate shared value for society and the environment.

2.4.3.1 Geographic Diversity and Sustainability Performance Relationship

The geographic diversity of an alliance portfolio is one of its most relevant and complex characteristics. For a company that operates globally, forging partnerships in different countries and regions is not just a way to expand markets but also a powerful tool to influence and improve its sustainability performance. This is manifested in several interconnected dynamics. For this reason, one of the metrics on which the thesis studies will then focus is precisely the geographic variety present in the analysed alliance portfolios.

First, alliances with partners in developing countries or emerging markets are fundamental for addressing value chain challenges and contributing to the Sustainable Development Goals (SDGs). For example, an alliance with a supplier in a country where labour rights or environmental standards are less developed can represent an opportunity for the multinational to transfer its knowledge and best practices. This not only improves working conditions and reduces the environmental impact in the supply chain but also contributes to the economic and social development of the region, generating shared value. On the other hand, collaborating with a company that operates in a very different regulatory and cultural context requires careful management. Differences in regulations, stakeholder expectations, and business practices can create friction and misunderstandings, and require a strong commitment to ensure that the partner respects the company's ethical and sustainability standards. Therefore, the same socio-cultural difficulties previously discussed for single partnerships are amplified in the case of an entire alliance portfolio.

In parallel, geographic diversity can act as a driver for innovation. Alliances with partners in regions with more stringent environmental regulations, such as in Northern European countries, can push a company to innovate and develop cleaner technologies or processes. The experiences and knowledge acquired in these markets can then be applied globally, raising the standards of the entire value chain. Furthermore, collaborating with partners in countries with a high density of research and development, such as the United States or Japan, can offer access to cutting-edge technologies for decarbonization or the circular economy (Wuyts et al, 2014; Jiang et al, 2010; Lavie, 2007).

In summary, the geographic diversity of the alliance portfolio is a double-edged sword. While it offers the opportunity to generate a positive global impact and acquire knowledge from different contexts, it also introduces significant management complexity. The success of this type of portfolio depends on the company's ability to act proactively, establishing clear sustainability expectations, implementing rigorous monitoring mechanisms, and building a trusting relationship that goes beyond geographic boundaries and cultural differences.

2.4.3.2 Operational Diversity and Sustainability Performance Relationship

Operational diversity represents another key dimension of alliance portfolio heterogeneity, referring to the variety of partners' core business activities, production processes, and organizational routines. Unlike technological or industrial diversity, which are related to the sectoral domain or type of innovation, operational diversity concerns *how* companies function on a day-to-day basis - how they produce, distribute, and deliver value. This dimension captures the practical and organizational complementarities or frictions that can emerge when firms with different operational logics collaborate toward common sustainability goals.

From a positive perspective, operational diversity can serve as a powerful catalyst for sustainable innovation. Collaborating with partners that operate in distinct segments of the value chain allows firms to access new competences, process know-how, and managerial practices. For example, a manufacturing company engaging with a logistics firm or a digital services provider can learn to optimize resource flows, improve waste management, or adopt data-driven approaches to energy efficiency. This horizontal complementarity enhances systemic thinking and supports the development of integrated sustainability solutions that transcend individual corporate boundaries - particularly valuable in circular economy initiatives, where coordination across production, distribution, and recovery processes is essential. Moreover, diverse operational structures expose firms to alternative approaches to problem-solving and organizational design, encouraging experimentation and cross-sectoral learning (Lavie, 2007).

However, operational diversity also introduces significant managerial challenges. High heterogeneity among partners' operational models can increase coordination costs, slow communication, and create goal misalignment. When firms differ too much in their routines, production cycles, or decision-making processes, the partnership may struggle to establish shared priorities and coherent implementation strategies. For instance, an alliance between a fast-paced technology company and a capital-intensive industrial firm may face difficulties synchronizing innovation timelines or investment horizons. In the context of sustainability alliances - where collaboration requires mutual trust, shared standards, and long-term commitment - these discrepancies can undermine efficiency and reduce the tangible environmental benefits of the partnership (Lee et al., 2017).

Additionally, excessive operational variety may dilute strategic focus. When the portfolio includes partners with very diverse operational structures, it becomes harder to define uniform sustainability metrics or coordinate environmental reporting systems. This can lead to a fragmentation of efforts and a loss of accountability, especially in complex networks that span multiple industries or value chains (Lee et al., 2017).

In summary, operational diversity represents both an opportunity and a challenge for firms pursuing sustainability through alliances. When balanced and strategically managed, it enables knowledge integration, cross-sector collaboration, and innovation in sustainable practices. Conversely, when ungoverned or excessive, it can generate organizational complexity, misalignment, and inefficiency. The success of such diversity ultimately depends on the firm's ability to design governance mechanisms that harmonize distinct operational routines while preserving the innovative potential of heterogeneity.

2.4.3.3 Proactivity and Relational Governance: Success Factors for Sustainability

The success of an alliance portfolio, particularly in achieving sustainability goals, does not depend solely on its composition but is closely linked to two crucial management factors: proactivity and a sophisticated relational governance. A company that adopts a passive approach risks not fully leveraging the potential of its alliances, while active and relational management transforms the portfolio into a powerful tool for transformation.

Proactivity is manifested in a company's ability to anticipate risks and seize opportunities before they become evident. In the context of the alliance portfolio, this means not waiting for an emergency (like a supply chain crisis or a new regulation) to force intervention, but acting preventively to build relationships and collaboration platforms. A proactive company identifies partners with whom to align its sustainability goals, invests in building trusting relationships, and defines collaboration mechanisms that go beyond the simple contract. This proactive approach allows for addressing complex challenges, such as managing Scope 3 emissions along the entire value chain, through the co-creation of solutions rather than the mere imposition of requirements on suppliers (Dzhengiz et Al, 2020).

Relational governance is the second pillar of success. It is an approach to managing alliances that is based not only on formal contracts and control mechanisms but also on mutual trust, open communication, and shared commitment. While a contract defines rights and obligations, relational governance establishes the informal norms and culture of the partnership. In an alliance portfolio, this is particularly crucial because differences among partners - by sector, size, culture, and geography - can easily lead to misunderstandings and conflicts. Effective relational governance involves establishing fluid communication channels, creating joint management committees, and organizing periodic meetings to align goals and solve problems collaboratively. This creates an environment where companies do not just exchange goods or services but co-innovate and co-create solutions for a sustainable future (Dzhengiz et Al, 2020).

The combination of proactivity and relational governance is particularly effective in promoting innovation that is not limited to internal processes but extends to the entire value chain and adjacent sectors. Companies that excel in these two areas are able to transform sustainability risks into opportunities, accelerating the transition to more resilient and lower-impact business models. This thesis and previous researches highlight how a strategically managed alliance portfolio, with particular attention to the quality of relationships, leads to superior sustainability performance, measurable in terms of both environmental impact reduction and the creation of long-term social and financial value (Dzhengiz et Al., 2020).

2.4.4 The Role of Sustainable Procurement and Value Chain Management

In a globalized economy, most of a company's environmental and social impact is not generated within its own walls but along its extensive value chain, particularly during the procurement phase. Sustainable supplier management is therefore not an option, but a strategic imperative for any company that aims for responsible and resilient operations. Sustainable procurement is not limited to selecting low-cost suppliers but includes evaluating environmental, social, and governance (ESG) factors that can influence the company's reputation, product quality, and the stability of the supply chain. This proactive approach is fundamental for mitigating risks, ensuring regulatory compliance, and creating a lasting competitive advantage (Jolink et Al, 2021; Niesten et Al, 2020).

To translate the commitment to sustainable procurement into concrete actions, companies use formal tools, and the supplier code of conduct is undoubtedly the most crucial, as it provides an additional guideline that can contribute to the unification of methods and internal coordination within alliance portfolios. This document, an integral part of supply contracts, represents a binding agreement in which the supplier commits to respecting specific standards regarding human rights, working conditions, environmental protection, and business ethics. The code of conduct is not merely a statement of intent but a genuine governance tool that imposes clear and uniform rules on all partners in the value chain (Lin et Al, 2015).

The content of an effective code of conduct is generally articulated in different sections, each of which addresses a specific aspect of sustainability. The section on labour rights establishes strict rules against forced and child labour, defines minimum requirements for health and safety at work, and guarantees the right to association and freedom of collective bargaining. The goal is to protect workers and prevent abuse and exploitation throughout the supply chain. At the same time, the section on environmental protection imposes standards on energy efficiency, waste management, responsible use of water resources, and emission reduction. In this way, the company extends its environmental goals to suppliers, incentivizing cleaner practices and reducing the overall impact. Finally, the section on ethics and compliance establishes an explicit prohibition of corruption, illegal payments, and unfair competitive practices, ensuring that commercial transactions are conducted with the utmost transparency and integrity.

The effectiveness of the code of conduct, however, lies not only in its drafting but in its implementation and monitoring. The most mature companies support the code with rigorous verification mechanisms, such as third-party audits that assess suppliers' compliance with the established standards. These audits are not just a control tool but also an opportunity for collaboration: if a non-conformity is found, the company and the supplier can collaborate to implement an improvement plan. In this sense, the code of conduct transforms from a simple contractual requirement into a lever for skills development and continuous improvement along the entire value chain (Niesten et Al., 2020; Wassmer et al., 2014).

It can therefore be concluded that sustainability is a new global need, which at the same time represents a challenge that is too complex for a single company. Consequently, the construction of an alliance portfolio becomes the most effective solution to overcome the limitations that a single company can encounter, provided that all the difficulties related to coordinating relationships with other companies or potential competitors can be managed. In support of this, numerous norms, codes, and regulations have been created that help achieve sustainability through innovation (Payán-Sánchez et al., 2022; Jiang et al., 2010; Lee et al., 2017; Wuyts et Al., 2014).

2.5 Hypothesis Development

Following the analysis of the theoretical framework underpinning the central theme of this thesis - sustainable innovation resulting from corporate alliance portfolios - the hypotheses to be addressed in the subsequent chapters, along with their construction process, are presented below.

Initially, to elaborate on the aforementioned theoretical concepts, a comprehensive literature review was conducted concerning the core topics, such as the importance of studying strategic alliances and their characteristics, analysing how they are formed, the reasons why firms join them, and the effects they produce. The review commenced with an examination of the role of strategic partnerships and their distinguishing features, investigating their formation modalities, the motivations driving firms to establish them, and the resulting outcomes. The objective of this review was not merely to map the main available contributions but also to highlight the strengths and, crucially, the gaps within the academic debate, thereby establishing the theoretical foundation for the development of the present research.

The literature search was carried out using the Scopus platform, employing a combination of keywords strictly related to the theme of alliances and sustainability, such as "alliance," "ESG," "environment," "sustainability," "SDG17," "circular economy," "green," "company location," "company age," "performance," and "strategy". The analysis reveals that, while studies on sustainability are vast and characterized by diverse perspectives, the literature significantly narrows when the focus is placed specifically on strategic partnerships. Indeed, many contributions are limited to examining single cases of collaboration between two firms, failing to offer a broader picture based on large and diversified samples.

In recent years, interest in so-called green alliances has grown, yet the topic remains underexplored. Most studies tend to concentrate on circumscribed aspects - such as firm age or geographical location - to assess their impact on social or environmental responsibility, neglecting broader and more systematic analyses. A significant space thus remains for investigations capable of comparably evaluating the effect of articulated alliance portfolios on environmental performance. It is precisely in this context that, during the literature review dedicated to the regulatory history and strategic advantages of the alliance portfolio, a particularly relevant gap emerged: the lack of empirical evidence on the relationship between alliance diversity and firms' non-financial outcomes. This deficit constitutes the starting point for the empirical analysis proposed in this research (Lozano et al., 2021; Albino et al., 2012; Lopes Cancela et al., 2023).

First, it is necessary to clarify the reference theoretical frameworks upon which the hypotheses of this thesis will be constructed: the Resource-Based View (RBV) and the Knowledge-Based View (KBV). The RBV argues that a firm's internal resources, when valuable, rare, difficult to imitate, and non-substitutable, constitute the main source of competitive advantage; when applied to alliances, this perspective suggests that environmental partnerships allow access to specific resources and competencies otherwise unattainable. The KBV, on the other hand, considers knowledge the most important resource and interprets strategic alliances as crucial tools for the acquisition, creation, and utilization of new knowledge. A diversified alliance portfolio thus expands the firm's knowledge base, stimulating organizational learning and strengthening competitive advantage. Despite the recognized importance of these dynamics, empirical research has historically focused almost exclusively on financial outcomes, neglecting the impact on non-economic dimensions (Lin, 2012b; Falcke et al., 2024; Riegler et al., 2023).

Consequently, the literature on Alliance Portfolio Diversity has neglected to explore how the heterogeneity of partnerships can translate into tangible progress on complex and systemic challenges such as decarbonization, the circular economy, and eco-innovation. The primary limitation lies not only in the quantity of available data but also in their quality, as prior studies were predominantly based on cross-sectional analyses incapable of isolating the causal effect of diversity, failing to account for the intrinsic and immutable characteristics of individual firms, such as organizational culture or underlying sustainability orientation. This gap justifies the need for research that, through a robust methodology like panel analysis with fixed effects, can finally establish a dynamic and credible link between the variety of collaborations and environmental results. It is therefore essential to verify which dimensions of diversity prove most effective in the context of sustainability (Payán-Sánchez et al., 2022; Jiang et al., 2010; Lee et al., 2017; Wuyts et Al., 2014; Collins et Al., 2013).

In this perspective, the thesis aims to enrich the existing, predominantly theoretical literature by providing new empirical findings. The study *The Role of Alliance Portfolio Diversity for Corporate Decarbonization, Circular Economy and Eco-Innovation* is taken as a reference, as it analyses the correlation between specific corporate choices and environmental outcomes. The research is founded on a large panel dataset comprising 280 global firms, involved in 1,539 environmental alliances over a 22-year period. The data were collected by integrating three main sources: Thomson SDC Platinum Database (for alliances), Refinitiv's ESG database (for environmental performance), and Bureau Van Dijk Orbis (for financial and control data). Specifically, the study concentrates on three dimensions of diversity, to determine which are strategically most effective in the field of sustainable innovation: technological heterogeneity (variety of cleantech acquired), industrial heterogeneity (variety of partner sectors), and functional heterogeneity (variety of activities covered by the alliances). The hypotheses tested are indeed the following:

- *Hypothesis 1*: A firm's corporate environmental performance is positively associated with the Environmental Technology Diversity of its alliance portfolio.
- *Hypothesis 2*: A firm's corporate environmental performance is positively associated with the Industrial Diversity of its alliance portfolio.

- *Hypothesis 3*: A firm's corporate environmental performance is positively associated with the Functional Diversity of its alliance portfolio.

The results offer clear empirical support for the positive link between Alliance Portfolio Diversity and firm-level environmental performance measured within-firm: all three dimensions of Diversity - technological, industrial, and functional - showed positive and significant coefficients, aligning with the hypotheses when considered individually. However, when the three dimensions are analysed jointly in the most restrictive model, only Industrial Diversity maintains significant explanatory power for the aggregated environmental score. The objective of this thesis is therefore twofold: to confirm the results obtained by the reference paper and to contribute to the sustainability literature by exploring new dimensions of diversity, thereby deepening the causal link between a firm's strategic choices and the characteristics of its alliance portfolio.

The first additional hypothesis concerns the geographical variety of partners within an alliance portfolio. It is expected that alliances with partners located in different countries will positively influence firms' environmental performance, as geographic diversity enables access to a wider range of resources, technologies, and managerial practices. Exposure to heterogeneous regulatory frameworks and sustainability standards can stimulate innovation and the diffusion of cleaner technologies, fostering learning and adaptation across markets. At the same time, such heterogeneity may introduce coordination and governance challenges, as cultural, ethical, and institutional differences can hinder communication and trust or increase transaction costs (Payán-Sánchez et al., 2022; Jiang et al., 2010; Lee et al., 2017; Wuyts et al., 2014). Nonetheless, the potential benefits of knowledge transfer and cross-border collaboration are expected to outweigh these limitations. Therefore, the following hypothesis is proposed:

Hypothesis 1: A firm's corporate environmental performance is positively associated with the Geographical Diversity of its alliance portfolio.

A second line of inquiry concerns the diversity of partners' operational activities within the alliance portfolio. Unlike previous studies that primarily focused on broad sectoral classifications, this analysis investigates a more granular dimension — the heterogeneity of partners' specific business operations. It is expected that a higher degree of operational activity diversity will positively influence firms' environmental performance, as it facilitates the integration of complementary competences, technologies, and production processes.

The interaction among partners with distinct operational backgrounds can generate cross-learning opportunities and foster the diffusion of sustainable practices at the process level, ultimately promoting eco-innovation and efficiency improvements. However, excessive heterogeneity in partners' operational activities may also increase coordination complexity, as differences in organizational culture, production logic, and managerial routines can hinder effective collaboration and dilute strategic focus (Jolink et al., 2021; Niesten et al., 2020; Lin & Darnall, 2015; Stadtler et al., 2017). Nonetheless, the potential for operational complementarity and learning is expected to outweigh these drawbacks. Therefore, the following hypothesis is proposed:

Hypothesis 2: A firm's corporate environmental performance is positively associated with the Business Activity Diversity of its alliance portfolio.

In conclusion, the purpose of this thesis is to provide a quantitative contribution to the literature, filling the scarcity of empirical data on the operational and geographical dimensions of diversity. The intent is thus to understand whether firms with a higher degree of these dimensions of diversity typically presents better environmental performance, analysing how scores change during time.

Below is the methodology that represented the empirical basis with which it was sought to probe some of the dimensions described above, looking for a significance of the data that could support the theory described above.

3 Methodology

This chapter delineates the methodological approach employed in this quantitative thesis, detailing the sequential phases of data collection, preparation, and analysis. The research process was systematically organized into three distinct stages:

- Data Acquisition and Literature Review: This initial phase involved a comprehensive review of academic literature and a thorough examination of a specialized database pertaining to green alliances.
- Data Manipulation and Pre-processing: This stage focused on refining the raw dataset, through the following steps:
    - creation of new classifications and structural variables, to build a robust set of information and enable coherency;
    - data cleaning and variable refinement, to ensure reliability of the dataset;
    - transformation of the database's orientation, shifting the unit of analysis from individual alliances to the participating companies;
    - creation of firm's alliance portfolio through a panel of data, to provide a temporal dimension of firms' decisions;
- Diversity Indexes calculation and Environmental Scores addition: data about the intrinsic diversity related to different alliances' choices were calculated and environmental scores were added to a subgroup of companies, maintaining the temporal dimension through the panel.

The aim was to study the trend of environmental scores over the years, understanding which choices related to partnerships of a company are correlated with their sustainable results.

3.1 Data Acquisition and Database Analysis

The research commenced with an extensive review of existing literature to establish a robust theoretical foundation and contextual understanding of Environmental, Social, and Governance (ESG) factors and Green Alliances. This involved meticulously reviewing numerous academic articles sourced from scholarly databases, Scopus and Google Scholar. This preliminary research was crucial for grasping the intricacies of the subject matter and identifying key themes and gaps in the existing knowledge base.

Following the literature review, the empirical analysis began with a comprehensive dataset, comprised 1225 strategic alliances, providing several characteristics and details of partnerships and belonging partners. A preliminary examination of the database revealed the following key variables (TABLE 1).

Table 1: Main variables of the first dataset. It contained variables referred to each alliance, providing information about the single alliance and partners.

Variable	Explanation
Deal	This served as the primary identifier for each alliance. It uniquely paired a deal name with a numerical ID. It was observed that 37 out of 1225 occurrences featured repeated deal names, often indicating highly similar alliances in terms of participants and scope. To prevent data duplication and potential skewing of statistical results, these redundant occurrences were later addressed and resolved.
Deal Name	This variable provided the descriptive name of the alliance, distinct from the numerical identifier in the *Deal* data field.
Deal Synopsis Text	This crucial variable contained detailed textual descriptions of each alliance, including its type (e.g., strategic alliance, joint venture), the stated objectives from the participating companies, and any declared innovations aimed at achieving these goals. This qualitative information was instrumental for subsequent classification efforts.
Partners Name	This variable listed the names of the companies involved in each alliance.

Participant Nation **Partners City**	These variables provided the nationality and city of the participating entities, respectively. The order of participants in these columns consistently mirrored that in *NamePartners* to maintain coherence and clarity.
Partners Business Description	This variable offered insights into the business activities of individual participants, again maintaining the same order as *Partners Name* for consistency.
Partnership Nation **Partnership Date Announced** **Completed Date** **Expected Alliance Total Length** **Expected Expiration Date** **Expired Date**	These variables provided information related to the geographical location of the alliance and various temporal attributes (announcement date, completion date, expected total length, expected expiration date, and actual expiration date). However, a significant proportion of these attributes contained missing data, rendering them unsuitable for statistical analysis. Consequently, many of these temporal data fields were excluded from the final dataset.
Alliance Activity **Major Industry Partners** **High Technology Code Partnership** **JV Total Ownership by Participant**	These variables detailed the primary activities, industries, and technological aspects involved in each alliance and to specify ownership percentages in joint ventures.
Aim	This data field, pre-existing in the original database, represented an initial, coarse attempt at classifying the alliances based on their *Deal Synopsis Text*. However, this classification proved to be highly heterogeneous, containing a wide array of

	values. These ranged from more standardized categories like "renewable energy" to direct extractions from the *Deal Synopsis Text*, leading to a rudimentary and often inconsistent classification. Many values appeared only once, while analogous concepts were inconsistently transcribed with typographical errors, non-uniform capitalization, or varying nomenclature (e.g., "cc" and "carbon capture" for the same concept). Such a fragmented and unrefined classification was deemed unsuitable as a basis for rigorous statistical analysis.

In summary, the original database was structured with each row representing a specific alliance and its associated details. While it provided foundational information, the *Aim* variable, intended for initial classification, presented significant challenges due to its broad and inconsistent categories. Given that the primary objective of this quantitative thesis was to identify trends in alliances and participating companies, there was a clear imperative to develop more precise and rigorous classifications to facilitate robust statistical analysis.

3.2 Data Manipulation and Pre-processing

This section details the procedures undertaken to refine and transform the raw dataset, preparing it for the subsequent analytical phases. These manipulations were critical for ensuring data quality, consistency, and suitability for the intended statistical analyses.

3.2.1 Creation of New Classifications and Structural Variables

To address the limitations of the original *Aim* categorization and to facilitate a more nuanced understanding of the alliances, several new classifications were systematically created. These new variables (TABLE 2) aimed to categorize the alliances from multiple perspectives, providing a more structured and analysable framework – in the column Values of the table, are presented the attributes assigned to each alliance:

Table 2: Variables added during the data manipulation to build categorizations of alliances and partners. The aim was to study trends related to alliances and partners and building variables as baseline for blau indexes calculated during next phases.

Variable	Explanation	Values
Aim Classification	This classification was meticulously developed to establish a rigorous classification of alliances, primarily derived from a detailed analysis of the *Aim* and *Deal Synopsis Text* columns.	**Renewable energy**: Encompasses naturally regenerating energy sources that are non-depletable within a short timeframe, thereby reducing environmental impact compared to fossil fuels.
		Sustainable mobility: Refers to transportation systems and technologies designed to minimize emissions, resource consumption, and overall environmental footprint.
		Energy management: Involves the systematic monitoring, control, and optimization of energy use to enhance efficiency and reduce associated costs and emissions.
		Circular economy: An economic model focused on minimizing waste and maximizing the reuse, recycling, or regeneration of resources and materials throughout the production cycle.
		Artificial ecosystem services: Pertains to the artificial recreation or enhancement of regulatory ecosystem services, such as carbon sequestration, purification, or climate regulation.
		Other cleantech: Includes clean technologies that do not directly fall into the preceding categories but contribute significantly to environmental

		sustainability, pollution reduction, or resource optimization.
EU Taxonomy	This classification was created in alignment with European Union directives, specifically the EU Taxonomy for Sustainable Activities. This classification system defines which economic activities can be considered environmentally sustainable. It is a cornerstone of the EU's sustainable finance strategy and the European Green Deal, aiming to channel capital flows towards investments that contribute to the transition to a low-carbon, more circular economy. The alliances were categorized according to the six environmental objectives of the EU Taxonomy.	**Climate change mitigation:** Activities aimed at reducing greenhouse gas emissions to combat global warming.
		Climate change adaptation: Actions taken to prepare for and strengthen resilience to the ongoing or anticipated impacts of climate change.
		Sustainable use and protection of water and marine resources: Responsible water management and the safeguarding of aquatic and marine ecosystems.
		Transition to a circular economy: Strategies to minimize waste and maximize the reuse and recycling of materials.
		Pollution prevention and control: Measures to control and reduce harmful emissions to protect the environment and human health.
		Protection and restoration of biodiversity and ecosystems: Actions dedicated to preserving biological variety and ecological balance, which are fundamental for planetary health and climate resilience.
Scope	This classification emerged from a deeper categorization of the *Aim* and *EU Taxonomy* classifications. During the	**Circular economy:** An economic model aiming to maintain the value of products, materials, and resources for as long as possible, minimizing waste through

	analytical process, it became evident that many alliances shared fundamental approaches to achieving sustainability goals, despite varying technical descriptions. These variables represent a less formal classification, designed to simplify and clarify the practical choices made by the companies. Unlike the more technical *Aim Classification* classification, *Scope* aimed for more realistic and less technical categories that offered an immediate and concrete overview of the implemented measures.	reuse, repair, recycling, and sustainable design
		Sustainable energy: Energy produced and consumed in a manner that meets current needs without compromising those of future generations, while minimizing environmental, social, and economic impacts.
		Emission Reduction: A set of strategies, technologies, and practices designed to reduce greenhouse gas emissions and atmospheric pollutants.
		Digitalization: The application of digital technologies (including software, IoT systems, artificial intelligence) to enhance efficiency, traceability, transparency, and sustainability.
		Protection of biodiversity and ecosystems: Actions aimed at safeguarding biological diversity and ecological balances, which are essential for the planet's functioning and climate resilience.
		Other: A residual category for alliances not fitting into the before mentioned scopes.
Partners Activity	This classification was derived from a detailed analysis of the *AllianceActivity* column, which initially contained a total of 56 distinct activities, often combined in various ways for	**Manufacturing and Industrial:** Includes companies involved in the physical production of goods, components, or means, encompassing assembly, maintenance, and production-related waste disposal.

	each alliance. For each alliance, all associated activity classes were examined to determine the most appropriate resulting class, often in conjunction with the insights from *Deal Synopsis Text*.	**Distribution and Supply:** Activities related to transportation, sales, logistics, licensing, and physical or commercial distribution support for goods or services.
		R&D: Focuses on innovation, product/service improvement, software development, and engineering activities
		Utilities and Energy: Companies operating in the provision of electricity, gas, water, environmental management, and waste disposal services
		General/Consumer Services: Generic, community, or non-industrial services.
		Business Services: Corporate, financial, legal, digital, and management services

Further information (TABLE 3) was extracted from the alliances and organized into additional new variables.

Table 3: Further variables built to reorganize pre-existing information.

Variable	Explanation
Resources	This column was intended to capture the type of resources, predominantly natural ones, exploited within various alliances. However, this information was not consistently reported or relevant for all alliances. Consequently, due to this high percentage of missing data, this column was ultimately excluded from subsequent analyses.

Partnership Type	This column explicitly categorizes the nature of the partnership, distinguishing between **strategic alliances** and **joint ventures.**

In preparation for the structural reorganization of the dataset, a set of auxiliary variables was introduced to support the transition from alliance-level to company-level analysis. This transformation was essential to align the data structure with the research objectives, which focused on the strategic behaviour of individual firms. In the revised format, each record corresponds to a company's involvement in a specific partnership. Companies engaged in multiple alliances appear in multiple entries, each reflecting a distinct collaboration. To enable this restructuring, compound data fields were carefully parsed and redistributed to ensure clarity and consistency.

3.2.2 Data Cleaning and Variable Refinement

To ensure the reliability and relevance of the dataset, a structured data cleaning process was implemented. This involved a critical assessment of each variable's completeness and analytical value, leading to the removal of elements that did not meet the required standards.

Temporary variables used during the classification of alliance activities were discarded once the final categorization was consolidated. These elements had fulfilled their preparatory role and were no longer necessary for the subsequent analytical stages.

Building on the initial data refinement process, particular attention was devoted to the issue of missing information. Several variables were excluded due to insufficient data coverage, which would have compromised the reliability of the statistical outputs. The following table (TABLE 4) summarizes the elements removed and the rationale behind each decision.

Table 4: Percentage of missing data of the listed variables. These calculations were made to clean data and removing missing data.

Variable	Missing Data (%)
Completed Date	31.5%
Total Expected Alliance Length	97.6%
Expected Expiration Date	98.5%
Date Expired	100%

JV Total Ownership by Participant	40.8%
Resources	46,4%

Among these, the variable intended to capture resource-related information required a more nuanced evaluation. Although initially considered relevant for understanding the environmental scope of each alliance, it presented a substantial number of missing entries -46.4% of the dataset lacked any reference to resources, likely due to the nature of the partnerships or the absence of explicit mentions in the descriptive content. A focused analysis was conducted on alliances classified under renewable energy, where resource-related details were expected to be more consistently reported. However, even within this subset, 29.1% of the entries remained incomplete. Given these limitations, and in order to safeguard the integrity of the statistical analysis, the variable was excluded from the final dataset.

Variables considered excessively granular or peripheral to the core research questions were also excluded. For example, detailed locational data such as city names were deemed less informative than broader geographic indicators already available in the dataset.

As part of the final refinement, duplicate records representing similar partnerships under different identifiers were removed. This step was essential to prevent overrepresentation and to avoid distortions in the statistical outputs. Ensuring that each alliance was uniquely represented contributed to the overall validity of the empirical findings.

3.3 Data Finalization

3.3.1 Information Transposition: from Individual Alliances to Companies

One of the key preparatory steps for the analysis involved restructuring the dataset to reflect a different analytical focus. While the initial structure was organized around alliances as the central unit, the research objectives required a shift toward the participating companies. This transformation allowed for a more granular investigation of firm-level behaviors and strategic patterns over time.

To implement this restructuring, a series of operations were carried out to isolate each company’s participation across different alliances. Information originally grouped together - such as the names and nationalities of multiple participants - was separated and reorganized so that each record corresponded to a single company within a specific alliance. This required careful alignment of attributes and verification procedures to ensure consistency and eliminate erroneous pairings. The resulting dataset was then refined to remove incomplete entries and auxiliary elements, producing a clean structure suitable for firm-level analysis.

3.3.2 Firm's Alliance Portfolio Preparation and Variable Derivation

Once the dataset had been organized as described above, the next step was to introduce a temporal dimension to the decisions made by the companies. For this purpose, the data were structured in a panel format so that, for each company, the information related to the alliances appeared in sequence from 2002 to 2023. This approach makes it possible to observe the evolution of the companies' strategic choices over time, linking the composition of their alliance portfolios with the results achieved.

A fundamental step was the calculation of the diversity indices, carried out following the methodology adopted in the paper *The Role of Alliance Portfolio Diversity for Corporate Decarbonization, Circular Economy and Eco-Innovation*. The diversity of the alliance portfolio is measured through the Blau Index, a statistical indicator that captures the degree of heterogeneity within a categorical distribution. The general formula of the Blau Index is:

$$B = 1 - \sum_{i=1}^{k} p_i^2$$

where $p_i$represents the proportion of alliances belonging to category i, and k indicates the total number of categories considered. The value of the index ranges between 0 and 1: a value equal to 0 indicates complete homogeneity (all alliances belong to the same category), while higher values reflect greater diversity.

In the case of the present work, the approach was extended to calculate two additional Blau Indices do not present in the original study, aimed at measuring the Geographical Diversity and the Operational Activity Diversity. The first was calculated considering the distribution of the countries of origin of the partners, while the second was based on the variety of the business descriptions declared by the partners themselves. Both indices were calculated in cumulative form over the years, so as to reflect the progressive evolution and diversification of each company's alliance portfolio.

Subsequently, the dataset thus constructed was integrated with the database developed as the empirical basis of the aforementioned paper. This database includes 280 international companies involved in 1,539 environmental alliances between 1993 and 2014 and combines information from three main sources: Thomson SDC Platinum Database, from which the information on alliances was taken; Refinitiv ESG Database, which provides environmental performance scores; and Bureau van Dijk Orbis, used for financial and control variables. The variables taken from this paper and later used in the tested regressions are reported below (TABLE 5).

Table 5: Main variables of the second dataset. Variables are environmental scores and diversity variables with definitions taken from the reference paper The Role of Alliance Portfolio Diversity for Corporate Decarbonization, Circular Economy and Eco-Innovation.

Variable	Definition
Environmental Score	The overall environmental performance score is assigned by Refinitiv's ESG database on the basis of public ESG scores and private analytics and ranges from 0 to 100, where the higher the value, the better the performance.
Emission reduction score	It reflects corporate's commitment and effectiveness in minimizing production and operational emissions of greenhouse gases
Resource use score	It represents efficiency and impact reduction in materials, energy, and water, and proxying the overall circularity of the company
Innovation score	It measures the development of environmentally friendly solutions. E.g. an alliance with energy firms and transportation firms.
Industry Diversity	Firm level: The various industries represented in an alliance
Functional Diversity	Alliance level: Alliance function and/or activity. E.g. a portfolio with an alliance for

	marketing purposes and one for R&D purposes
Technological Diversity	Firm and alliance level: The different technologies deployed by each firm in the alliance or developed in the whole alliance. E.g. alliances with solar and wind manufacturers.

Moreover, firm size – based on the number of employees – firm age, and the size of the alliance portfolio in each respective year were incorporated as key information in the final dataset.

The merging of the two datasets made it possible to enrich the original panel with new diversity variables and with an extension of the time span up to 2023. The final result is therefore a balanced panel dataset in which, for each company, it is possible to observe the choices undertaken in terms of partners and alliances, the growth and changes in the composition of the portfolio, and the trend of the environmental scores over time. In this way, the dynamic dimension of the relationship between alliance strategy and performance was preserved, allowing the study of how the geographical and operational diversification of the partners contributes to the evolution of the environmental results of the companies during the period 2002–2023.

3.3.3 Empirical Model

Once the panel database was built and the diversity indices were defined, the empirical analysis was conducted with the aim of evaluating the extent to which the composition of the alliance portfolio influences the environmental performance of the companies over time. The OLS model used is the following:

$$y_{it} = \alpha + \beta_1 B_{it} + \gamma X_{it} + \varepsilon_{it}$$

The dependent variable y used represents the environmental scores of company i in period t, namely the Environmental Score, Emission Reduction Score, Resource Use Score, and Innovation Score, which provide a comprehensive and consolidated measure of corporate environmental performance, capable of capturing the progress achieved in terms of energy efficiency, emission reduction, and sustainable resource management.

The main independent variables of company i in period t, represented by B, consist of the diversity indices of the alliance portfolio, calculated annually for each company and in cumulative form over time in order to capture their evolutionary nature. In particular, five distinct indices were included: technological diversity, industrial diversity, functional diversity, geographical diversity, and operational activity diversity. The last two represent an extension of the analysis, aimed at evaluating respectively the heterogeneity of the countries of origin of the partners and the variety of their business activities.

To ensure the robustness of the results, the model also incorporates a set of control variables X of company i in period t, aimed at taking into account the structural characteristics of the firms. In particular, firm age measures the age of the company, indicative of the experience accumulated and the capacity to manage partnerships; number of employees is used as a proxy for organizational size; and portfolio size represents the overall dimensions of the portfolio held by the company in each year.

Finally, ε_{it} represents the idiosyncratic error term.

4 Results

After completing the data preparation, the next step consisted in conducting the empirical analysis. As an initial stage, several summary statistics were computed in order to gain a clearer understanding of the dataset and the main variables involved. Subsequently, the analysis proceeded with the examination of variable correlations and the estimation of linear regressions.

The purpose of this thesis is to investigate whether and to what extent the diversity of alliance portfolios influences firms' environmental performance. In particular, the analysis aims to test two additional hypotheses concerning the potential impact of geographical diversity among partners and operational activity diversity within the alliance portfolio on corporate environmental scores.

These relationships are explored to understand if a higher degree of diversity, whether geographical or operational, could facilitate access to a broader pool of resources, technologies, and competences, enhancing firms' capacity to innovate sustainably. At the same time, excessive heterogeneity may introduce coordination challenges, cultural barriers, or strategic misalignments that could offset potential benefits. The empirical analysis therefore seeks to determine the actual nature and significance of these effects.

4.1 Summary Statistics

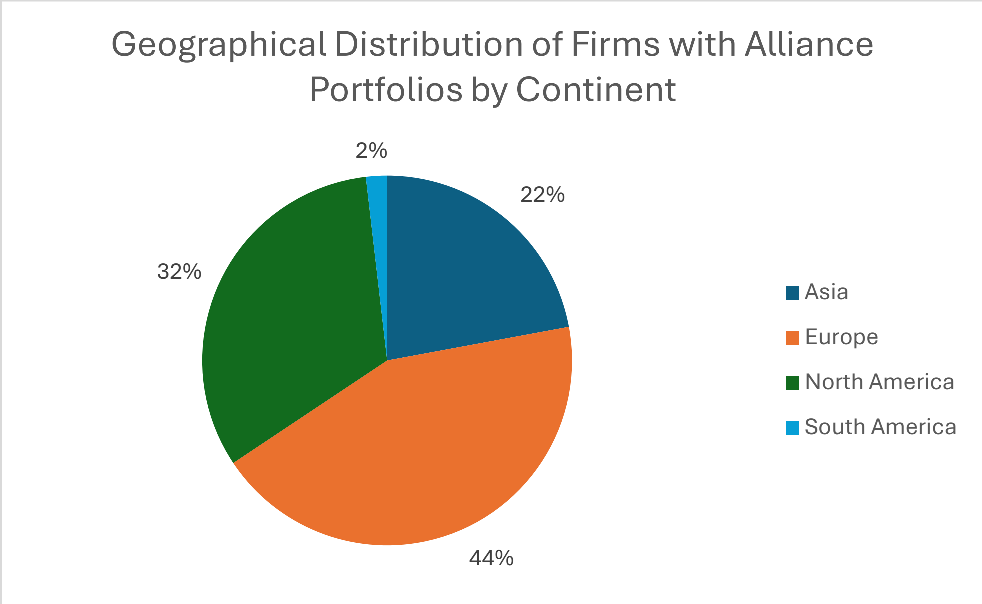
As a preliminary step, the characteristics of the final dataset were analysed in order to provide an overview of the firms and alliance portfolios under examination. The final database, obtained from the merge of the two previously described sources, comprises 164 firms involved in 618 sustainable alliances.

As already mentioned, the sample focuses specifically on alliances in which at least one participating firm operates in the Electrical and Electronic Equipment (EEE) sector. This choice is motivated by three main considerations.
First, EEE companies act as enablers of sustainability, as they play a central role in electrification and digitalization — two processes that are fundamental to the green transition. Second, this sector has a significant environmental impact, being characterized by high resource intensity and large amounts of electronic waste (e-waste), which makes it subject to increasing regulatory pressure to integrate sustainability into its business models. Finally, EEE firms occupy a strategic position in alliance networks, often acting as

connectors among different high-tech sectors and providing essential technologies for decarbonization and circular economy initiatives.

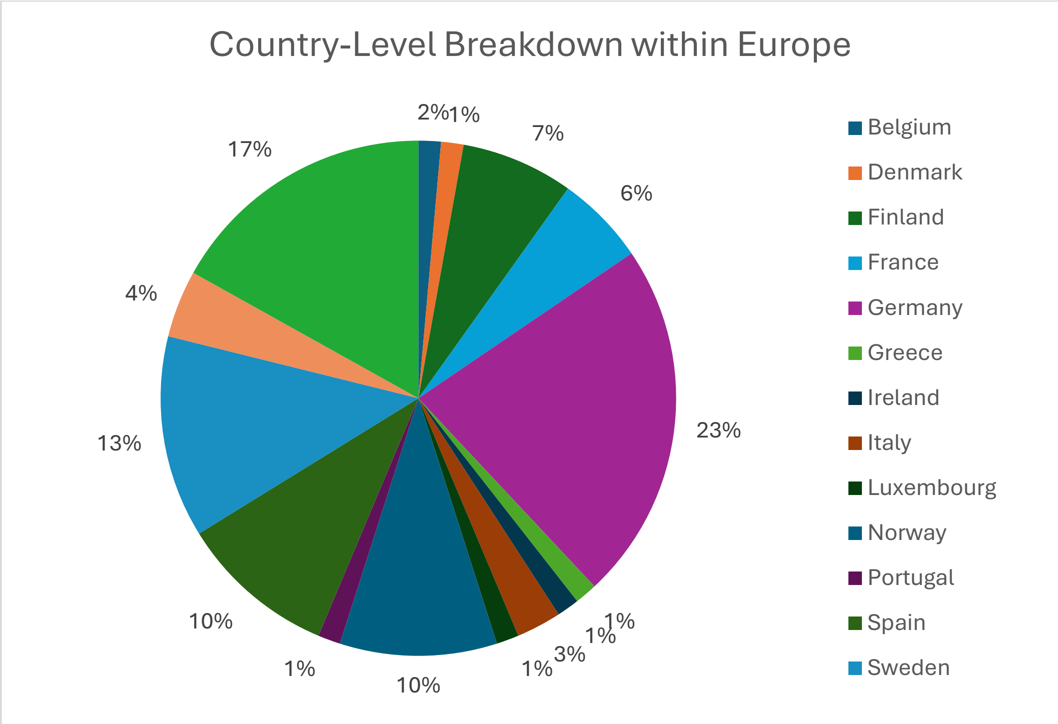
From a geographical perspective (FIGURE 1), the majority of firms in the sample are located in Europe, followed by North America and Asia, with a minor presence in South America. This overall distribution reflects the global concentration of industrialized economies with strong innovation ecosystems, regulatory frameworks supporting sustainability, and active participation in international environmental agreements. Europe’s leading role can be associated with its coordinated policies on climate change, renewable energy adoption, and corporate responsibility, which create favourable conditions for firms to engage in structured collaborations focused on sustainability. North America’s significant representation, especially the United States, reflects both its large market size and its technological capacity to develop and implement clean technologies. The Asian region, particularly countries such as Japan and China, combines advanced technological infrastructure with strong state-led initiatives to promote environmental innovation and sustainable industrial practices, contributing to a dynamic environment for inter-firm collaborations. The relatively smaller presence of firms in South America may indicate that emerging markets in this region still face structural and regulatory barriers that limit the proliferation of alliances centred on sustainability objectives (OECD, 2022).

Figure 1: Graph illustrating the share of firms by continent that developed an alliance portfolio.



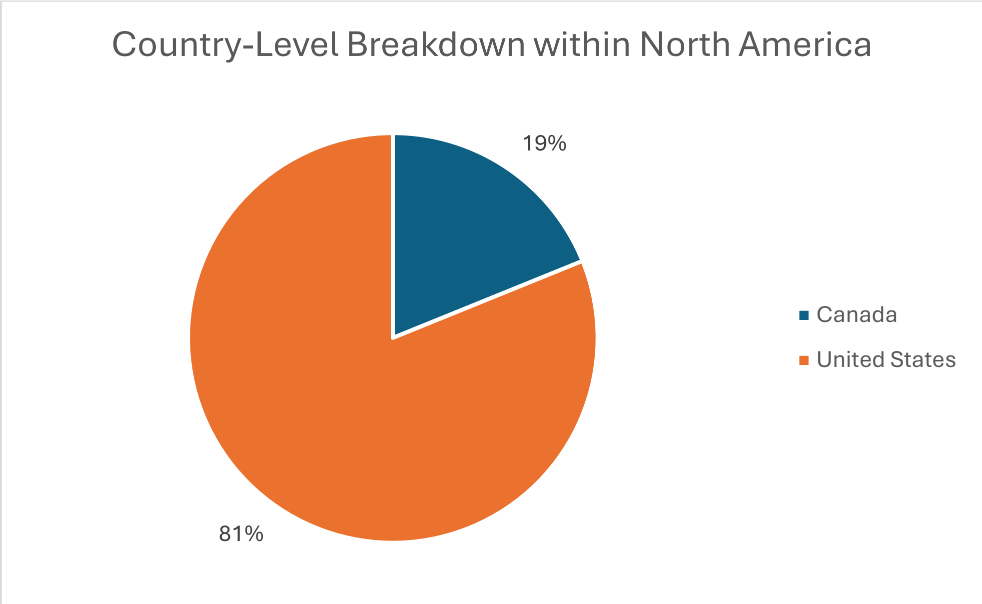
Within Europe (FIGURE 2), firms are spread across several countries, with a clear concentration in Germany, the United Kingdom, and Sweden. Germany stands out due to its industrial base, high R&D investment, and pioneering policies in energy transition, which make it a hub for clean technology collaborations. The United Kingdom combines strong financial markets with active government incentives for sustainability-oriented initiatives, supporting corporate engagement in transnational alliances. Sweden's prominence reflects its long-standing focus on environmental performance, innovation in green technologies, and corporate culture oriented toward social responsibility. Together, these clusters suggest that European firms benefit from both national policy frameworks and regional networks that facilitate knowledge exchange and strategic partnerships, which are key for developing structured alliance portfolios (OECD, 2022).

Figure 2: Graph illustrating the share of firms by European country that developed an alliance portfolio.



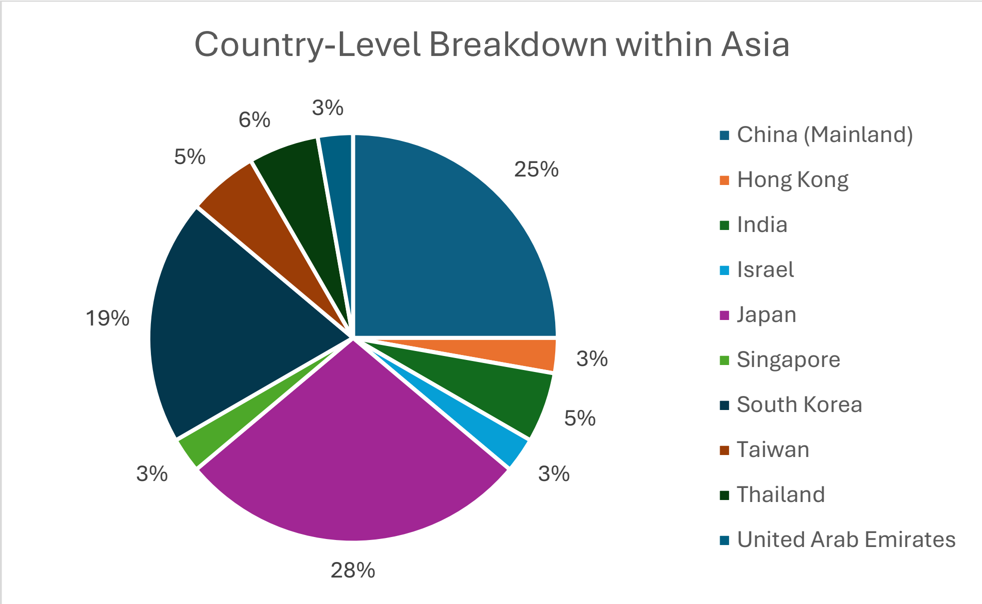
In North America (FIGURE 3), nearly all firms belong to the United States, with a smaller subset in Canada. The U.S. has historically led in clean tech innovation, supported by a combination of private sector investment, venture capital funding, and state-level environmental regulations. Canada, while smaller in absolute numbers, shows a strong commitment to green innovation through federal programs and public-private alliances, contributing to the formation of alliances in specific sectors such as renewable energy, clean manufacturing, and sustainable infrastructure. This distribution highlights the role of mature innovation ecosystems (Gallagher & Zhang, 2019).

Figure 3: Graph illustrating the share of firms by North American country that developed an alliance portfolio.



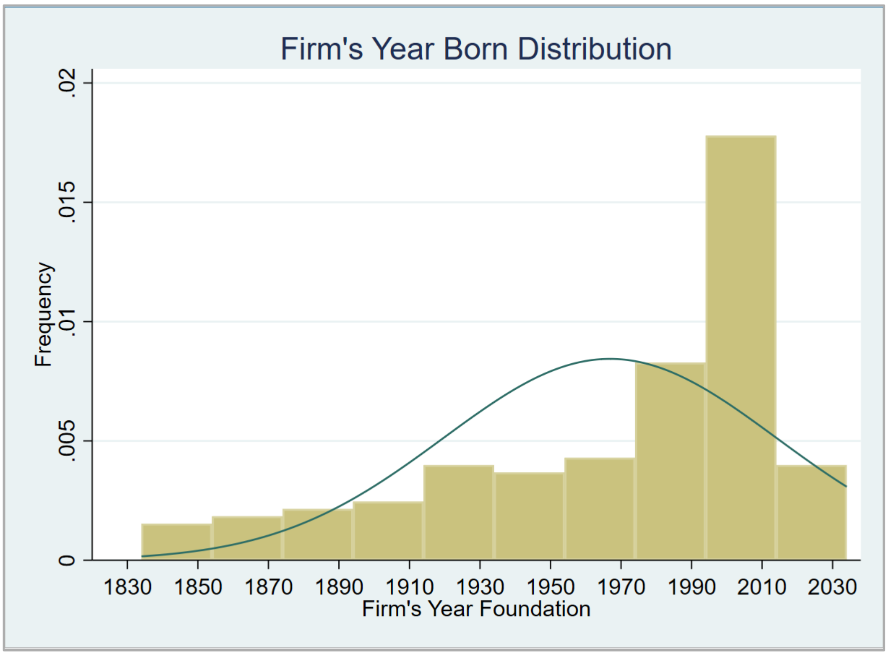
The Asian region (FIGURE 4) presents a more diversified distribution, with a prevalence of firms from Japan and China, followed by smaller representations from countries such as South Korea, India, and Singapore. Japan's prominence is linked to its advanced technological infrastructure, government-led incentives for environmental innovation, and corporate culture emphasizing incremental and collaborative R&D. China's representation reflects its rapid industrial growth combined with state-driven policies targeting clean energy and sustainable industrial practices. South Korea, India, and Singapore, while smaller contributors, illustrate emerging engagement in global sustainability networks, often driven by targeted government programs and multinational partnerships. The overall Asian distribution indicates that firms are concentrated in countries with strong policy support, technological capabilities, and access to international knowledge networks, which are critical for developing structured alliances focused on sustainability (Zhang & Li, 2021).

Figure 4: Graph illustrating the share of firms by Asian country that developed an alliance portfolio.



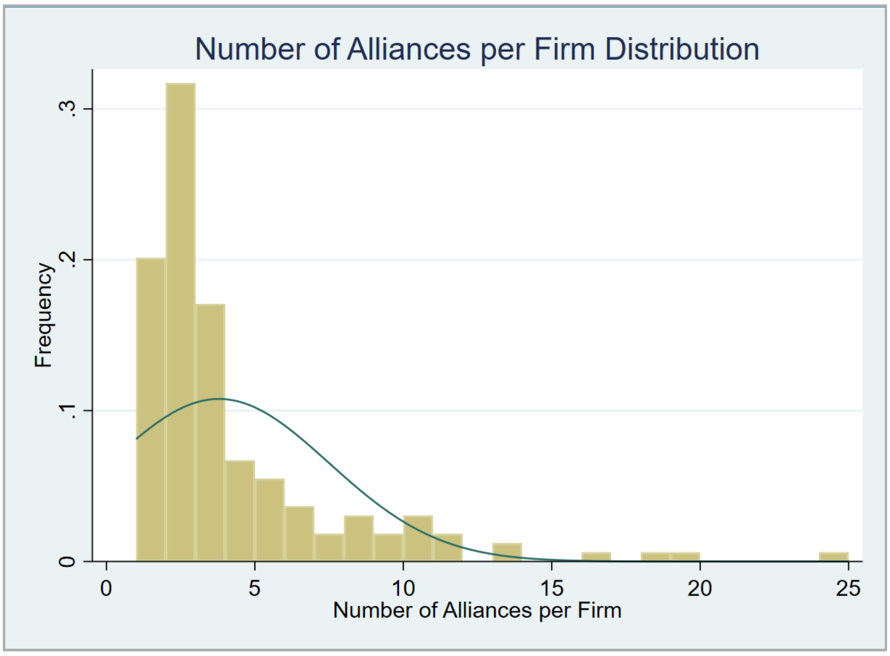
In terms of firm year born (FIGURE 5), the distribution is left-skewed, with a higher frequency of companies founded between 1990 and 2010. This indicates that the sample is composed predominantly of relatively young but already established firms. These companies are not start-ups, but rather medium-to-large organizations that have reached a sufficient degree of maturity to engage in strategic alliances while still maintaining a strong innovative orientation. This balance allows them to combine the agility and openness typical of younger firms with the financial resources and organizational capabilities required to participate effectively in collaborative sustainability initiatives. The time window also reflects the decades in which environmental responsibility and innovation gained prominence globally: many of these firms emerged or underwent restructuring during the expansion of ESG frameworks, the rise of renewable energy markets, and the diffusion of environmental certifications - all factors that have encouraged firms to integrate sustainability partnerships into their core strategies (Calvino et Al., 2022).

Figure 5: Graph showing the distribution of the founding year of firms with an alliance portfolio.



The analysis of alliance structures provides additional insights into the firms' strategic behaviour. The number of partnerships per firm (FIGURE 6) follows a right-skewed distribution: most companies hold between one and three alliances, with a mode around two partnerships. This implies that while the majority of firms maintain a small number of collaborations - possibly to ensure focus and manageability - a few firms act as central hubs with numerous partnerships. Such a pattern is typical of strategic alliance networks, where a limited number of firms assume a key brokerage role in knowledge and technology exchange.

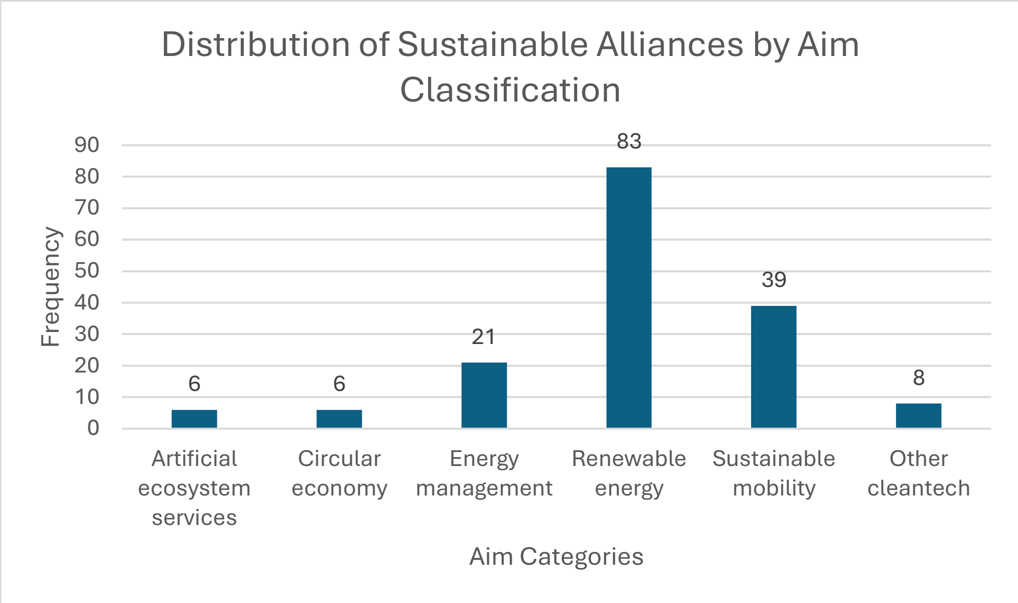
Figure 6: Graph showing the distribution of the number of alliances per firm with an alliance portfolio.



Regarding the composition of alliances, the average number of participants per alliance is close to two, suggesting that most collaborations are bilateral. This is a logical outcome, as bilateral alliances tend to be easier to coordinate and allow for more direct knowledge transfer and clearer governance structures than larger consortiums. This is also confirmed by the fact that e data show that strategic alliances prevail over joint ventures (see APPENDIX, FIGURE 7). This may be attributed to the higher flexibility and lower capital commitment associated with strategic alliances, which make them particularly suitable for sustainability-oriented collaborations, where firms often aim to share technologies or develop eco-innovations without formal ownership integration.

On the qualitative side, examining the technological and thematic focus of the alliances, as classified under Aim Classification (FIGURE 8), the majority of alliances concentrate on renewable energy projects, followed by sustainable mobility and energy management. Together, these areas account for more than 80% of the total sample. Other categories - such as circular economy, artificial ecosystem services, and other cleantech initiatives - represent smaller portions. This distribution is consistent with global investment trends in sustainable technologies, where renewable energy and low-carbon mobility receive the largest financial and regulatory support due to their central role in decarbonization. Consistently, when looking at the Scope classification (see APPENDIX, FIGURE 9), the two dominant categories are sustainable energy development and emission reduction, reflecting a strategic alignment between firms' partnership activities and the broader climate goals defined by international frameworks such as the Paris Agreement.

Figure 8: Graph illustrating the frequency of the resulting classification of the aim of each portfolio of alliances – it was built by analysing each alliance within a portfolio, understanding the resulting aim of the entire portfolio.



Finally, according to the EU Taxonomy classification (see APPENDIX, FIGURE 10), the majority of alliances fall within the category of climate change mitigation, which appears intentionally broad and inclusive. This is not unexpected, as the taxonomy framework tends to group most low-carbon and energy-related initiatives under this label. While this limits the granularity of the analysis, it confirms that the alliance portfolios in this study primarily target projects consistent with mitigation objectives and the transition toward a low-carbon economy.

4.2 Correlation between variables analysis

As previously mentioned, the analysis was conducted using Stata. The dependent variables of interest are the four environmental scores: Environmental Score, Emission Reduction Score, Resource Use Score, and Innovation Score, which provide a comprehensive measure of firms' environmental performance. The main regressors include the five diversity indices of the alliance portfolio: Technological Diversity, Industrial Diversity, Functional Diversity, Geographical Diversity and Operational Activity Diversity. The control variables incorporated in the model are firm age, number of employees, and portfolio size.

As a preliminary step, the correlations among the variables were studies through Stata. The results (TABLE 6) show that both the regressors and the control variables are significantly correlated with all four environmental performance measures. The only exception is the geographical diversity, which does not display a statistically significant correlation with the Environmental Innovation Score. This indicates that the geographical diversity of partners with which a company forms alliances does not vary consistently with changes in innovation-related environmental performance.

Table 6: EnvPerformance (1); EmissionsScore (2); ResourceUseScore (3); EnvInnovScore (4); FunctionalDiv (5); IndustryDiv (6); EnvTechDiv (7); GeoDiv (8); OpActivityDiv (9). Table with correlation coefficients between variables. The important relationship under analysis is the one between dipendent variables - scores -and indipendent variables - regressors.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
(1)	1.000								
(2)	0.8456*	1.000							
(3)	0.8661*	0.7859*	1.000						
(4)	0.6602*	0.3299*	0.3887*	1.000					
(5)	0.2561*	0.2502*	0.2251*	0.1769*	1.000				
(6)	0.2593*	0.2248*	0.1490*	0.2835*	0.5349*	1.000			
(7)	0.1910*	0.1484*	0.0908*	0.2458*	0.2754*	0.5552*	1.000		
(8)	0.2082*	0.2730*	0.2539*	0.0822	0.2431*	0.2599*	0.1925*	1.000	
(9)	0.1252*	0.1517*	0.1377*	0.1013*	0.4271*	0.3915*	0.2556*	0.6675*	1.000

** An asterisk indicates statistical significance p<0.05.*

From this preliminary analysis, it can be concluded that there is a consistent positive correlation between the diversity indices and the environmental scores, suggesting that proceeding with further linear regressions is meaningful. The next step therefore focuses on determining whether these correlations reflect causal relationships, testing whether the regressors and control variables effectively influence the variation in firms' environmental performance over time.

4.3 Results Analysis

After the correlation analysis, the next step was to proceed with the regression analysis. The objective of this stage was to verify whether the selected regressors effectively influence the trends of the environmental scores, first without and subsequently with the inclusion of the control variables. This stepwise approach allows for a more accurate attribution of causality, assessing whether the regressors of interest consistently contribute to explaining variations in the environmental outcomes.

The analysis begins with the estimation of the overall environmental performance models (TABLE 7), presented in Columns 1–12. Columns 1, 3, 5, 7, 9, and 11 report baseline regressions including only the diversity indices, while Columns 2, 4, 6, 8, 10, and 12 include control variables (firm age, number of employees, and portfolio size) to capture firm-specific structural heterogeneity.

Table 7: Table reporting results from the regression of Env Performance. In columns 1,3,5,7,9 regressions were made by just analysing the relationship between Env Performance and the single regressor; in columns 2,4,6,8,10 control variables are included; in columns 11,12 the regression was made by using together all regressors without (11) and with (12) control variables.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
FunctionalDiv	24.38***	16.06***									12.97**	14.79***
IndustryDiv			20.55***	14.73***							7.78*	0.51
EnvTechDiv					16.35***	10.49***					3.86	5.90
GeoDiv							42.69***	29.03***			53.64***	47.21***
OpActivityDiv									28.79***	-1.64	-29.69*	-45.87***
Observations	615	568	596	549	617	570	532	474	532	474	492	453
Controls	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

**p<0.10, **p<0.05, ***p<0.01.*

The results for the first three dimensions of alliance portfolio diversity - Functional, Industrial, and Technological Diversity - broadly confirm the findings of *The Role of Alliance Portfolio Diversity for Corporate Decarbonization, Circular Economy and Eco-Innovation*. All three dimensions show a positive and statistically significant relationship with environmental performance, indicating that a diversified alliance portfolio enhances a firm's overall sustainability outcomes.

From a theoretical standpoint, these results can be interpreted through the lenses of the Resource-Based View (RBV) and the Knowledge-Based View (KBV). Functional and industrial diversity expand the firm's access to heterogeneous resources and capabilities, facilitating cross-industry learning and the recombination of complementary assets.

Technological diversity, in turn, stimulates innovation through the exchange of clean technologies and environmental know-how, enabling firms to accelerate the adoption of eco-efficient processes. Together, these effects generate cumulative learning and spillovers that strengthen firms’ adaptive capacity and environmental performance over time.

Turning to the newly introduced dimensions, Geographical Diversity (GeoDiv) maintains a positive and significant effect across both specifications supporting the idea that collaborations with international partners expose firms to diverse institutional, cultural, and regulatory environments. This cross-border heterogeneity can promote the diffusion of sustainable practices, broaden the pool of environmental technologies, and foster greater adaptability in global sustainability challenges.

By contrast, Operational Activity Diversity (OpActivityDiv) displays a negative and statistically significant coefficient, especially when all regressors are used at the same time. This suggests that excessive heterogeneity in partners’ operational focus may introduce coordination inefficiencies, communication barriers, and goal misalignment, ultimately reducing the effectiveness of alliance-driven environmental strategies. While variety can promote learning, too much dispersion in operational activities may create managerial complexity that limits firms’ ability to capture synergies.

When considering all five diversity dimensions simultaneously (Columns 11 and 12), the individual coefficients tend to lose part of their statistical significance, although the joint explanatory power of the model remains robust. This outcome is consistent with expectations, as the different dimensions of diversity are often interrelated and may capture overlapping aspects of portfolio heterogeneity. In such cases, part of the variance explained by one variable is absorbed by others, leading to a reduction in the magnitude and significance of individual effects. Nevertheless, the combined model confirms the overall relevance of alliance portfolio diversity as a key driver of corporate environmental performance, underscoring that these forms of diversity operate jointly rather than independently in shaping firms’ sustainability outcomes.

In summary, the empirical results indicate that functional, industrial, and technological diversity positively influence environmental performance, aligning with previous research and confirming the strategic value of heterogeneous partnerships. Geographical diversity also enhances sustainability outcomes, while excessive operational heterogeneity may hinder them. The attenuation of coefficients in the full model further reinforces the idea that these dimensions of diversity are interrelated, jointly shaping the effectiveness of corporate sustainability strategies. Firms, therefore, should aim to strike a strategic balance between diversification and coherence when designing their alliance portfolios to maximize environmental benefits without incurring coordination costs.

We can then further break down the results for specific environmental performance indicators, namely the scores for carbon emissions, resource use, and green innovation. Tables below illustrate the different effects – for brevity, only the results including control variables are reported, corresponding to the more conservative specification. Overall, the results confirm that the different types of alliance portfolio diversity are relevant also for these specific environmental dimensions, though with varying levels of strength and significance.

For the Emission Reduction Score (TABLE 8), the patterns of association largely mirror those observed for the overall Environmental Performance Score. Functional diversity retains a positive and significant relationship, indicating that collaborations across different organizational functions are consistently associated with lower carbon emissions. Industry diversity and technological diversity show weaker or non-significant coefficients in some specifications, suggesting that their contribution to emissions-related outcomes may be more context-dependent. Geographical diversity continues to exhibit strong positive associations, reinforcing the relevance of cross-border heterogeneity for environmental management. Operational activity diversity shows mixed results, with negative coefficients emerging in specifications that include all diversity dimensions, consistent with the idea that excessive operational heterogeneity can hinder coordinated emissions reduction efforts.

Table 8: Table reporting results from the regression of Emission Reduction Score. In columns 1,2,3,4,5 regressions were made by analysing the relationship between Emission Reduction Score and the single regressor with control variables; in the column 6 the regression was made by using together all regressors with control variables.

	(1)	(2)	(3)	(4)	(5)	(6)
FunctionalDiv	19.08***					17.33***
IndustryDiv		13.32***				-4.14
EnvTechDiv			7.24**			1.35
GeoDiv				46.46***		67.95***
OpActivityDiv					7.65	-49.09***
Observations	568	549	570	474	474	453

Controls	YES	YES	YES	YES	YES	YES

**p<0.10, **p<0.05, ***p<0.01*

Regarding Resource Use Score (TABLE 9), functional diversity again demonstrates a positive and significant association, highlighting the role of cross-functional collaborations in promoting more efficient use of materials and energy. Industry and technological diversity appear less consistently related to resource use, with significance often lost when controls are introduced. Geographical diversity maintains positive associations, though effect sizes are smaller than in the Environmental Performance and Emissions Scores, indicating that exposure to international practices may contribute to efficiency improvements, albeit to a lesser extent. Operational activity diversity shows some negative associations in the full models, further supporting the view that overly heterogeneous operational portfolios may complicate the implementation of resource optimization initiatives.

Table 9: Table reporting results from the regression of Resource Use Score. In columns 1,2,3,4,5 regressions were made by analysing the relationship between Resource Use Score and the single regressor with control variables; in the column 6 the regression was made by using together all regressors with control variables.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
FunctionalDiv	16.75***					16.23***
IndustryDiv		3.86				-9.81
EnvTechDiv			1.70			-0.52
GeoDiv				0.3**		56.12***
OpActivityDiv					6.31	-38.85**
Observations	568	549	570	543	474	453
Controls	YES	YES	YES	YES	YES	YES

**p<0.10, **p<0.05, ***p<0.01*

Finally, for the Environmental Innovation Score (TABLE 10) technological diversity emerges as the most consistently significant dimension, reflecting its central role in driving eco-innovation. Industry diversity also retains positive associations in several specifications, particularly when controls are included, suggesting that cross-sector collaborations can foster the development of new environmental solutions. Functional and geographical diversity exhibit weaker or non-significant effects, implying that their impact on innovation outcomes may be less direct or diffuse across contexts. Operational activity diversity does not show robust associations with innovation, highlighting that variation in operational focus alone may not suffice to stimulate new environmental technologies or practices.

Table 10: Table reporting results from the regression of Environmental Innovation Score. In columns 1,2,3,4,5 regressions were made by analysing the relationship between Environmental Innovation Score and the single regressor with control variables; in the column 6 the regression was made by using together all regressors with control variables.

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
FunctionalDiv	10.70*					2.71
IndustryDiv		25.98***				13.06*
EnvTechDiv			22.77***			16.03***
GeoDiv				7.75		6.47
OpActivityDiv					0.65	-13.62
Observations	569	550	571	475	475	454
Controls	YES	YES	YES	YES	YES	YES

**p<0.10, **p<0.05, ***p<0.01*

In summary, the analyses of the three derived environmental scores generally confirm the trends observed for the overall Environmental Performance Score, though the strength and significance of individual diversity dimensions vary across specific environmental outcomes. The positive associations of Functional, Industrial, and Technological Diversity with environmental performance are consistent with *The Role of Alliance Portfolio Diversity for Corporate Decarbonization, Circular Economy and Eco-Innovation*, confirming the strategic relevance of these dimensions for corporate sustainability. Functional diversity consistently supports improved performance, technological and industry diversity are particularly relevant for innovation and sector-specific outcomes, and geographical diversity maintains positive but sometimes attenuated associations. Operational activity diversity tends to exert negative effects when combined with other forms of diversity, suggesting that careful portfolio management is required to balance heterogeneity and coordination across all dimensions. These results reinforce the notion that the effectiveness of alliance portfolio diversity depends on both the type of environmental outcome considered and the interplay between the various forms of diversity.

4.4 Geographical Diversity Results Discussion

The positive and generally significant coefficients observed for Geographical Diversity in relation to the Environmental Performance Score can be interpreted as reflecting several practical mechanisms inherent to internationally dispersed alliances, confirming the first hypothesis of the thesis. Firms that maintain partnerships across multiple countries are exposed to heterogeneous regulatory, institutional, and cultural environments, which often translates into access to a wider array of environmental technologies, practices, and approaches. For instance, collaborations with partners in countries with stringent environmental regulations or advanced research and development capabilities, such as Northern Europe, the United States, or Japan, may increase a firm’s exposure to innovative eco-efficient processes and best practices that are later adopted or adapted across the global value chain.

Similarly, alliances in emerging markets or developing countries may allow firms to transfer knowledge and management practices, contributing to improved sustainability outcomes not only within the partner firms but also along extended supply chains. Such engagements can support better resource use, emission management, and the adoption of circular economy practices, which are directly captured by the Environmental Performance Score.

The fact that the coefficient is only tending toward significance in some specifications can be attributed to the inherent complexity of managing geographically diverse portfolios. Cross-border partnerships often involve coordination and governance challenges, such as differences in regulatory frameworks, business practices, and cultural norms. These challenges may reduce the ability of firms to fully leverage the potential benefits of geographic diversity, diluting the strength of the observed association in certain model specifications.

Overall, the positive association observed in the results reflects that firms with more internationally distributed alliances tend to have broader exposure to sustainable practices and technologies, which can contribute to higher Environmental Performance Scores. While the relationship should be interpreted as an association rather than a direct causal effect, it highlights the practical relevance of geographic heterogeneity in shaping environmental outcomes in corporate alliance portfolios.

4.5 Operational Diversity Results Discussion

Contrary to the second hypothesis of this thesis, which predicted a positive association between Operational Activity Diversity and Environmental Performance, the results indicate that this dimension tends to show negative or non-significant associations, particularly when included alongside the other diversity dimensions. This outcome suggests that, in practice, the risks and coordination challenges associated with high operational heterogeneity tend to outweigh the potential benefits in terms of sustainability performance.

Firms collaborating with partners that operate under very different routines, production cycles, or organizational logics may face difficulties in synchronizing environmental practices across the portfolio. For example, integrating the operations of a fast-paced technology firm with those of a capital-intensive industrial partner could slow decision-making and reduce the efficiency of shared sustainability projects. Similarly, defining common sustainability metrics or coordinating environmental reporting becomes more challenging in highly operationally diverse portfolios, potentially fragmenting efforts and limiting improvements in the Environmental Performance Score.

At the same time, these findings do not imply that operational diversity is inherently detrimental. Rather, they reflect the trade-off between potential learning and innovation opportunities and the practical challenges of managing heterogeneous operations. While collaboration across distinct operational domains could theoretically enhance process efficiencies, waste reduction practices, or circular economy solutions, the empirical evidence suggests that the managerial burden and coordination costs may dominate when operational diversity is too high.

Overall, the results highlight that operational diversity requires careful management and governance. Firms with more varied operational partners may need structured coordination processes, clear role definitions, and alignment of sustainability objectives to capture potential benefits. The observed negative associations underscore that, without such mechanisms, operational variety can constrain the effectiveness of alliance-driven environmental strategies, contrasting with the generally positive associations observed for functional, industrial, technological, and geographical diversity.

5 Conclusions

Over the past decades, sustainability has progressively evolved from a peripheral concern to a core performance metric alongside profitability and growth. Firms are now increasingly evaluated not only by their financial outcomes but also by their capacity to reduce environmental impact, contribute to decarbonization, and promote circular economy principles. This shift reflects a broader transformation in both market expectations and regulatory frameworks: governments, supranational institutions, and investors have introduced new standards and reporting requirements that incentivize - and, in many cases, mandate - transparent environmental accountability. As a result, sustainability has become a strategic imperative that firms must integrate into their long-term competitive logic.

However, addressing complex environmental challenges such as climate change, pollution reduction, and resource efficiency often exceeds the capabilities of a single organization. Achieving meaningful progress requires the pooling of complementary resources, technologies, and expertise, which has led to a growing emphasis on strategic alliances as vehicles for innovation and sustainable transformation. Through inter-firm collaborations, companies can access specialized knowledge, share risks, and accelerate the diffusion of green technologies that would otherwise be difficult or costly to develop independently.

Yet, the effectiveness of a single alliance can be limited, as firms increasingly operate within broader networks of interdependent relationships. Consequently, attention has shifted from individual partnerships to the concept of alliance portfolios, which capture the diversity and configuration of a firm's entire collaboration landscape. The structure of these portfolios shapes the firm's ability to integrate knowledge across boundaries and to translate it into measurable environmental performance gains.

While the strategic importance of alliance diversity has been widely acknowledged in the theoretical literature, empirical evidence remains scarce. Most prior studies have focused on financial or innovation-related outcomes, leaving the link between alliance portfolio diversity and environmental performance underexplored. This research contributes to filling that gap by providing quantitative evidence on how different forms of alliance heterogeneity influence firms' environmental achievements, thus bridging the divide between theory and empirical validation in the sustainability–strategy nexus.

Three dimensions of alliance diversity discussed in the literature - technological, industrial, and functional - were first examined to assess their influence on firms' environmental results.

In addition, two new dimensions were introduced to extend the existing framework: Geographical Diversity, which captures the variety of partner locations, and Operational Activity Diversity, which measures the heterogeneity of partners' business activities.

Specifically, two additional hypotheses were formulated to extend the existing framework of alliance portfolio diversity. The first examines the Geographical Diversity, proposing that collaborations with partners located in different countries are positively associated with improved environmental performance, as firms operating in more internationally diversified networks can access a wider range of regulatory contexts, technological capabilities, and sustainability practices, which may facilitate the diffusion of greener standards and innovations. The second concerns Operational Activity Diversity, suggesting that a greater variety in partners' core business activities is positively associated with enhanced environmental outcomes, since the combination of distinct but complementary operational competencies may foster process innovation and efficiency. However, both hypotheses also consider that excessive heterogeneity could generate managerial complexity and coordination challenges, potentially offsetting the expected benefits.

The empirical analysis was conducted on a final sample of 164 firms engaged in 618 sustainability-oriented alliances, primarily operating within the Electrical and Electronic Equipment (EEE) sector. Most companies in the sample are based in Europe, followed by North America and Asia, reflecting the global distribution of innovation and sustainability leadership. The firms are generally young but established - mostly founded between 1990 and 2010 - a profile that combines sufficient organizational maturity to manage complex partnerships with the flexibility and innovative mindset typical of more recent enterprises.

Overall, the descriptive evidence shows that the majority of firms maintain relatively small and focused alliance portfolios, typically composed of one to three partners, with bilateral collaborations being the most common form. Thematic classifications highlight a predominance of projects related to renewable energy, sustainable mobility, and energy management, confirming the central role of these areas in the ongoing green transition. Taken together, these features depict a sample of companies strategically engaged in environmental innovation, using alliances as a key mechanism to pursue their sustainability goals.

The regression results show that Functional, Industrial, and Technological Diversity have a positive and statistically significant association with firms' overall environmental performance. These findings confirm the results of previous studies and align with both the Resource-Based and Knowledge-Based Views. Functional heterogeneity enhances complementarities across organizational roles, facilitating coordination and the sharing of managerial capabilities. Industrial diversity expands the range of cross-sectoral knowledge available within alliances, fostering adaptive learning and innovation. Technological diversity promotes the diffusion and recombination of clean technologies, accelerating eco-innovation and efficiency improvements. Together, these observations suggest that better environmental outcomes are associated with more heterogeneous alliance portfolios, as they can draw on a richer combination of resources, expertise, and technological inputs.

Turning to the newly introduced dimensions, Geographical Diversity shows a positive and significant association with environmental performance, confirming the first hypothesis of this thesis. This result suggests that firms collaborating with international partners are exposed to a broader set of regulatory, cultural, and technological contexts, which can enrich their environmental practices. Alliances with firms in regions characterized by advanced sustainability standards may facilitate the adoption of cleaner technologies and stricter environmental procedures. Collaborations with partners in emerging markets, on the other hand, may encourage the diffusion of sustainability practices along global supply chains and generate social and environmental improvements through knowledge transfer.

However, this relationship remains associative rather than causal: while firms with more geographically diverse alliances tend to exhibit higher environmental performance, the direction of influence may be bidirectional. Nonetheless, the evidence supports the view that international exposure broadens firms’ sustainability capabilities, making them more adaptable to global environmental challenges.

By contrast, Operational Activity Diversity does not confirm the expected hypothesis, instead showing a negative and statistically significant association with environmental performance. This result suggests that, among the firms analysed, excessive heterogeneity in partners’ core activities tends to be correlated with higher coordination costs, communication barriers, and goal misalignment, which may offset the potential benefits of diversity. In sustainability-oriented alliances - where strategic alignment and trust are critical - complexity arising from partners operating in distinct segments of the value chain or following divergent operational logics can dilute strategic focus and hinder the achievement of environmental objectives.

However, these results do not imply that operational diversity is inherently detrimental. Collaborations across distinct operational domains can, in principle, enable firms to improve process efficiency, reduce waste, and develop circular economy solutions. The key lies in the observed trade-off between the potential for cross-functional learning and the coordination challenges typical of highly heterogeneous networks. In this sense, operational diversity becomes an asset only when its complexity is proactively managed and aligned with the firm's environmental strategy, through robust governance mechanisms and structured coordination processes. In the absence of such mechanisms, managerial burden and strategic misalignment tend to prevail, limiting the effectiveness of alliance-driven environmental initiatives.

When environmental performance is decomposed into its sub-indicators - Emission Reduction, Resource Use, and Environmental Innovation - the patterns largely confirm the trends observed for the overall score, though with varying intensity. Functional and geographical diversity are most strongly linked to improvements in emission reduction and resource efficiency, reflecting their role in facilitating the diffusion of efficient operational and managerial practices across contexts. Industrial and technological diversity, on the other hand, show a stronger association with environmental innovation, highlighting how cross-sector and technological collaborations foster the generation and recombination of green knowledge. Operational diversity, consistently, retains a negative or insignificant relationship across all three dimensions, reinforcing the notion that excessive heterogeneity in partners' operational structures undermines coordination and strategic coherence.

Taken together, the results of this thesis provide a clear contribution to the literature on corporate sustainability and alliance management. By empirically examining multiple dimensions of alliance portfolio diversity the study extends previous research by showing how different forms of heterogeneity are associated with firms' environmental performance. The findings confirm and refine existing theoretical perspectives, highlighting that moderate diversity fosters learning, knowledge recombination, and innovation, while excessive heterogeneity, particularly in operational activities, may generate managerial challenges that limit environmental gains. In doing so, the thesis not only reinforces the relevance of alliance portfolio diversity for sustainability outcomes but also offers a nuanced understanding of how different diversity dimensions operate in practice, providing both theoretical insights and a foundation for future research in strategic management and corporate environmental performance.

While the results are robust, the study also presents some limitations that should be acknowledged. First, the analysis relies on secondary data sources and publicly available databases, which may not capture the full richness of alliance dynamics or informal collaboration mechanisms. The proxies used for diversity dimensions are based on observable characteristics - such as sector, technology, or geography - but cannot fully represent the depth of relational or cognitive diversity among partners.

Second, the environmental performance measures employed are derived from ESG databases, which, although widely used in academic and managerial research, may not always provide a completely accurate reflection of a firm's true sustainability performance. ESG scores can be influenced by measurement bias, inconsistencies in disclosure practices, and in some cases even greenwashing, where companies strategically overstate their environmental achievements to enhance reputation or attract investment.

Third, there may also be unobserved or omitted variables that cannot be directly measured but are likely to play a relevant role in shaping both ESG strategies and alliance decisions. Factors such as managerial culture, leadership priorities, or internal incentive systems may simultaneously influence a firm's sustainability orientation and its networking behaviour, potentially introducing some degree of endogeneity into the analysis.

Moreover, the temporal structure of the data, though longitudinal, may not fully capture the lag between alliance formation and measurable environmental outcomes. Sustainability impacts often manifest over extended periods, suggesting that future studies could employ more refined temporal models to capture these delayed or cumulative effects.

Finally, the research focuses exclusively on environmental performance, leaving aside the potential interactions with social or governance dimensions of corporate responsibility. Integrating ESG components could provide a more holistic view of how alliances contribute to sustainable value creation. Future research could also explore non-linear relationships between diversity and performance, testing whether an optimal threshold of heterogeneity exists beyond which coordination costs outweigh the benefits of learning and innovation.

6 Appendix

Figure 7: Graph showing the type of alliance that results from the entire portfolio - it was built by analysing each alliance within a portfolio, understanding the preference of the firm in building joint venures or strategic alliances.

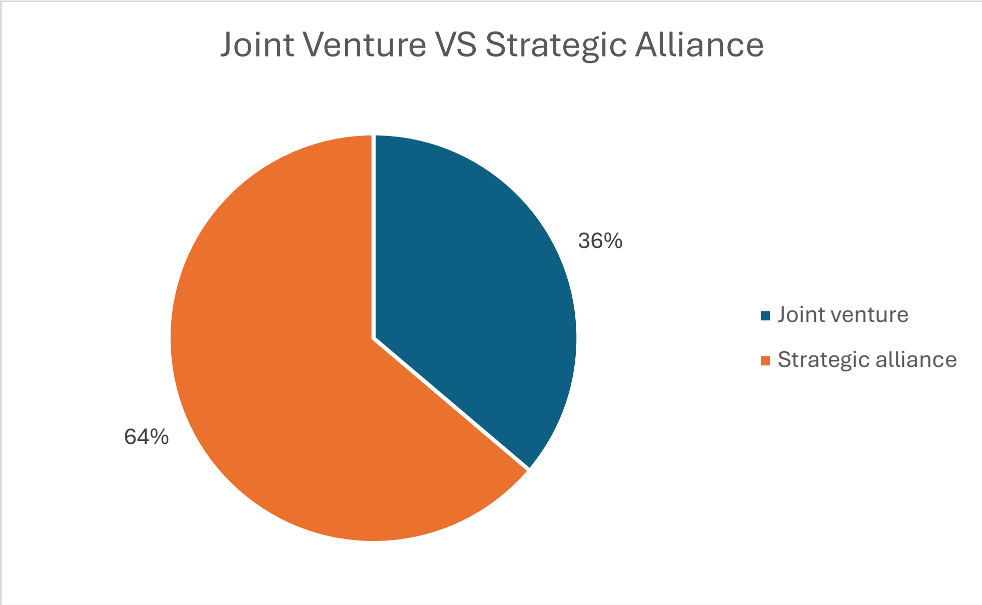


Figure 9: Graph illustrating the frequency of the resulting classification of the scope of each portfolio of alliances – it was built by analysing each alliance within a portfolio, understanding the resulting scope of the entire portfolio.

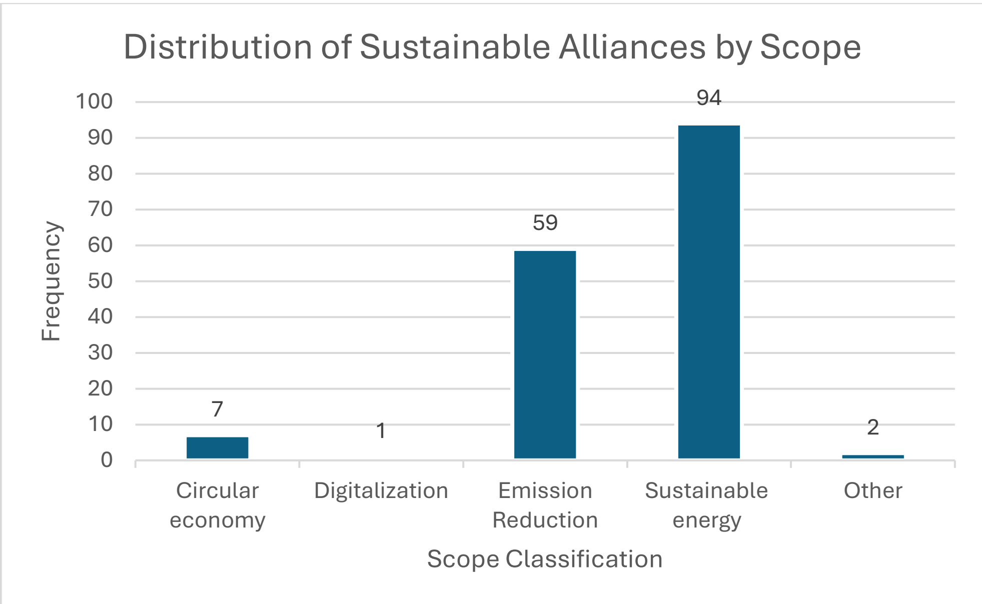
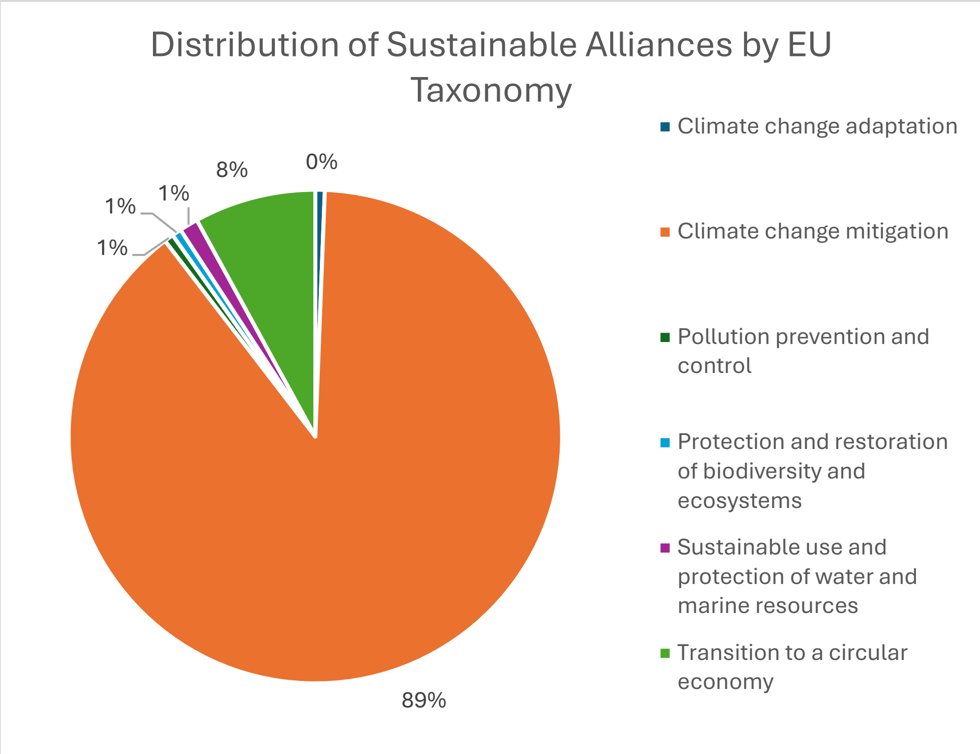


Figure 10: Graph illustrating the frequency of the resulting European Taxonomy classification of each portfolio of alliances – it was built by analysing each alliance within a portfolio, understanding the resulting category of the entire portfolio.



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