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PIANO NAZIONALE
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Finanziato nell'ambito del Piano Nazionale di Ripresa e Resilienza PNRR. Missione 4, Componente 2, Investimento 1.3 Creazione di "Partenariati estesi alle università, ai centri di ricerca, alle aziende per il finanziamento di progetti di ricerca di base"



GRINS
FOUNDATION

Collection and pooling of secondary data

Document data	
Title	Spoke 1 Work Package 2 D2.1 Collection and pooling of secondary data (M12)
Owner	Bocconi University
Contributor/s	Bocconi University (main contribution) in collaboration with the University of Padua (internal first referee) and Rome Tor Vergata (internal second referee)
Document version	D2.1 – v.1
Last version date	30/11/2023

Executive summary

This report examines how Italian companies are integrating sustainability and resilience into their strategies. The focus is on various managerial practices, performance metrics, and the adoption of emergent technologies, with a particular emphasis on the application of Global Reporting Initiative (GRI) standards. Since the aim of the report is to pull for secondary data, it analyzes a sample of 525 Italian companies post the first COVID-19 wave, offering a comprehensive understanding of their adaptive strategies amidst significant disruptions.

The study compares the 'Leaders' in sustainability against the small and medium firms, showing that higher resilience and commitment to sustainability exist among leading companies. Case studies of global corporations like Intel, Google, IKEA, and Nestlé enrich the report and confirm the findings from secondary data.

The findings offer invaluable insights for policymakers, business leaders, and researchers, emphasizing the importance of sustainability and resilience in contemporary business practices. Specifically, the report provides outputs of this report provide insights into the strengths and vulnerabilities of companies in facing disruptions like COVID-19. So, this report enhances the stakeholders' understanding of the supply chain challenges and adjustments

made during the pandemic and consequently they can utilize the main outputs of the report in devising new strategies and innovative and tailored solutions to overcome the risks emerging in future crises. Accordingly, the findings of the report can be summarized as follows:

1. Among the managerial practices, Italian companies were not successful in receiving support from their partners through commercial and financial aid (only 19.42% and 20.19% of the cases respectively). Additionally, there is a meaningful variation among companies in accessing commercial and financial aid because of differences in the capacity of partners, market dynamics, and specific strategies employed during the pandemic. Moreover, the major parts of the companies (72% of the cases) were not able to provide price relief to potentially impact maintaining demand and sustaining market activity.
2. Italian companies had a better performance in adjustment of contractual terms (33% of the cases), and support for consumers by offering more promotions and deals (44.76% of the cases) compared to other managerial practices. However, the adoption rates are not significant and although companies had a moderate level of success in supporting the consumers through promotions and deals over the supply chain, the high standard deviation (49.78%) reveals the complex challenges and difficulties in adapting to disruptions in the supply chains and providing promotions aligned with the emerging needs and preferences of consumers.
3. In terms of performance indicators, Italian companies showed a strong commitment to ensuring customer satisfaction by delivering high-quality products and adapting themselves to the new market conditions using proper business strategies position (93.54% and 90.91% of the cases respectively). Moreover, they were successful in implementing approaches to ensure on-time delivery, customer service, stock availability, and ROI but with a higher variety of desperation compared to product quality and market share. However, only 66.42% of the cases could maintain their sales which shows that disruption can adversely affect the demand rates and companies are not agile to compensate for the lost demand.
4. The analysis shows that strong sales gains increased credibility and companies have more chance to receive financial assistance from the stakeholders. However, it is crucial to make a balance between leveraging support and maintaining financial autonomy. In addition, reducing prices to support customers during the disruption may lead to more demand but it also may cause shortages, decreasing customer service, and increasing on-time delivery.

Moreover, although appealing promotions and captivating deals drive sales, companies had difficulties in developing proper systems to manage the sudden demand fluctuations due to promotional offerings which negatively affected customer experience.

5. Among the new technologies, social networks, mobile apps, and omnichannel have the highest rate of adoption (53%, 24%, and 23% of cases respectively). However, the results of Bayesian Network analysis show that firms can increase the probability of being highly resilient by adopting omnichannel, SC coordination, AI, and mobile apps as a portfolio of SC practices.
6. Notwithstanding the fact that the lack of investment in green technologies, green packaging, and green practices can adversely affect companies' sustainability performance during the pandemic, Italian companies had a low performance in implementing them (43%, 7%, and 3% of the sample respectively). For instance, using drones, electric delivery vehicles, and green packaging could mitigate environmental issues when there is a significant increment in online shopping.
7. Analyzing the firms' resilience in terms of time to recovery indicates that 49.58% of the cases can recover in less than 3 months, 46.22% of the cases can recover in less than 6 months (46.22%), 3.36% of them can recover in less than 12 months, and the others (0.84%) can recover in more than 12 months. According to the correlation analysis, adequate stock ensures a consistent supply and is a safeguard against unexpected demand changes. Additionally, maintaining customer service and product quality at a high level alleviates customer concerns increases customer loyalty, and leads to a quicker recovery. Moreover, companies require implementing strategies to retain or expand their market share to maintain their dominance besides expediting their post-disruption recovery.
8. During the COVID-19 outbreak, improving traditionally significant facets like customer service, ROI, product quality, market share, and on-time delivery doesn't manifestly expedite the resilience and recovery process. However, companies could harness the power of robust sales dynamics to carve a path of resilience and reduce recovery time.
9. The stochastic analysis reveals that the probability of performing significant actions to optimize inventory processes depends on the probability of having high sales even during COVID-19. Moreover, having an efficient delivery lead time during the lockdown guarantees a good performance in customer service and raw material procurement. Furthermore, the

probability that firms have a successful performance in delivery time and quality level is related to the probability of ensuring visibility along the supply chain.

10. Further analysis using the indicates that companies adopt omnichannel when they are focusing on mitigating the risks of sales, ROI, inventory, and quality simultaneously. Moreover, they most likely pursue SC coordination to alleviate the risks of low quality, inventory shortage, and sales reduction. Furthermore, the adoption of big data and machine learning occurs when the risks linked to customer service, delivery time, SC visibility, and quality are present simultaneously. Otherwise, the only risk that individually persuades the decision-makers to implement big data and ML is decreasing ROI.

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1. Introduction

Nowadays, sustainability and resilience are no longer optional but inclusive parts of the firms' corporate strategies. Understanding how companies, particularly in Italy, are integrating these practices into their business model represents a critical challenge. This report seeks to comprehensively explore the sustainability practices adopted by Italian companies, investigating resilience, performance, technologies, and supply chain practices. The report offers an in-depth look at how these entities are navigating this complex landscape, by applying the Global Reporting Initiative (GRI) standards.

At the heart of this study is a tri-fold analysis encompassing economic, environmental, and social dimensions. These areas are critical in the full spectrum of sustainability practices and the extent to which Italian companies are embedding these practices into their core strategies. A critical part of this analysis is the distinction in GRI practice adoption between SMEs and larger corporations. The report identifies clear disparities, which is attributed to factors such as greater resources, heightened public scrutiny, and more complex regulatory demands.

The report goes a step further to analyze 'Leaders' in sustainability and compare them against the others. To validate the statistical analysis developed using secondary data, the report also integrates case studies from global giants like Intel, Google, IKEA, and Nestlé. These cases provide valuable insights into diverse ways of integrating sustainability into business operations, demonstrating how various initiatives can be effectively aligned with GRI standards.

Moreover, this report delves into the heart of the challenges experienced by Italian companies. By examining a sample of 525 Italian companies, gathered through extensive interviews following the first wave of COVID-19, this study offers an overview into the strategies employed by Italian companies to overcome the disruption. The goal is to comprehensively understand the firms' capacity to maintain their performance levels even in case of crisis and to identify the managerial practices, performance indicators, and technological advancements they leveraged. These analyses have been then completed by the analysis of the digital technologies that firms adopt, the green practices that they implement, and the supply chain relationships that they establish.

The rest of the report is composed of section 2, which analyzes the GRI framework by pooling secondary data and surveys, and section 3, which investigates the firms' resilience in details. Section 4 concludes.

2. Pooling of secondary data and surveys

2.1 Introduction

In a time where prioritising sustainability is becoming an essential and urgent imperative for businesses. The transition from traditional business metrics to a broader, more holistic view encompassing environmental, social, and governance (ESG) aspects marks a transformative phase in the corporate world (Sciarelli et al., 2021). This evolution is significantly driven by frameworks like the Global Reporting Initiative (GRI), which stands as a pivotal benchmark for sustainability reporting. Originating in the wake of the Exxon Valdez Oil Spill, GRI's guidelines have become instrumental in fostering corporate transparency and accountability, steering businesses on their journey towards sustainability (Bell & Lundblad, 2011).

This report delves into the sustainability practices of 272 Italian companies, meticulously examining their alignment with the GRI framework. The analysis reveals how factors such as company size and industry sector not only influence sustainability efforts but also impact organisational resilience. This aligns with national initiatives aimed at sustainable development and provides insights into how GRI-aligned practices shape managerial strategies in crucial areas such as resilience, economic sustainability, and governance.

In this report, we delve into the intricacies of how Italian companies across various industries and regions have adopted and integrated the GRI standards into their corporate sustainability strategies. Beginning with an extensive overview in Section 4.1, our analysis provides a foundational understanding of the general adoption of GRI practices. This analysis is pivotal for advancing a benchmark against which organizations can measure their organization's sustainability performance.

In Section 4.2, we concentrate on the differences in GRI practices between SMEs and large corporations. This differentiation is crucial, highlighting how organisations of varying scales approach sustainability. By calculating the mean and standard deviation of GRI practices for

both SMEs and large companies, we offer a nuanced view of sustainability adoption across business sizes. This section, enriched by the Pearson Chi-Square test, further reveals significant disparities in GRI adoption, underscoring the impact of organizational size on sustainability strategies.

Furthermore, Section 4.3 employs the Pearson correlation coefficient to examine the interconnections among various GRI disclosures. This analysis is vital for organisations seeking to create a more cohesive and comprehensive sustainability strategy, ensuring that different GRI practices reinforce each other. Moreover, the sector-specific adoption patterns, explored in Section 4.4, provide insights into industry-specific sustainability trends. This information is invaluable for organizations aiming to align their practices with sector benchmarks and unique industry challenges.

Taking the analysis deeper, Section 5 presents the connection between GRI and Sustainable projects, supplemented with real-world case studies. This section serves as an essential resource for managers, offering practical examples of effective sustainability strategies that have been implemented successfully across different industries.

In Section 6, we highlight the relationship between Resilience and GRI standards. We show that organisations with a comprehensive GRI disclosure are more resilient. This crucial insight links thorough sustainability reporting with enhanced organizational resilience, emphasizing the role of comprehensive sustainability practices in navigating dynamic business environments.

The insights gathered from this report are invaluable for a wide array of stakeholders aiming to fortify their commitment to sustainable practices and enhance organizational resilience in the face of evolving business landscapes. For businesses striving to integrate and elevate their sustainability strategies, the report's findings on the adoption of GRI standards provide a robust framework for action. The correlation between GRI practices and various aspects of corporate performance offers practical guidance for managerial decisions, aiding companies in navigating the complexities of today's sustainability challenges more effectively.

Supply chain managers and professionals will find the report particularly insightful. It provides a deeper understanding of how sustainability practices, aligned with GRI standards, impact and enhance supply chain resilience. This is especially pertinent in times of disruption, such as the COVID-19 pandemic, where traditional supply chain models are tested.

Academics, researchers, and PhD students will discover in this report a rich source of information to expand their knowledge in the realms of corporate sustainability, ESG practices, and organizational resilience. The detailed analysis of GRI standards adoption across different industries and company sizes offers a fertile ground for further research and reporting.

Public authorities and government bodies can leverage the comprehensive analysis presented in the report to inform policymaking and strategy development. The insights into how companies adopt and integrate GRI standards can guide the formulation of policies aimed at encouraging sustainable business practices and enhancing overall industry resilience.

Business leaders and executives, regardless of industry, can draw critical lessons from the report. It provides a blueprint for adapting business strategies to not only comply with global sustainability standards but to also use these standards as a catalyst for innovation and competitive advantage.

Industry associations and trade groups can use the report to foster a collaborative approach to sustainability. By sharing knowledge and best practices, these groups can lead the way in collective resilience and sustainability, setting new benchmarks for their respective industries.

For investors and financial analysts, the report offers a lens to assess companies' sustainability performance and their resilience to future challenges. Understanding a company's commitment to GRI standards can be a key indicator of its long-term viability and adaptability.

Finally, consulting firms specializing in corporate sustainability can find in this report a valuable resource for benchmarking and developing tailored solutions for their clients. By leveraging the insights and analyses provided, these firms can assist their clients in navigating the challenges of sustainability and optimizing their strategies for a more sustainable future.

2.2 Methodology

This section outlines our systematic methodology, which spans from initial data collection to the final stages of data analysis. A schematic diagram in **Figure 1.** provides a clear visual guide to the sequential stages of our analysis, with further specifics to be discussed in the following sections. Section 2.2.1 details the data collection process, highlighting our strategic approach to gathering a dataset that is foundational for the subsequent analysis. This part of the report focuses on the careful selection and compilation of data from a range of sources, selected to

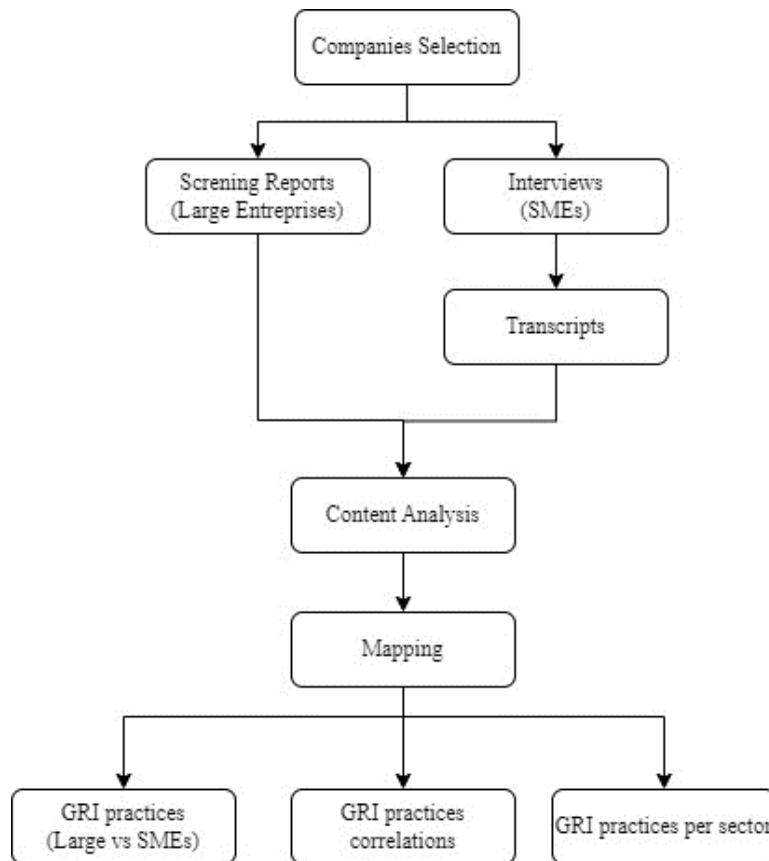
accurately reflect the diversity within the corporate sector. In Section 2.2.2, we turn to our data processing methods. Here, we explain the rigorous process of transcribing, categorizing, and coding the raw data. This meticulous effort is crucial for transforming the initial datasets into a format that is ready for thorough analysis. Section 2.2.3 is devoted to the description of our data analysis techniques, which include both statistical and qualitative methods. This section elucidates how we employ these methods to interpret the data, aiming to extract meaningful insights about the adoption of GRI practices within corporate structures. Each methodological phase is carefully crafted to build on the last, ensuring a methodical and coherent approach that strengthens the overall research process and the reliability of our findings.

2.2.1 Data Collection

In this report, we employed a mixed-method approach to gather data from a diverse sample of Italian companies. The data collection process involved two primary methods: screening sustainable reports and conducting interviews.

Firstly, we selected a sample of 100 leading Italian companies for analysis by screening their sustainable reports. These companies had publicly available reports on their websites. Our selection process was based on their prominence and influence within their respective industries, ensuring representation from various sectors of the Italian economy. The sustainable reports provided a valuable source of information about the companies' sustainability practices and initiatives, including their adherence to the GRI standards.

Figure 1. Methodological Steps



Source: Authors' elaboration

Additionally, within the secondary database, apart from analysing sustainable reports, we conducted interviews to gather insights from a sample of 172 SMEs in Italy. Since sustainable reports were not accessible for these SMEs, interviews offered a means to comprehend their sustainability practices, especially concerning the GRI standards. We selected SMEs for interviews through a purposive sampling strategy, aiming to cover a diverse range of industries and geographic locations. We conducted interviews using a semi-structured interview guide covering topics such as sustainability practices, GRI standards adherence, challenges faced, and strategies employed. Depending on participant preference and availability, the interviews took place either in person or through remote communication channels.

provides some descriptive information about the utilized sample. The sample consists of 277 companies. SMEs constitute 62% of the sample, while the remaining 38% represents the Leaders category. The sample encompasses companies from a range of industries, providing a diversified representation. The largest sector within the sample is Manufacturing, accounting for 36% of the companies. Additional notable industries include Agri-food, representing 19% of the

sample, followed by Information and Communication Technology (ICT) at 17%. Other industries within the sample include Engineering (13%), Healthcare (7%), Services (5%), Financials (1%), and Education (1%).

Figure 2 Company Size

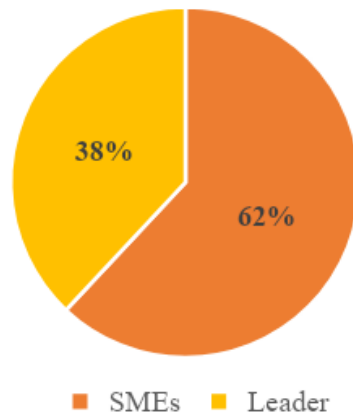
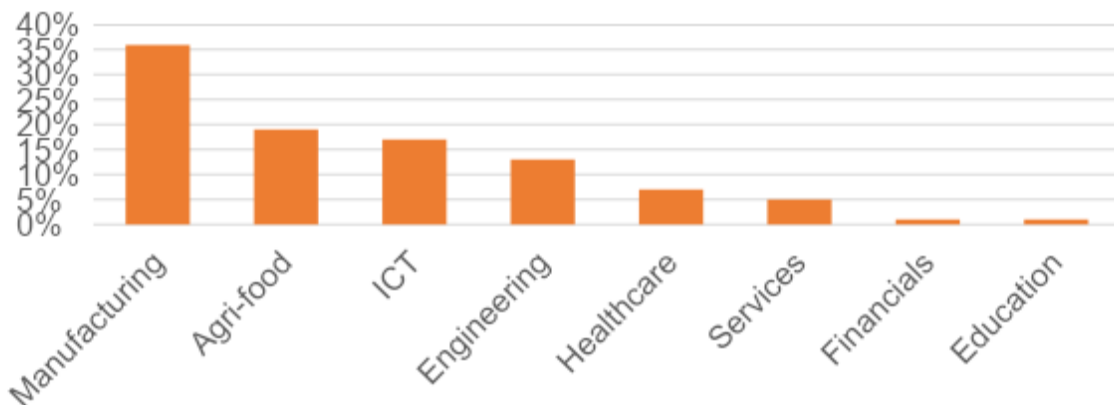


Figure 3 Company Sector



2.2.2 Data Processing

The data processing methodology involves the utilization of two distinct procedures, aligned with the data collection process. In the case of small companies, interviews were recorded and subsequently transcribed. These transcriptions were then used for the content analysis. In the case of leader companies, the report content was directly subjected to content analysis.

The content analysis process entailed a systematic breakdown of both transcribed interviews and report contents. This analysis was guided by the purposes of this report and structured around predetermined coding units (aligned with the GRI Standards). Relevant textual segments, those containing statements pertinent to the research questions, were systematically identified. During this process, we followed Mayring's three-step content analysis procedure – Reduction, Explication, and Structuring (Mayring, 2021).

The selection of the content analysis method was based on previous studies. In the literature, it is possible to see that content analysis is a widely employed methodology for the analysis of textual data (Landrum & Ohsowski, 2018). This method is widely employed to scrutinize corporate reports (Bowman, 1988) analyse sustainability reports across various industries (Amini et al., 2018), understand the role of human resources in sustainability reports (Jang & Ardichvili, 2020), investigate firms' engagement with UN Sustainable Development Goals (Nylund et al., 2022), among others. Topics are close to the one approach in this report. Therefore, the method was suitable for the analysis at hand.

Following the content analysis, both the Leader Report and SME interview data were subjected to a mapping technique. If a GRI disclosure is identified in the report during this process, it is marked with an "X" within the corresponding category. Conversely, if no disclosure aligns with a specific standard, the category remains empty. A parallel analysis was executed for interview data, with the responses provided by SMEs meticulously reviewed and evaluated for alignment with GRI standards. Instances where SMEs had disclosed information consistent with GRI standards are denoted with an "X". Otherwise, the category remains empty.

The outcome of this thorough analysis unveils identifiable patterns, trends, and discrepancies in the adoption of GRI-related disclosure practices across diverse companies and sectors. This not only facilitates meaningful comparisons but also simplifies the process of data analysis.

2.2.3 Data Analysis: GRI as a Standard Framework

In this report, we have taken a series of statistical analyses to explore the adoption of GRI practices across various dimensions. These dimensions include company size, sectoral distribution, and the intensity of GRI practice implementation, focusing on social and

environmental aspects. We aim to understand not only the extent of GRI standards adoption but also the depth of their integration into corporate sustainability strategies. For data analysis:

We calculated the mean and standard deviation of GRI practices adoption. (Section 3.1)

We calculated the mean and standard deviation of GRI practices adoption for both SMEs and large companies. (Section 3.2)

We utilized a Pearson Chi-Square test, following the approach of Swain et al. (2017), to assess significant differences in GRI practices adoption between SMEs and large companies. (Section 3.2)

We employed the Pearson correlation coefficient, as Khan et al. (2023), for investigating the relationship between GRI practices disclosure, this statistical measure evaluated the strength and direction of the linear relationship among various GRI practices. (Section 3.3)

We calculated the mean and standard deviation of GRI practices adoption for different company sectors. (Section 3.4)

Due to the limited number of firms in certain sectors, we did not conduct any statistical tests for comparing different sectors.

The analyses were carried out using IBM SPSS v.25 for the Pearson Chi-Square test comparisons and Microsoft Excel for calculating descriptive statistics. Both software tools are widely recognized and utilized for statistical analysis and data manipulation, ensuring precision and consistency throughout the analysis process.

In this report, we used the GRI standards as a framework for data analysis. The GRI standards are a suite of internationally recognized guidelines that provide a framework for companies to report on their economic, environmental, and social sustainability. Developed to achieve a sustainable global economy, the GRI standards offer a consistent and structured approach to public disclosure of sustainability performance, facilitating greater organizational transparency. They enable businesses to measure and communicate their impact on critical sustainability issues such as climate change, human rights, governance, and social well-being. The standards are designed to apply to organizations of any size, sector, or location and are developed through a multi-stakeholder process, which includes inputs from business, civil society, labour,

and academic institutions, ensuring a comprehensive perspective on the issues that are most material to stakeholders and businesses alike.

Under the GRI Standards, Economic, Environmental and Social categories are addressed, including Market Presence (GRI1), Economic Performance (GRI2), Indirect Economic Impacts (GRI3), Procurement Practices (GRI4), Anti-corruption (GRI5), Anti-competitive Behaviour (GRI6), Tax (GRI7), Materials (GRI8), Energy (GRI9), Water & Effluents (GRI10), Biodiversity (GRI11), Emissions (pollutants and GHG) (GRI12), Waste (GRI13), Environmental Compliance (GRI14), Supplier Environmental Assessment (GRI15), Employment (GRI16), Labor/Management Relations (GRI17), among others.

Each category consists of specific metrics and indicators that capture various aspects of companies' sustainability performance. These disclosures enable companies to track their progress, identify areas for improvement, and communicate their performance to stakeholders. The aspects considered are presented in the attachment and follow all the disclosures contemplated in the Consolidated Set of the GRI Standards report¹. A summary table of all the GRI standards is provided in **Appendix 1**.

2.3 Discussion and Results

In this section, we conduct a detailed analysis of the disclosure of GRI standards among Italian companies. We delve into each GRI indicator, providing information and statistical data on the level of adoption within the sample. This includes a presentation of both the mean and standard deviation for each indicator, offering a quantitative perspective on the extent to which these practices have been integrated into corporate reporting. This approach not only reveals the average adoption rates but also gives insight into the variability and consistency of GRI standards implementation across different organizations in Italy.

2.3.1. Environmental Indicators

Environmental Indicators within the GRI Standards play a crucial role in shaping sustainable and responsible business practices. They provide a comprehensive standard for organizations to measure, manage, and communicate their environmental impact, covering aspects such as

¹ Link: <https://www.globalreporting.org/standards/download-the-standards/>

emissions, energy usage, water consumption, waste management, and biodiversity. By adhering to these standardized metrics and guidelines, companies can present a transparent and reliable account of their environmental performance, enabling stakeholders to assess their commitment to sustainability.

In this section, we delve deep into these specific GRI Standards, unravelling the nuances of each and exploring the prevalent reporting standards among 277 Italian companies. Our analysis sheds light on the challenges, opportunities, and imperatives for enhancing environmental sustainability reporting.

Figure 4 reports the means and standard deviations for each one of the indicators.

Materials (GRI8) evaluates the use of raw materials in business operations, emphasizing the adoption of sustainable practices such as using recycled materials and reclaiming products and packaging. This standard aims to increase transparency, accountability, and efficiency in resource utilization, encouraging a transition toward a circular economy. In our sample, 43% of the companies report Materials Practices, with a standard deviation of 0.495. This percentage, while substantial, indicates that there is still a significant portion of companies that have not yet fully integrated these standards into their operations.

Energy (GRI9) assesses the consumption of energy within organizations and promotes reductions in energy use and improvements in energy efficiency. The standard is crucial for tracking and disclosing energy usage and enhancing energy performance across operations and supply chains. 44% of companies in our sample report Energy Practices, with a standard deviation of 0.498. Water & Effluents (GRI10) focuses on responsible water use, waste management, and effluent treatment. Companies need to manage these aspects efficiently to mitigate their environmental impact and ensure sustainable operations. In our dataset, 44% of companies report Water & Effluents Practices, with a standard deviation of 0.497. This reflects a growing awareness of the importance of water and waste management in corporate sustainability. However, it also indicates that a significant number of companies may not have fully implemented effective water and waste management practices. The challenges could range from technical and infrastructural issues to financial constraints. Increasing awareness and providing support for water and effluent management can drive more companies to adopt sustainable practices in this area.

Biodiversity (GRI11) evaluates the impact of business operations on biodiversity and ecosystems. This standard is crucial for conserving biodiversity and ensuring sustainable business practices. Only 21% of companies in our sample report Biodiversity Practices, with a standard deviation of 0.410. This low percentage is concerning and highlights a critical gap in corporate sustainability practices. The lack of reporting could be attributed to a variety of factors, including a lack of awareness of the importance of biodiversity, challenges in measuring impacts on biodiversity, and the perceived complexity of implementing biodiversity conservation measures. Addressing these challenges and promoting the adoption of biodiversity-friendly practices are vital for the long-term sustainability of businesses and ecosystems.

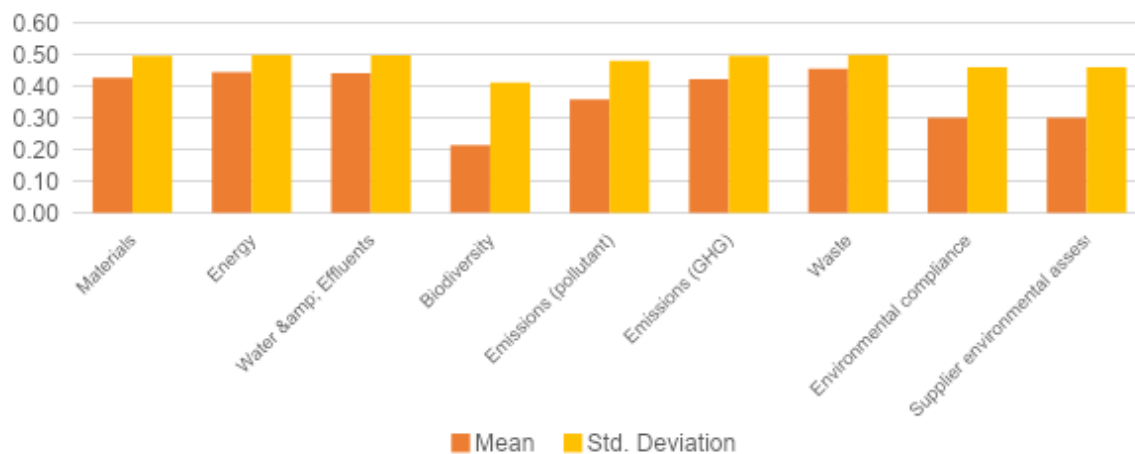
Emissions (GRI12 and GRI13) cover greenhouse gas emissions and other significant air pollutants. Reporting on these standards is essential for tracking an organization's contribution to climate change and air pollution, and for identifying opportunities to reduce emissions. In our dataset, 36% of companies report Pollutant Emissions Practices, and 42% report GHG Emissions Practices, with standard deviations of 0.480 and 0.410, respectively. These percentages indicate a moderate level of adoption, but they also highlight that a significant number of companies are not fully addressing their emissions. The barriers to adoption could include the complexity of emissions calculations, lack of access to necessary data, or perceived high costs of emission reduction measures. Enhancing awareness, providing technical support, and promoting the benefits of emissions reduction can encourage more companies to adopt these practices.

Waste (GRI14) emphasizes transparent reporting on waste generation and management. This standard is essential for promoting responsible waste handling and minimizing the environmental impact of waste. 45% of companies in our sample report Waste Practices, with a standard deviation of 0.499. This reflects a relatively high level of awareness and adoption of waste management practices. However, there is still room for improvement, as more than half of the companies do not report on this standard. Challenges in waste management can range from logistical issues, and lack of recycling facilities, to financial constraints. Promoting the benefits of effective waste management and providing support can drive higher adoption of these practices.

Environmental Compliance (GRI15) focuses on an organization's adherence to environmental laws and regulations. Reporting on this standard is crucial for ensuring legal compliance and minimizing the risk of regulatory fines and penalties. In our sample, 30% of companies report

Environmental Compliance Practices, with a standard deviation of 0.459. This percentage indicates that a significant number of companies might not be transparently reporting their compliance status. Supplier Environmental Assessment (GRI16) evaluates the environmental performance of suppliers, promoting sustainable sourcing practices. In our dataset, 30% of companies report on this standard, with a standard deviation of 0.459. This highlights a need for greater attention to sustainable procurement practices. Challenges in adopting this standard could include difficulties in assessing suppliers' environmental performance, lack of control over suppliers' operations, and potential cost implications of switching to more sustainable suppliers.

Figure 4 Mean and Standard Deviation – GRI Environmental Standards



2.3.2 Social Indicators

Social Indicators, a critical component of GRI standards, play a pivotal role in illuminating an organization's influence on social aspects, ranging from labour practices and human rights to societal engagement and product responsibility. In this section, we investigate these specific GRI Standards, unravelling the nuances of each and exploring the prevalent reporting practices among 277 Italian companies. Our analysis sheds light on the challenges, opportunities, and imperatives for enhancing social sustainability reporting. Figure 5 and Figure 6 reports the means and standard deviations for each one of the indicators.

Employment (GRI17) evaluates an organization's employment practices, focusing on job creation, employment stability, and workforce composition. This indicator is crucial as it provides insights into the organization's commitment to creating and maintaining quality employment

opportunities and fostering stable and diverse work environments. In our sample, 52% of the companies report Employment Practices (std dev. 0.500). The 52% reporting rate reflects a balanced distribution where just over half of the companies are actively disclosing their employment practices. This indicates a growing awareness and commitment to transparency in employment practices.

Labour/Management Relations (GRI18) assesses an organization's relationships between management and workers. It evaluates the policies, processes, and communication channels in place to foster constructive labour-management relations. This indicator is important as it reflects the organization's commitment to maintaining a positive and collaborative relationship between labour and management, enhancing the work environment and productivity. In our sample, 35% of the companies report Labor/Management Relations Practices (std dev. 0.478).

Occupational Health and Safety (GRI19) focuses on an organization's efforts to provide a safe and healthy work environment. It assesses measures, incidents, and programs related to occupational health and safety. This indicator is crucial as it reflects the organization's commitment to ensuring the well-being of its workforce, preventing work-related injuries and illnesses, and promoting a safe workplace culture. 78% of companies report Occupational Health and Safety Practices, with a standard deviation of 0.418.

Training and Education (GRI20) evaluates an organization's investment in employee training and education. It includes the average hours of training provided to employees and the availability of learning opportunities. This indicator is important as it demonstrates the organization's commitment to employee development and skill enhancement, fostering a skilled and adaptable workforce. It is significant as it measures the organization's investment in continuous learning and skill development for its workforce, which is crucial for adaptability and long-term success. 78% of companies report Training and Education, with a standard deviation of 0.418.

Diversity and Equal Opportunities (GRI21) evaluate an organization's efforts to promote diversity and ensure equal opportunities. It assesses policies, practices, and the composition of the workforce regarding diversity. This indicator is essential as it reflects the organization's commitment to fostering an inclusive and diverse workplace, ensuring equal opportunities for all

employees. 52% of companies report Diversity and Equal Opportunities Practices, with a standard deviation of 0.500.

Non-discrimination (GRI22) focuses on an organization's measures to prevent discrimination in hiring and employment practices. It assesses policies and incidents of discrimination. This indicator is crucial as it demonstrates the organization's commitment to fostering a work environment free from discrimination and ensuring fair treatment and opportunities for all employees. 33% of companies report Non-discrimination Practices, with a standard deviation of 0.472.

Freedom of Association and Collective Bargaining (GRI23) evaluates an organization's respect for the freedom of association and collective bargaining rights. It assesses the policies and practices regarding these fundamental rights of workers. This indicator is crucial as it demonstrates the organization's commitment to respecting and upholding workers' rights to form associations and engage in collective bargaining, fostering a fair and equitable work environment. 19% of companies report Freedom of Association and Collective Bargaining, with a standard deviation of 0.391.

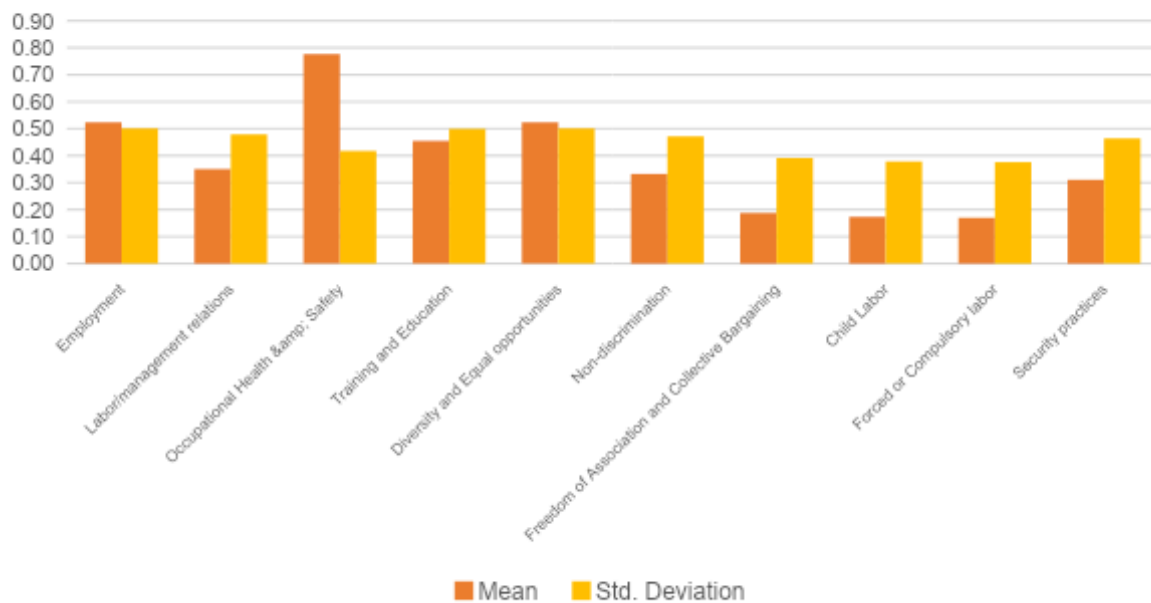
Child Labor (GRI24) focuses on an organization's efforts to eradicate and prevent child labour within its operations and supply chain. It assesses policies, due diligence processes, and remediation efforts to eliminate child labour. This indicator is paramount as it reflects the organization's dedication to ensuring that children are not involved in any form of labour, ensuring their well-being and access to education. 17% of companies report on Child Labor, with a standard deviation of 0.379.

Forced or Compulsory Labor (GRI25) evaluates an organization's measures to eradicate forced or compulsory labour. It includes policies, due diligence processes, and remediation efforts to eliminate such practices within the organization and its supply chain. This indicator is critical as it reflects the organization's commitment to respecting human rights and ensuring that no one is subjected to forced labour, contributing to fair and ethical labour practices. 17% of companies report Forced or Compulsory Labor, with a standard deviation of 0.376.

Security Practices (GRI26) focuses on an organization's practices related to security, including the impacts of security measures on stakeholders and local communities. It assesses policies and practices regarding the use of security personnel and their training. This indicator is

significant as it ensures that an organization's security measures are in line with human rights standards, respecting the safety and rights of both its employees and the communities it operates in. 31% of companies report Security Practices, with a standard deviation of 0.464.

Figure 5 Mean and Standard Deviation – GRI Social Standards GRI17–GRI26



Rights of Indigenous People (GRI27) evaluates an organization's respect for the rights of indigenous peoples. It assesses the impact of an organization's operations on indigenous communities and the measures taken to respect their rights and cultures. This indicator is crucial as it ensures that the organization's activities are conducted in a manner that respects the rights, cultures, and traditions of indigenous communities, fostering mutual respect and sustainability. 7% of companies report the Rights of Indigenous People, with a standard deviation of 0.259.

Human Rights Assessment (GRI28) addresses an organization's evaluation and reporting on its human rights impact. This includes identifying, assessing, and disclosing the organization's human rights risks and impacts on its stakeholders. It requires an understanding of potential human rights vulnerabilities within the company's operations and across its value chain. The assessment focuses on ensuring that the organization respects human rights, identifies potential risks, and implements measures to mitigate any adverse impacts. The goal is to

promote transparency and accountability regarding an organization's commitment to upholding human rights, both within its operations and throughout its broader sphere of influence. 28% of companies report Human Rights Assessment, with a standard deviation of 0.451.

Local Communities (GRI29) focuses on an organization's impact on local communities where it operates. It examines the efforts made to engage, support, and contribute to the development and well-being of these communities. This indicator is essential as it reflects the organization's commitment to being a responsible corporate citizen by positively influencing and supporting the communities in which it operates. 38% of companies report on Local Communities, with a standard deviation of 0.487.

Supplier Social Assessment (GRI30) evaluates an organization's efforts to assess and manage social impacts within its supply chain. It assesses the measures and policies in place to identify, address, and improve social issues among suppliers. This indicator is crucial as it highlights the organization's commitment to ensuring that its suppliers maintain socially responsible practices, contributing to a more sustainable supply chain. 29% of companies report Supplier Social Assessment, with a standard deviation of 0.456.

Public Policy (GRI31) focuses on an organization's involvement in public policy. It examines the organization's participation in the development, review, and promotion of public policy. This indicator is important as it demonstrates the organization's engagement in policy-making processes and its contributions to policies that promote sustainability and societal well-being. 16% of Leader companies report Public Policy, with a standard deviation of 0.366.

Customer Health and Safety (GRI32) assesses an organization's responsibility and measures taken to ensure the health and safety of its customers. It includes the policies, procedures, and product safety standards in place. This indicator is crucial as it reflects the organization's commitment to providing safe and reliable products or services, ensuring the well-being and safety of its customers. 33% of companies report Customer Health and Safety, with a standard deviation of 0.471.

Marketing and Labeling (GRI33) evaluates an organization's marketing and labelling practices. It assesses the adherence to marketing and advertising standards, ensuring accuracy and ethical promotional practices. This indicator is important as it reflects the organization's commitment to

truthful and ethical marketing, promoting transparency and integrity in its communications. 19% of companies report Marketing and Labelling, with a standard deviation of 0.394.

Customer Privacy (GRI34) focuses on an organization's commitment to protecting customer privacy. It assesses policies, practices, and measures to safeguard customer data and information. This indicator is critical as it reflects the organization's dedication to respecting and protecting the privacy of its customers, ensuring trust and confidentiality in its interactions. 37% of companies report Customer Privacy, with a standard deviation of 0.484.

The Socio-Economic Compliance (GRI35) standard encompasses an organization's adherence to social and economic regulations, standards, and norms. It requires reporting on the company's compliance with various socio-economic aspects, including labour laws, fair competition, anti-corruption measures, and ethical business practices. This standard addresses the organization's commitment to complying with legal and ethical guidelines, ensuring fair business practices, and fostering a positive socio-economic impact within its operations and across its supply chain. It focuses on upholding principles that contribute to societal well-being, ethical conduct, and legal compliance, promoting responsible business behaviour and accountability. 19% of companies report Socio-Economic Compliance, with a standard deviation of 0.391.

Figure 6 Mean and Standard Deviation – GRI Social Standards GRI27-GRI35



2.3.2 GRI practices adoption comparison between SMEs and Leaders

The adoption of GRI practices varies significantly between SMEs and larger corporations, reflecting disparities in resources, organizational structure, and strategic priorities. Larger organizations tend to have more established reporting practices, often driven by greater public scrutiny, more complex regulatory requirements, and a higher demand for transparency from investors and consumers. They typically possess the necessary financial and human resources to invest in comprehensive GRI reporting, ensuring a detailed disclosure of their sustainability practices. SMEs, on the other hand, may find the adoption of GRI standards more challenging due to limited resources, less formalized processes, and a lack of in-house expertise on sustainability reporting. Despite these challenges, many SMEs recognize the value of GRI practices in enhancing their market reputation, building trust with stakeholders, and identifying opportunities for operational efficiency and innovation. As a result, there is a growing trend of GRI adoption among SMEs, although the extent and depth of reporting may not match that of larger counterparts. Initiatives aimed at simplifying and supporting GRI reporting for SMEs are crucial in levelling the playing field and fostering a universal commitment to sustainability across businesses of all sizes. In this session, we will delve into a descriptive analysis of the adoption rates of GRI practices among SMEs and larger enterprises, shedding light on the prevailing trends and patterns.

2.3.3 Leaders and SMEs – GRI Environmental Standards

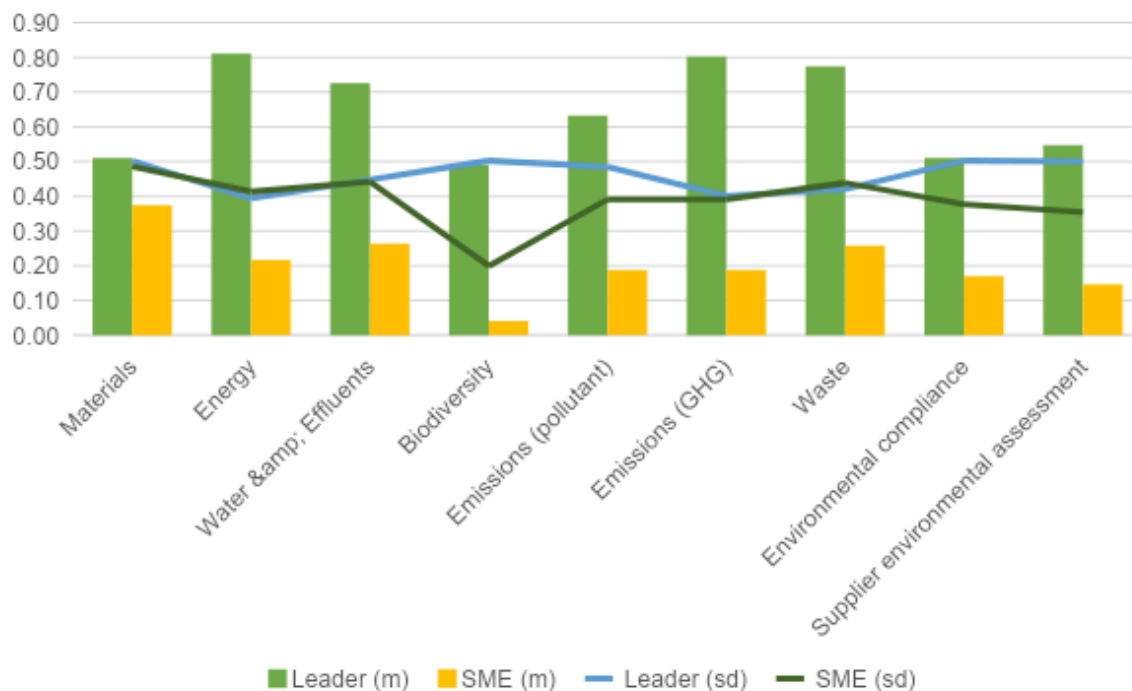
In this subsection, we examine the mean and standard deviation for Environmental Indicators under the GRI standards, after dividing the sample into leaders and SMEs. Figure 7 presents the standards in analysis. A discussion of the results will follow this statistical evaluation.

Leaders demonstrate a robust commitment to environmental stewardship across all categories, evidenced by their consistently higher mean scores. For example, their mean score in energy (GRI19) is exceptionally high ($m=0.81$), which could suggest that leaders are prioritizing energy efficiency and possibly investing in renewable energy sources. However, the standard deviation

(Sd=0.393) indicates a degree of variance in performance, which may be due to differing levels of investment or success in implementing energy initiatives.

In water and effluents (GRI10), leaders again show a strong mean score (m=0.73), indicating effective water stewardship. The standard deviation (Sd=0.448) suggests some variability, which might reflect the complexity of managing water resources in various operational contexts. On the other hand, biodiversity (GRI11) shows the greatest disparity in mean scores (leader m=0.49, SME m=0.04), with leaders significantly outperforming SMEs, although the leaders' standard deviation (Sd=0.502) points to diverse outcomes, which may result from the varying scales at which leaders can influence biodiversity initiatives.

Figure 7 GRI Environmental Standards (Leaders vs SMEs)



In pollutant emissions (GRI12), leaders have a higher mean score (m=0.63) compared to SMEs (m=0.19), with a standard deviation (Sd=0.485) that implies varying degrees of control over emission sources. The same pattern holds for greenhouse gas emissions (GRI13), where the leaders' mean score (m=0.80) far exceeds that of SMEs (m=0.19), and a lower standard deviation (Sd=0.400) suggests more consistent management among leaders. Moreover, Waste Management (GRI14) also sees leaders ahead (m=0.77), with a moderate standard deviation (Sd=0.420), indicating that while leaders are generally effective in waste reduction and recycling efforts, there is room for improvement in standardizing practices.

For environmental compliance (GRI15), leaders have a mean score of 0.51, with a standard deviation of 0.502, which could indicate that while leaders are generally compliant, the high variability might stem from differing regulatory challenges across regions or sectors. Lastly, in supplier environmental assessment (GRI16), leaders' mean score of 0.55 versus SMEs' 0.15, with a standard deviation of 0.500, suggests that leaders are more diligent in evaluating the environmental practices of their supply chain, although the consistency of such evaluations varies.

2.3.4 Leaders and SMEs – GRI Social Standards

In this subsection, we examine the mean and standard deviation for Social Indicators under the GRI standards, after dividing the sample into leaders and SMEs. Figure 8 and Figure 9 present the standards in analysis. A discussion of the results will follow this statistical evaluation.

Starting with employment (GRI17), leaders have a mean score of 0.75 with a standard deviation of 0.438, indicating a strong performance in employment practices with a moderate degree of variance. In contrast, SMEs have a lower mean score of 0.39 and a higher standard deviation of 0.488, suggesting not only a lower performance in employment practices but also less consistency. Moreover, in labour/management relations (GRI18), the mean score for leaders is 0.48 with a standard deviation of 0.502, while SMEs have a mean of 0.27 and a standard deviation of 0.445.

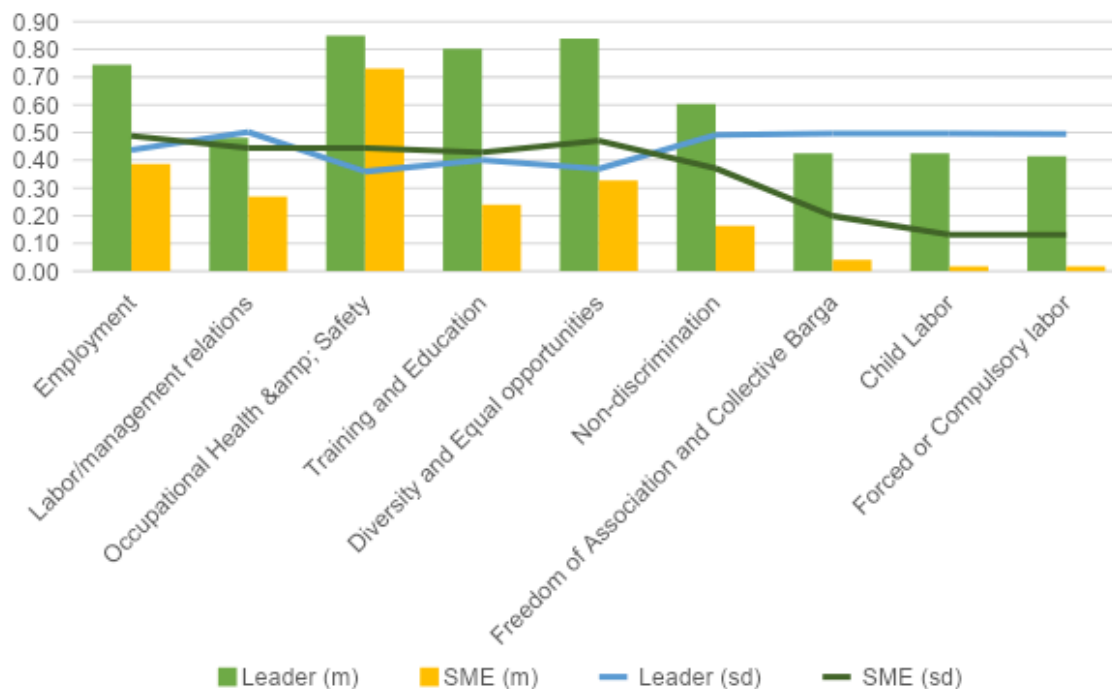
On employment (GRI17), leaders show an average score of 0.75 and a standard deviation of 0.438 reflecting good practice with moderate variability. On the other hand, SMEs have a mean score of 0.39 and a wider standard deviation of 0.488 thus indicating poorer practice in employment and less stability too. The average leader in labour management (GRI18) has a mean of 0.48 and a standard deviation of 0.502. While the mean of SMEs is 0.27 with a standard deviation of 0.445.

A critical part of workplace welfare, i.e., occupational health and safety (GRI19), scores an impressive mean value of 0.85, and it has a low variation (standard deviation) value of 0.360, meaning that there is considerable compliance as well as stability. Furthermore, SMEs have an average score of 0.73 but a high standard deviation (Sd=0.445), referring to different levels of knowledge and compliance with safety measures. On the part of training and education

(GRI20), leaders scored highly ($m=0.80$) with a standard deviation of ($Sd=0.400$), highlighting great commitment towards staff development. The mean score for SMEs is much lower ($m=0.24$) and the standard deviation is 0.428 points which indicates a vital growth point and the need to further invest in this area.

Leaders report a mean score of 0.84 for diversity and equality (GRI21) with a standard deviation of 0.369. This shows that leaders have implemented a strong strategy on diversity with fairly equitable application. SMEs' lower mean score of 0.33 and higher standard deviation of 0.471 suggest that while there is an understanding of diversity's importance, its implementation is not as effective or consistent.

Figure 8 GRI Social Standards (Leaders vs SMEs) – GRI17-GRI25



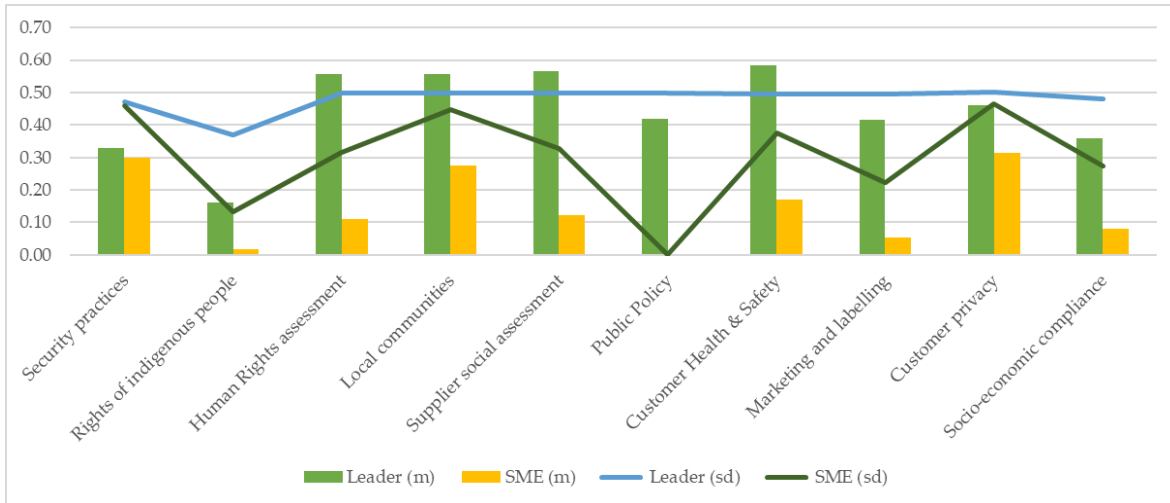
In non-discrimination (GRI22), leaders' mean score is 0.60 with a standard deviation of 0.491 while that of SMEs is 0.16 with a standard deviation of 0.371. Although leaders are more efficient at implementing non-discrimination policies, high standard deviation suggests uneven application of these practices throughout the firm. Increased training and awareness programs for SMEs with lower mean and standard deviations could have helped since they are not well-experienced. Concerning collective bargaining and freedom of association (GRI23), the average disclosure is lower for both groups (leaders=0.42 and mSMEs=0.04), but the higher

standard deviation for leaders (Sd=0.497) compared to SMEs (Sd=0.199) suggests a higher variability in terms of disclosure practices among leaders.

For security practices (GRI26), leaders have an average score (m=0.33) slightly higher than that of SMEs (m=0.30), suggesting leaders are somewhat more engaged in implementing appropriate security disclosures. In protecting the rights of indigenous people (GRI27), the leaders' mean score is notably low (m=0.16) with a relatively small standard deviation (Sd=0.369), indicating minimal engagement but some degree of consistency in whatever practices are in place. SMEs score even lower (m=0.02), with a very low standard deviation (SD=0.132), suggesting both a lack of engagement and consistent practices across the board. Human rights assessments (GRI28) show a significant difference, with leaders scoring a mean of 0.56, indicating a stronger focus on human rights practices compared to SMEs, who average 0.11. The similar standard deviation (leaders at 0.499 and SMEs at 0.315) suggests variability in both groups.

Engagement with local communities (GRI29) is more pronounced among leaders (m=0.56) compared to SMEs (m=0.27), with both groups displaying a high standard deviation (leaders at 0.499 and SMEs at 0.448). Leaders also score higher in supplier social assessment (GRI30) (m=0.57) and customer health & safety (GRI32) (m=0.58), demonstrating a commitment to social responsibility in the supply chain and customer welfare. However, the high standard deviations (Sd=0.498 and 0.495, respectively) indicate a wide variance in how these standards are applied. Moreover, Marketing, and labelling practices (GRI33) also show higher leader engagement (m=0.42) over SMEs (m=0.05), with a considerable standard deviation in the leader group (Sd=0.495) suggesting the varied application of marketing standards.

Figure 9 GRI Social Standards (Leaders vs SMEs) – GRI26–GRI35

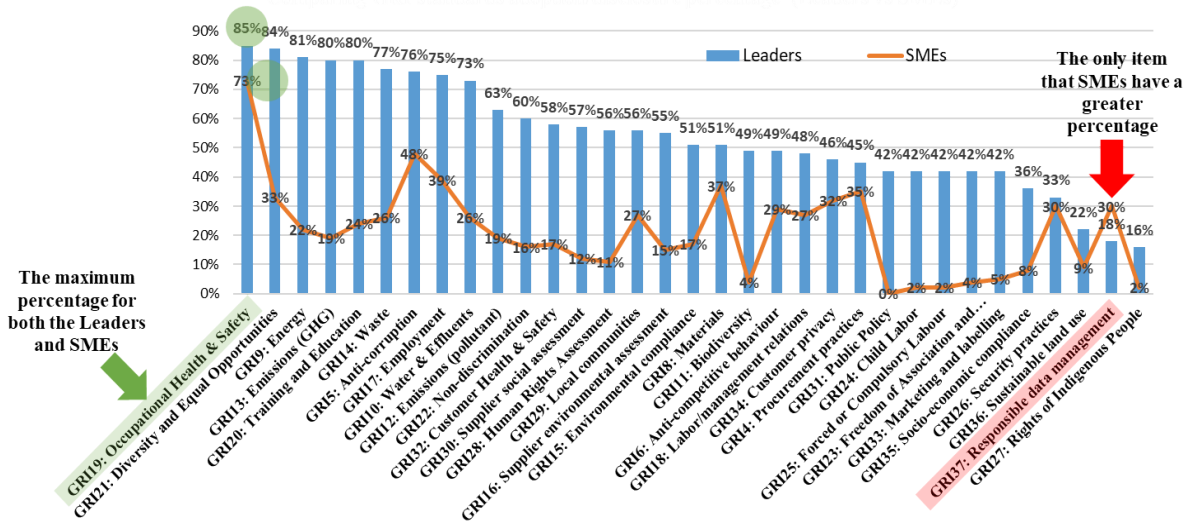


In customer privacy (GRI34), leaders average higher ($m=0.46$) than SMEs ($m=0.32$), yet the high standard deviation for leaders ($Sd=0.501$) compared to SMEs ($Sd=0.466$) denotes inconsistency among leaders in protecting customer data. Lastly, socio-economic compliance (GRI35) has a low mean score for both leaders ($m=0.36$) and SMEs ($m=0.08$), with leaders showing a wider variability ($Sd=0.482$) compared to SMEs ($Sd=0.275$), which could be due to the complex nature of socio-economic issues and the varying degrees of regulatory environments across different operational areas.

2.3.5 Leaders and SMEs – Statistical tests

In this subsection, we examine the main statistical differences between leaders and SMEs when looking at the 35 GRI. Figure 10 analysis compares the GRI standards adoption and disclosure between SMEs and leader companies considering all the indicators. Accordingly, “occupational health and safety (GRI19)” has the maximum share in implementing relevant practice and disclosure in both SMEs and leader firms. This may be related to the available compulsory rules about the safety of workers which have been implemented for many years. Moreover, this figure shows that the leading companies are more interested in all the standards (except “responsible data management, GRI37”) compared to SMEs.

Figure 10. GRI Standards (Leaders vs SMEs)



The leaders have more access to a big data analysis approach to evaluate various aspects of their businesses. This gives them a higher responsibility regarding responsible data management which requires more attempts to achieve this goal. Moreover, the analysis indicates that leaders are investing more in practices related to improving diversity, energy consumption, emissions, training, waste, and anti-corruption compared to activities related to sustainable land use, security practices, socio-economic compliance, marketing, and labelling, forced compulsory labour and child labour.

We conduct a statistical test to discern any significant differences in adoption rates between these two groups, aiming to provide a robust understanding of the current landscape and inform future strategies to promote sustainable practices across all business sizes. We performed a Pearson Chi-Square test to evaluate distinctions between SMEs and industry leaders. Through this Pearson Chi-Square test, we highlighted standards with significant differences, aiming to establish a robust statistical method for identifying variations in GRI standards adoption between these groups. Significant differences in standards are denoted with . In instances where information was unavailable, indicated by "-", concluding was not feasible. The analysis was conducted using IBM SPSS v.25.

The findings revealed significant variations between SMEs and leaders across multiple GRI standards. Leaders surpassed SMEs in disclosing practices related to Anti-corruption (76.42% vs. 47.95%, $\chi^2 = 21.889^{***}$), Anti-competitive behaviour (49.06% vs. 29.24%, $\chi^2 = 11.046^{***}$), Biodiversity (49.06% vs. 4.09%, $\chi^2 = 78.920^*$), Emissions (Pollutant) (63.21% vs. 18.71%, $\chi^2 =$

56.407***). Significant differences were also observed in the areas of Employment (74.53% vs. 38.60%, $\chi^2 = 33.869^{***}$), Labor/Management Relations (48.11% vs. 26.90%, $\chi^2 = 12.940^{***}$), Human Rights Assessment (55.66% vs. 11.11%, $\chi^2 = 64.197^{***}$), Supplier Social Assessment (56.60% vs. 12.28%, $\chi^2 = 62.130^{***}$), Public Policy (41.51% vs. 0.00%, $\chi^2 = 84.385^{***}$), Marketing and Labelling (41.51% vs. 5.26%, $\chi^2 = 55.563^{***}$), Socio-economic Compliance (35.85% vs. 8.19%, $\chi^2 = 32.837^{***}$), Sustainable Land Use (21.70% vs. 8.77%, $\chi^2 = 9.237^{***}$), and Responsible Data Management (17.92% vs. 29.82%, $\chi^2 = 4.907^{**}$). No significant differences were found under the disclosure of Security practices ($\chi^2 = 0.312$), with both SMEs and leaders presenting a low disclosure rate (about 30%).

These findings highlight the disparities in sustainability reporting practices between SMEs and industry leaders. Leaders demonstrate a higher level of commitment to implementing and reporting on sustainable practices and corporate social responsibility initiatives across a range of GRI standards. The observed significant differences underscore areas where SMEs lag leaders in terms of disclosing their practices. These findings underscore the importance of SMEs enhancing their efforts to align with global sustainability standards and improve their disclosure practices to bridge the gap with industry leaders.

These findings can be discussed considering the results from the KPMG research on sustainability reporting. The KPMG Survey of Sustainability Reporting conducted in 2022 sheds light on the disclosure practices of leading companies worldwide. The study encompasses the disclosure practices of the G250, consisting of the top 250 companies by revenue, as well as an expanded sample of the top 100 businesses in each of 58 countries, known as the N100 (KPMG, 2022).

According to the KPMG research, sustainability reporting is becoming increasingly important within the business landscape, with a high percentage of companies reporting on sustainability or ESG matters. The study indicates that 96% of the G250 companies and 79% of the N100 companies engage in sustainability reporting (KPMG, 2022). This aligns with the analysis findings that highlight the higher levels of disclosure among industry leaders in various GRI standards. The leaders in the sample demonstrate a greater commitment to implementing and reporting on sustainable practices, which is consistent with the broader trend of sustainability reporting observed by KPMG.

The KPMG research also highlights the significance of carbon reduction as a widely disclosed topic, with a high percentage of companies reporting on their efforts in this area. Specifically, 80% of the G250 companies and 71% of the N100 companies disclose their carbon reduction initiatives (KPMG, 2022). This finding is consistent with the analysis results, where leaders demonstrate higher levels of disclosure in areas such as Emissions (Pollutant) and Emissions (GHG). It suggests that companies, especially industry leaders, recognize the importance of addressing climate change and are actively reporting their efforts to reduce carbon emissions.

However, the KPMG research also emphasizes an area that requires further attention: biodiversity reporting. The study reveals that less than half of the surveyed companies, 46% of the G250 companies and 40% of the N100 companies, report on biodiversity-related issues (KPMG, 2022). This finding is consistent with the analysis results, which indicate a significant disparity in the disclosure of biodiversity practices between SMEs and leaders. SMEs show a much lower level of disclosure in the Biodiversity GRI standard compared to leaders. These findings highlight the need for enhanced focus and disclosure on preserving and protecting biodiversity within sustainability reporting practices, both for SMEs and leaders. Overall, while the analysis findings demonstrate disparities in sustainability reporting practices between SMEs and industry leaders, they align with the broader trend identified by the KPMG research, which highlights the growing importance of sustainability reporting.

2.3.6 Correlation between GRI practices disclosure

Hereby, we calculate the correlations between different GRI practice disclosures. Understanding the correlation between these disclosures is vital; it indicates how reporting on one area may relate to or affect reporting on another. This is crucial for identifying which sustainability practices are frequently addressed together, which can signal to stakeholders the integrated nature of a company's sustainability efforts. It also helps organizations to ensure that their reporting is comprehensive and reflects the interconnectedness of various sustainability issues, which is essential for accurate and transparent reporting to all stakeholders interested in the organization's impact on sustainability.

To analyse the correlations, we performed a heatmap based on the correlations in RStudio. In the heatmap (Figure 11), each square represents the correlation between the practices on the x-axis and y-axis. The dendrogram – the tree-like structures on both axes – groups together

practice that have similar profiles based on their correlations. The colours indicate the strength of the correlation: red squares signal a strong positive correlation, meaning that as one practice is reported more extensively, the other tends to be as well. Blue squares would indicate a negative or very low correlation, meaning that there is no strong relationship between how those two practices are reported. Yellow to light blue squares represent a moderate correlation, suggesting a more nuanced or less consistent relationship between the reporting of those practices.

Additionally, we calculated the correlation matrix using the Pearson correlation coefficient (following the methodology of Khan et al., 2023), in IBM SPSS – see **Appendix 3**. The observed significant correlations are denoted by significant correlations at the 0.01 level (2-tailed) – highlighted with “***” and significant correlations at the 0.05 level (2-tailed) – highlighted with “**”. This underscores the interdependencies and potential co-adoption patterns among diverse GRI practices.

The analysis of the heatmap alongside the correlation matrix reveals the intricate relationships between various GRI practices, providing a strategic perspective on corporate sustainability efforts. Notably, the correlation between Supplier Environmental Assessment (GRI16) and Supplier Social Assessment (GRI30) ($r=0.654^{**}$) suggests that companies are not treating environmental and social considerations as separate entities but are integrating them into their supplier evaluations. This integrated approach is in line with broader Environmental, Social, and Governance (ESG) frameworks, emphasizing the holistic assessment of suppliers.

A similarly strong correlation is observed between Procurement practices (GRI4) and Anti-corruption (GRI5) ($r=0.458^{**}$), indicating that firms with well-developed procurement policies are also proactive in their anti-corruption efforts. This link likely stems from the recognition of the inherent risks of corruption within procurement processes and the understanding that robust anti-corruption measures are essential for risk mitigation and preserving organizational integrity.

Furthermore, the significant correlation between Occupational Health & Safety (GRI19) and Training and Education (GRI20) ($r=0.570^{**}$) underlines that organizations committed to workforce development also place great importance on safety practices. This could reflect a

policy-driven approach where training is viewed as a fundamental component of a comprehensive health and safety program.

In addition, the strong correlation between Training and Education (GRI20) and Diversity and Equal Opportunities (GRI21) ($r=0.465^{**}$) implies that companies dedicated to employee development are simultaneously focusing on creating diverse and equitable workplaces. This indicates that training programs are likely being leveraged to enhance understanding and implementation of diversity policies.

Moreover, the correlation between Diversity and Equal Opportunity (GRI21) and Non-discrimination (GRI22) ($r=0.412^{**}$), shows that non-discrimination and diversity are very connected. Companies not only advocate for diversity but actively enforce policies against discrimination, ensuring that diversity is not merely represented but is genuinely operationalized within the company. Even though diversity brings different perspectives and backgrounds, it fosters creativity and innovation. However, without inclusion (non-discrimination)—where these diverse voices are heard and valued—the benefits of diversity are lost, leading to a potentially toxic environment.

In terms of environmental management, the correlation between Energy (GRI9) and GHG Emissions (GRI13) ($r=0.545^{**}$), as well as between Energy (GRI9) and Water & Effluents (GRI10) ($r=0.510^{**}$), suggests that companies are adopting a coordinated approach to managing their environmental impact. Energy efficiency initiatives appear to go hand in hand with reductions in both GHG emissions and water usage, reflecting a comprehensive resource management strategy aimed at sustainability and operational efficiency.

Additionally, the relationship between Biodiversity (GRI11) and Environmental Compliance (GRI15) ($r=0.372^{**}$), suggests that firms with a focus on biodiversity also exhibit a strong adherence to environmental regulations. This may indicate that companies are responding to both ecological concerns and regulatory pressures, particularly in regions with rich biodiversity.

Lastly, the connection between Local Communities (GRI29) and Human Rights Assessment (GRI28) ($r=0.349^{**}$), illustrates that firms engaging with local community concerns are also thorough in their human rights evaluations. This reflects a broader CSR strategy that views community relations and human rights as complementary aspects of a company's social responsibilities.

Our analysis, through the examination of a heatmap and correlation matrix, has uncovered significant relationships between various GRI practices, offering a strategic lens on corporate sustainability efforts. We discuss now, some managerial implications that might derive from the analysis of these correlations.

The correlation between Supplier Environmental Assessment (GRI16) and Supplier Social Assessment (GRI30) indicates that companies are integrating environmental and social considerations in their supplier evaluations, rather than treating them as separate entities. This integrated approach aligns with the broader Environmental, Social, and Governance frameworks, as confirmed in the research of Eccles et al. (2012), emphasizing holistic assessments in line with ESG principles.

Similarly, the strong correlation between Procurement practices (GRI4) and Anti-corruption (GRI5) suggests that companies with well-developed procurement policies are also proactive in anti-corruption efforts. This likely stems from a recognition of the inherent corruption risks within procurement processes and an understanding that robust anti-corruption measures are essential for risk mitigation. Porter and Kramer (2011) have highlighted how such integrated strategies can enhance corporate reputation and stakeholder trust, affirming our findings.

Moreover, the significant correlation between Occupational Health & Safety (GRI19) and Training and Education (GRI20) underlines the connection between workforce development and safety practices. This could indicate a policy-driven approach where training is integral to health and safety programs, resonating with Cascio and Aguinis (2008) who emphasize the role of training in fostering a safe and inclusive work environment.

Moreover, the strong correlation between Training and Education (GRI20) and Diversity and Equal Opportunities (GRI21) and the correlation between Diversity and Equal Opportunity (GRI21) and Non-discrimination (GRI22) shows that companies are not only advocating for diversity but also actively enforcing anti-discrimination policies. This reflects the critical need for inclusion alongside diversity, a concept supported by Porter and Kramer (2011), who assert the importance of creating an inclusive environment where diverse voices are heard and valued.

In environmental management, the correlations between Energy (GRI9), GHG Emissions (GRI13) and Water and effluents (GRI10) suggest that companies are adopting coordinated strategies for managing environmental impact. This comprehensive approach to resource management

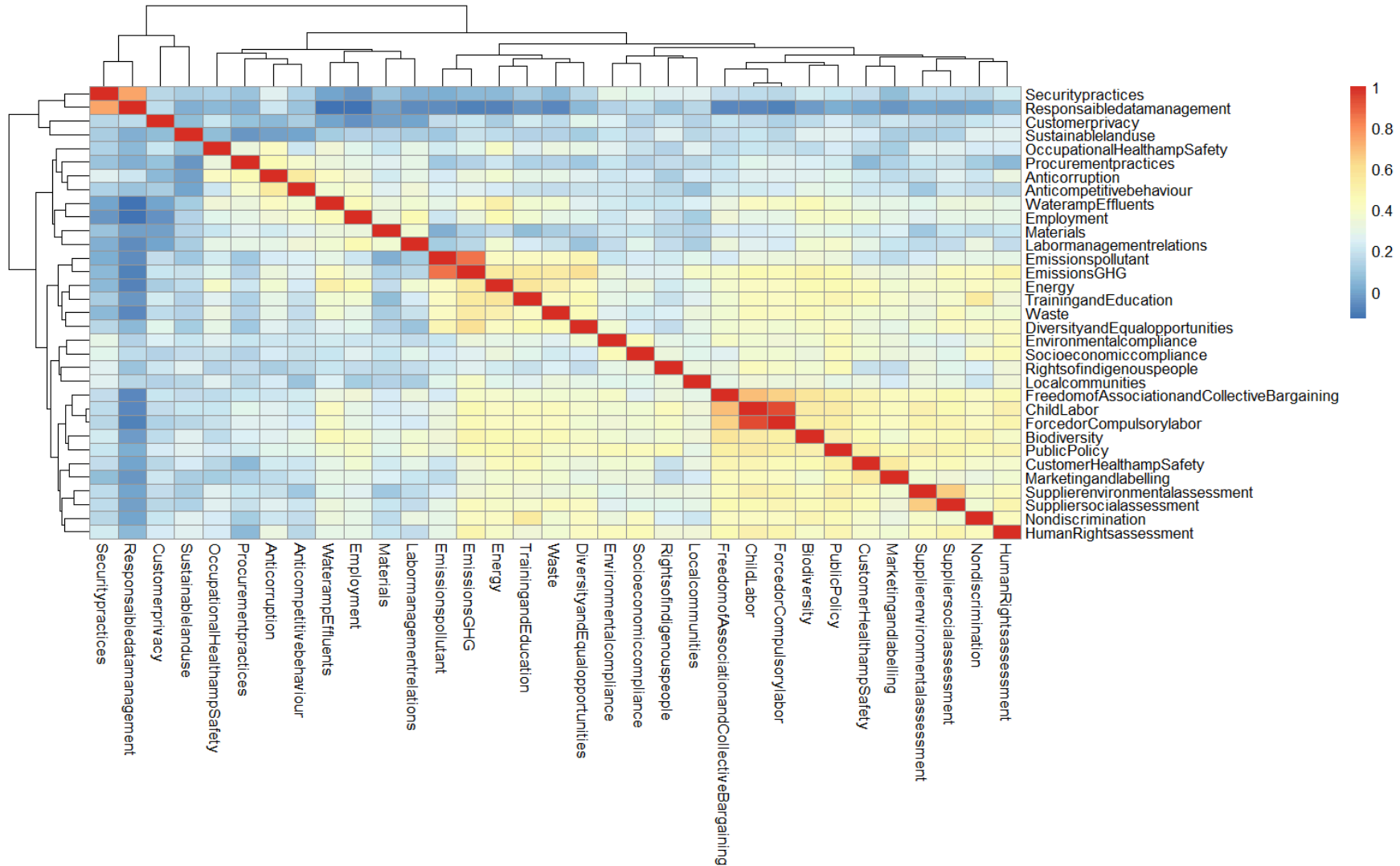
is consistent with the findings of McCarthy et al. (2020), who emphasize the interconnectedness of energy and environmental strategies.

The relationship between Biodiversity (GRI11) and Environmental Compliance (GRI15) ($r=0.372^{**}$) indicates that companies focusing on biodiversity are also adhering strongly to environmental regulations, a point that Kelijn and Sutherland (2003) have noted as critical for maintaining ecological balance, as biodiversity can have a very positive impact in the environment and vice-versa.

Lastly, the connection between Local Communities (GRI29) and Human Rights Assessment (GRI28) illustrates that companies engaging with local communities are also thorough in their human rights evaluations. This reflects a comprehensive CSR strategy that considers community relations and human rights as complementary aspects of a company's social responsibilities, an approach supported by Ruggie (2013) in his framework on corporate responsibility to respect human rights.

In essence, the strategic integration of sustainability reflects the shifting paradigm where sustainability becomes inseparable from the organization's overall strategy, guiding principles, and daily operations. This integrated mindset ensures that sustainability is not an afterthought but a driving force that shapes business practices, leading to more resilient, responsible, and ethically grounded organizations.

Figure 11. GRI Standards Correlations



2.4 GRI practices adoption per sector

This section gives a clear overview of sustainability practices in different sectors, using the GRI standards as a framework. Section 4.3.1. to 4.3.8 assesses each sector's sustainability performance based on key indicators, including human rights and environmental compliance. Then, section 4.3.9. performs a comparison across the main sectors. This analysis helps to understand how various sectors are performing in terms of sustainability, identifying both their achievements and areas where improvement is needed.

2.4.1 Agri-food Sector

The Agri-food sector demonstrates varying levels of adoption of GRI standards. Notably, the sector exhibits a high adoption rate of Occupational Health and Safety (GRI19) and Anti-corruption (GRI5) standards at 77.00% and 62.00% respectively. However, it places lower importance on standards such as the Rights of Indigenous People (GRI27) and Sustainable Land Use (GRI36), which have adoption rates of only 12.00% and 23.00%. This suggests a strong focus on ensuring employee well-being and ethical conduct, while matters related to indigenous rights and sustainable land use appear to be of lesser concern. Figure 12 exhibits GRI standards with more than 50% disclosure.

We can find the main reason for investing in health and safety (GRI19) in the report published by the International Labour Organization² which mentions that more than one-third of the labour force belongs to agriculture and meanwhile, it is one the most hazardous of all economic sectors. Moreover, it is known as the largest sector for employing women noting that it also has approximately 70% of child labour worldwide. Additionally, the benefits of new technologies such as nanotechnology for agriculture and the food industry still need to be balanced against concerns for environmental issues as well as the occupational health of workers (Sekhon, 2014). So, considering GRI19 as one of the priorities in this sector is a necessity and the output of analysing the dataset shows that a major part of the companies is investing in improving this indicator.

2

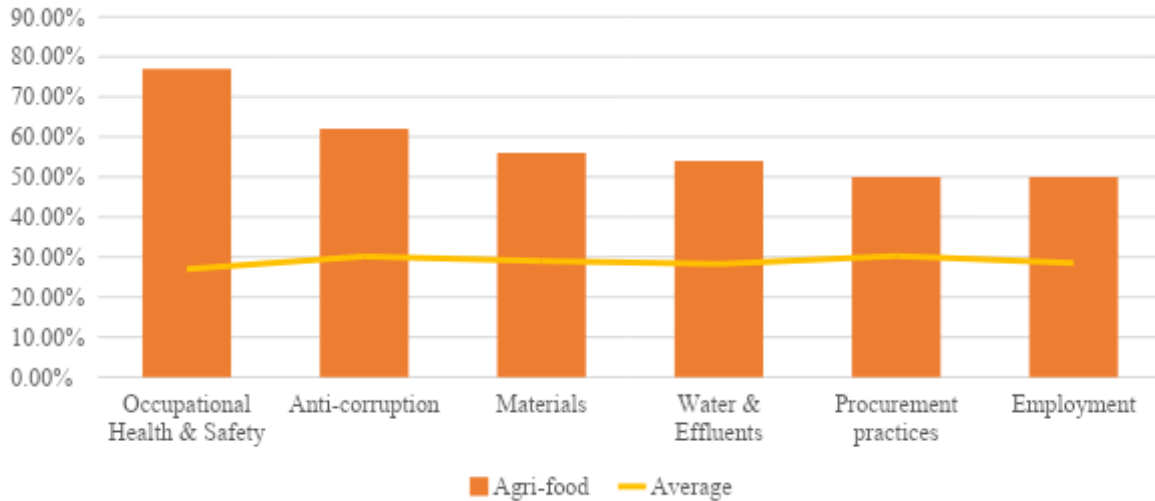
https://www.ilo.org/global/topics/safety-and-health-at-work/normative-instruments/code-of-practice/WCMS_161135/lang--en/index.htm

In terms of anti-corruption (GRI15), this sector is working on the relevant indicators to enhance them and as mentioned before, 62% of the companies are taking actions regarding it. According to the report of the European Commission, in 202³, although the business environment is improving in Italy, strengthening its public administration, justice system and anti-corruption standards remains a challenge. There is substantial progress in fighting tax evasion and some progress in items like “ensuring that active labour market and social policies are effectively integrated and reach out to vulnerable groups” but only limited progress in “improving the effectiveness of the fight against corruption, by reforming procedural rules to reduce the length of criminal trials”. Anti-corruption is one of the main frontiers in the agri-food sector and food fraud not only causes economic losses but leads to a serious threat to human health (Antonucci et al., 2019). Hence, companies in this sector should make more investments in improving the anticorruption indexes and revealing their actions in their annual reports. As the immutable food and transactions register enables source identification of foodborne illness, it can be a potential solution to avoid fraud by using proper digital technologies such as blockchain which promotes on-farm data sharing (Antonucci et al., 2019).

The results of our analyses show even though we are facing global warming challenges and serious environmental issues, this sector is not interested in Sustainable Land Use (GRI36). Land use impacts are widely acknowledged to have profound consequences for biodiversity, water quality, and climate. For instance, Oil is the world’s number one fruit crop as in the last five years it has been used widely for making half of all consumer goods, from soaps and detergents to breakfast cereals and biofuels and consequently caused the clearing and burning of huge tracts of rainforests to open land for palm oil plantations (Notarnicola et al, 2012.). This is not only related to the firms that are investing in palm oil cultivation but also the producers of food and detergent products remain responsible for the profound consequences. So, it seems although sustainable land use is a crucial factor in sustainable development it is ignored by most of the firms.

Figure 12. Agriculture – Most disclosure GRI practices (>=50%)

³ <https://osservatoriocpi.unicatt.it/ocpi-cpi-Country%20Report%20Italy%202020.pdf>



2.4.2 Education Sector

The Education sector actively embraces GRI standards, with all firms adopting Occupational Health & Safety (GRI19), reflecting a commitment to maintaining a safe environment. This aligns with Fissi et al.'s research (2021), emphasizing schools' role in constructing a sustainable society, prioritizing factors related to the health, safety, and welfare of society. Moreover, the sector demonstrates a significant emphasis on Diversity and Equal opportunities (GRI21), with a high adoption rate of 67.00%. However, standards like Child Labor (GRI24) and Forced or Compulsory labour (GRI25) have minimal significance, each showing a 0.00% adoption rate. This highlights the sector's strong dedication to diversity and safety in the workforce, along with an absence of concerns related to child and forced labour. Figure 13 exhibits GRI standards with more than 50% disclosure.

Based on the report published by the European Agency for Safety and Health at Work⁴ the educational workplace is shared between students and pupils, and it has its hazards as many other workplaces as these people can be vulnerable, being young, inexperienced, and often ignorant of safety and health hazards. So, educational workplaces require a safe working environment, continuous maintenance, fire safety and emergency planning, health and safety in laboratories and workshops, and avoiding musculoskeletal disorders

4

https://osha.europa.eu/sites/default/files/Factsheet_46_-_Occupational_safety_and_health_in_the_education_sector.pdf

as well as violence and bullying. According to the outputs of the sample data analysis, the educational sector is providing reports about Occupational Health & Safety (GRI19) regarding this issue, and it is considered one of their priorities.

The inclusion and diversity in the educational system are not limited to culture and race and they include facets of gender issues, sexual orientation, and physical and mental disability (Shahi, 2021). The educational sector should consider fairness, equality and justice amongst students besides providing equal job opportunities for all genders. In the sample data, 67% of the firms announced being active and acting for enhancing their performance in Diversity and Equal opportunities indicators but there is still a long way to achieve main sustainable goals efficiently. According to the report published by the European Commission (European Education Area)⁵ the concrete issues regarding “Inclusive education, equality, equity, non-discrimination and the promotion of civic competencies” are as follows which should be considered in the educational sector for improvement:

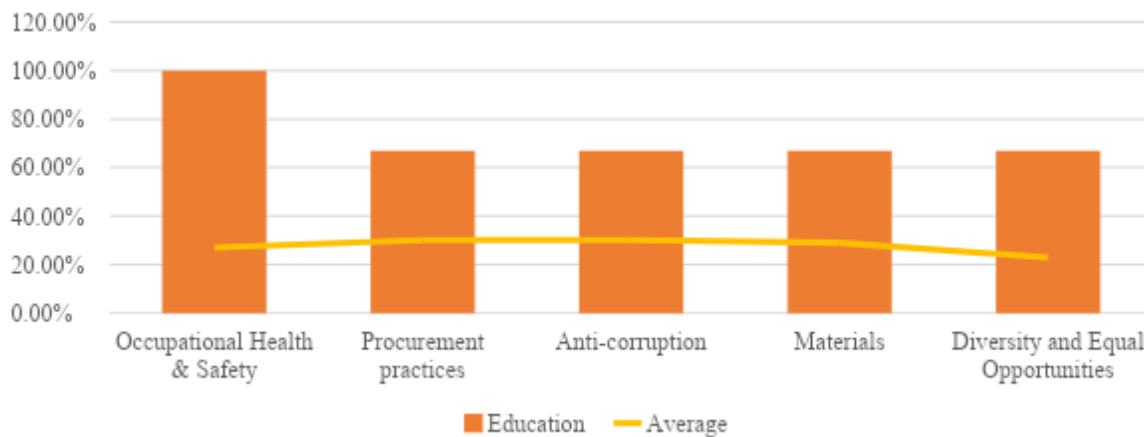
- Addressing the increasing diversity of learners and enhancing access to quality and inclusive mainstream education and training for all learners.
- Addressing the issue of gender gaps in education and training, unequal opportunities for women and men, and promoting more gender-balanced educational choices.
- Facilitating the effective acquisition of the language(s) of instruction and employment by migrants through formal and non-formal learning.
- Promoting civic, intercultural, and social competencies, mutual understanding and respect, and ownership of democratic values and fundamental rights at all levels of education and training.
- Enhancing critical thinking, along with cyber and media literacy.

The analysis of the sample data shows nothing regarding the is nothing mentioned regarding Child Labor (GRI24) and Forced or Compulsory labour (GRI25). This may be related to not using child labour in the education sector of Italy, but we should not forget that the education system is indirectly responsible for child labour and compulsory labour

⁵ <https://education.ec.europa.eu/focus-topics/improving-quality/inclusive-education>

as some research shows that parents with no or low education are more likely to choose work options for their children (Nkamleu and Kielland, 2006). Therefore, the education sector needs to take more serious action toward the proposed sustainability goals by providing more learning opportunities for everyone.

Figure 13. Education – Most disclosure GRI practices (>=50%)



2.4.3 Engineering Sector

The Engineering sector highlights varying levels of engagement with GRI standards. Notably, it places substantial emphasis on Occupational Health and Safety (GRI19), with an impressive adoption rate of 89.00%, and Diversity and Equal Opportunities (GRI21), with a notable rate of 70.00%. This aligns with the Royal Academy of Engineering's ethical perspective report (2011), which reinforces the engineering companies' path towards a more ethical and socially responsible world. However, the sector demonstrates limited focus on Emissions (pollutant) (GRI12), Emissions (GHG) (GRI13), and Local communities (GRI29), each having a 0.00% adoption rate. This suggests a strong commitment to ensuring employee well-being and promoting diversity, while concerns related to emissions and community engagement are less prioritized. Figure 14 exhibits GRI standards with more than 50% disclosure.

The main goals of Occupational Safety and Health (GRI19) in the engineering sector are related to enhancing injury, occupational disease, and damage by analysing operating

procedures and conditions at work sites. Based on the report of Eurostat⁶ the rate of fatal accidents at work in the EU in 2019 was 1.7 incidents per 100000 persons employed and this rate was 2.1 for Italy in the same year which is greater than the average rate of the EU and it is greater than the rate of countries such as the Netherlands (0.5 incidents per 100000 persons) and Sweden (0.7 incidents per 100000 persons). However, it is much better than the rate related to France (3.5 incidents per 100000 persons) and Bulgaria (3.4 incidents per 100000 persons). The results of analysing the sample data show most of the firms have plans to improve this index.

In terms of Diversity and Equal Opportunities (GRI21), according to the statistics provided by the European Institute for Gender Equality⁷ Italy improved its score in the domain of work (The domain of work measures the extent to which women and men can benefit from equal access to employment and good working conditions) since 2005 (now it is estimated 63.2). The full-time equivalent (FTE) employment rate for women is much lower than men Although the gender gap decreased it requires more effort to reduce this gap compared to the average gender gap in the EU. However, the engineering sector is considering GRI21 in its sustainability goals based on the sample data analysis (70%).

The data analysis regarding environmental issues like Emissions (pollutants) (GRI12) and emissions (GHG) (GRI13) shows low participation in implementing actions and projects to mitigate these issues and providing them in the annual reports.

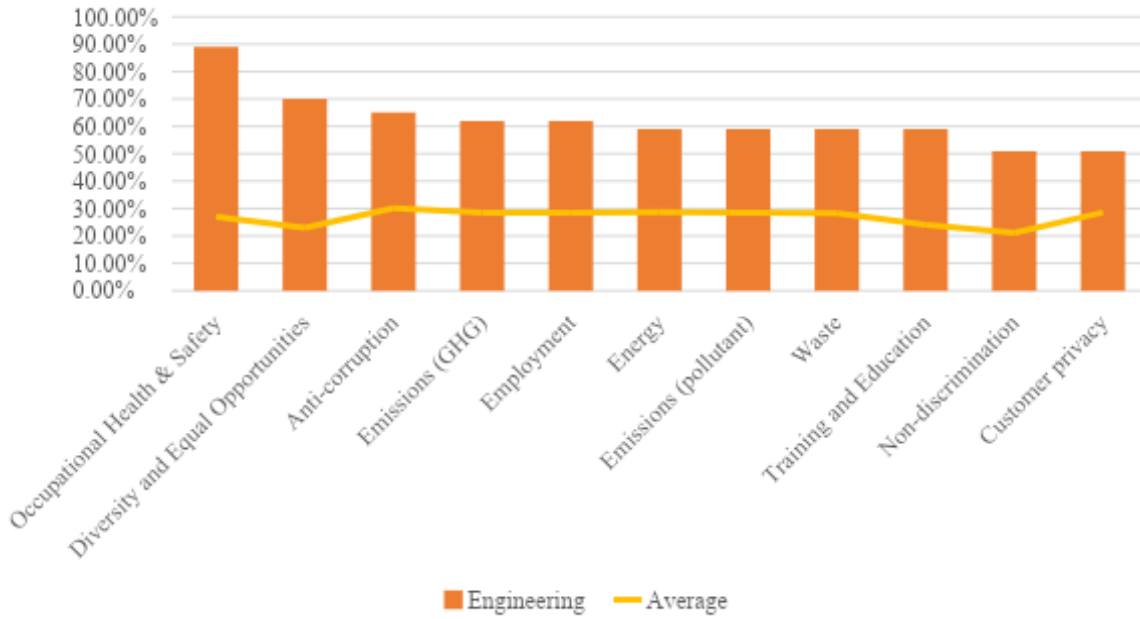
The European Environmental Agency⁸ provides some sustainability initiatives for industries which should be considered by the engineering sector to improve its performance in the relevant indexes. For instance, the widespread adoption of environmental management practices through the European Eco-Management and Audit Scheme (EMAS) and ISO14001 and having Voluntary Corporate Social Responsibility (CSR) initiatives to achieve social and environmental objectives beyond the legal requirements.

Figure 14. Engineering – Most disclosure GRI practices (>=50%)

⁶ https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Accidents_at_work_statistics

⁷ <https://eige.europa.eu/gender-equality-index/2019/domain/work/IT>

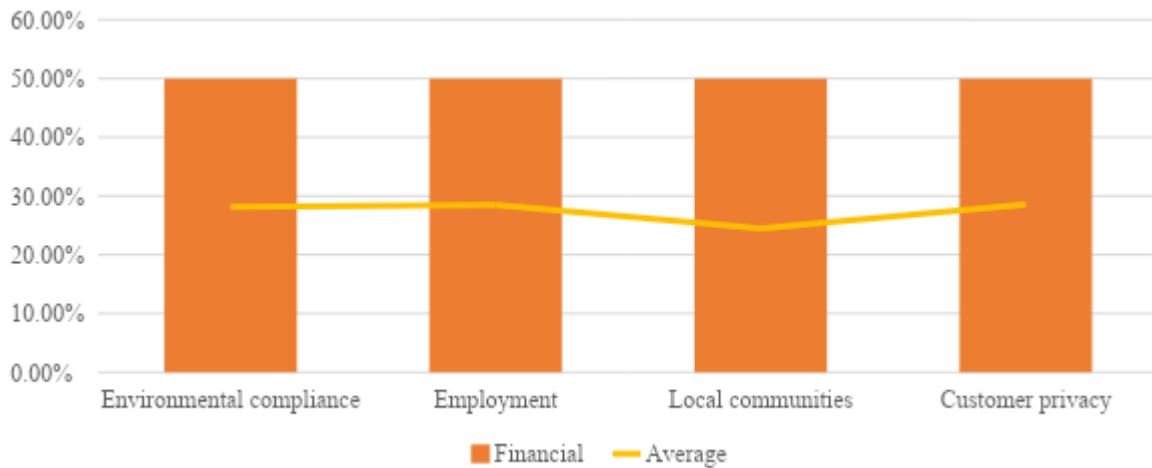
⁸ <https://www.eea.europa.eu/themes/industry/intro>



2.4.4 Financial Sector

The Financial sector actively addresses specific GRI standards. Notably, it demonstrates a robust focus on Diversity and Equal opportunities (GRI21) and Human Rights assessment (GRI28), with adoption rates of 67.00% and 47.00% respectively). This is aligned with the BankTrack report (2022) indicating improvements in human rights policy integration and diligence processes among banks. However, the sector exhibits limited attention to Marketing and labelling (GRI33), with a 14.00% adoption rate. This indicates the sector's commitment to promoting diversity and respecting human rights, while certain aspects of regulatory compliance and marketing receive less attention. Figure 15 exhibits GRI standards with more than 50% disclosure.

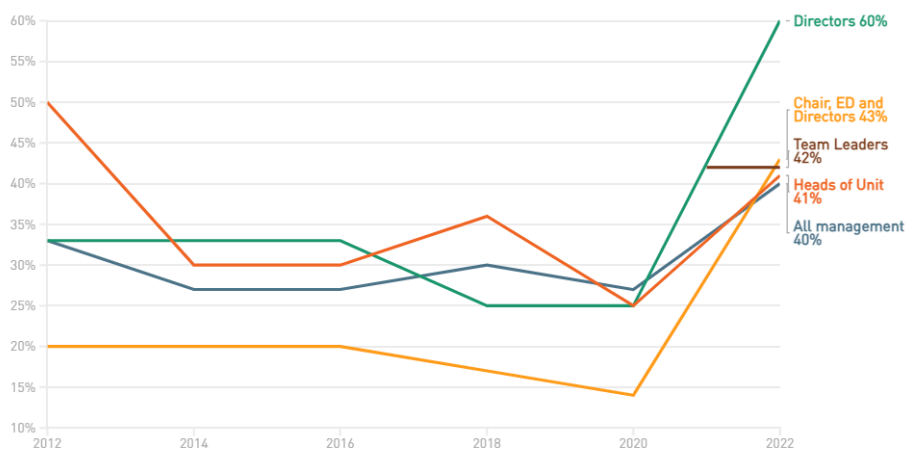
Figure 15. Financial– Most disclosure GRI practices (>=50%)



When diversity management gets more ingrained in the organization, the desire to serve is expected to grow as employees are respected, consistently protected, and treated equitably (Bizri, 2018). The European Banking Authority (EBA)⁹ pays the highest attention to ensuring equal chances for men and women and considers fair and equal opportunities for staff as well as the prevention of any discrimination at its core working culture. The following graph (

Figure 16) shows the percentage of women in leadership which shows an improvement between the years 2020 and 2022.

Figure 16 The percentage of women in EBA leadership based on the EBA report.



The Italian banking system is not so dramatically ranked among the EU countries as in the recent past. Although the number of women on the board of directors has tripled in ten years, the gender rebalance of the Italian banking system in management bodies could be considered rather satisfying. In non-listed banks, women are still relegated to an

⁹ <https://www.eba.europa.eu/about-us/diversity-and-inclusion>

under-represented position (13 per cent on boards of directors) which is 33 per cent in listed banks. Moreover, no CEOs are women in listed banks, and women are always more represented in non-executive functions (De Vita and Magliocco, 2018).

Proper labelling for services and products in the financial sector is a prerequisite for the uptake of green finance, and it can increase trust among customers and investors as it can be useful for analysing sustainability goals' performance. Accordingly, besides the marketing and labelling activities from traditional banking (offering financial products and services under its brand name), the projects of the white label (non-bank entities offering financial products and services using the infrastructure and licenses of a partnering bank) should be considered in the sustainability reports.

2.4.5 Healthcare Sector

The Healthcare sector places significant importance on Customer Health and safety (GRI32) and Occupational Health and Safety (GRI19), with adoption rates of 53.00% and 95.00% respectively. Additionally, the sector demonstrates a considerable focus on Anti-corruption (GRI5), with a high adoption rate of 84.00%. However, the sector exhibits limited attention to the Rights of indigenous people (GRI27), with a 0.00% adoption rate. This underscores the sector's commitment to ensuring patient and employee safety, coupled with robust measures to combat corruption. Figure 17 exhibits GRI standards with more than 50% disclosure.

These results are aligned with the healthcare core business. In the healthcare field, Customer Health and safety are very important, as a small delay in help or the giving of a patient's incorrect information could have fatal consequences. Patient health and safety are essential components of quality health care, making the quality of the service the key to its success.

In this context, it is possible to see that the healthcare sector actively prioritizes customer service, notably adopting a patient-centric approach. A very clear example of this was the response to the COVID-19 pandemic (Freshworks, 2022). The pandemic triggered a notable shift in consumer behaviour concerning medical and healthcare services. In

response to concerns about patient safety and the strain on healthcare facilities, the sector quickly answered by implementing virtual doctor consultations (Freshworks, 2022).

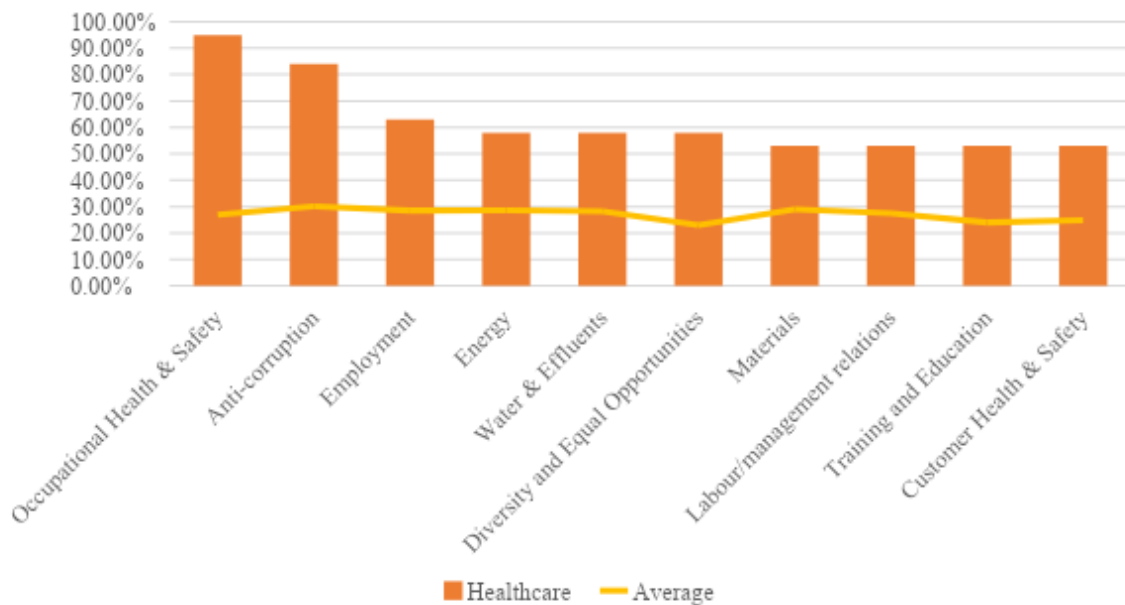
A report by PwC on global healthcare trends underscores this phenomenon, revealing that 91% of consumers have utilized video virtual clinical care and express their intent to continue doing so (PwC, n.d.). Furthermore, data from the Centres for Disease Control and Prevention highlights a remarkable 154% increase in telehealth usage in March 2020 compared to the same period in 2019 (CDCP, 2020).

Healthcare workers' Occupational Health and Safety are also of great importance. According to the European Commission, Directorate-General for Employment, Social Affairs, and Inclusion, (2011), about 10% of workers in the European Union belong to the health and welfare sector. These workers are often exposed to a variety of risks, raising the debate on the need for a careful approach to improving the protection and safety of hospital workers. Directorate-General for Employment, Social Affairs and Inclusion has released a report containing several important measures to be considered by hospitals to protect the safety and health of their workers.

In the Healthcare sector, corruption represents a significant threat to health systems due to factors such as extensive resource allocation, information disparities, the involvement of numerous stakeholders, complex system structures, fragmentation, and the globalized supply chain for pharmaceuticals and medical equipment (Hussmann, 2020). For the above reasons the health sector normally implements several anti-corruption practices, concentrating on specific issues, processes, or institutions, with comprehensive, strategic, and long-term initiatives remaining relatively rare (Hussmann, 2020).

Notably, international initiatives have arisen, particularly within the pharmaceutical sub-sector and health-related procurement, focusing on specific risk areas like drug pricing transparency and clinical trials. However, these tools often adopt a normative and prescriptive approach, failing to comprehensively address the intricate dynamics underlying corrupt behaviours (Hussmann, 2020).

Figure 17. Healthcare– Most disclosure GRI practices (>=50%)



2.4.6 Engineering Sector

In the ICT sector, Occupational Health, and Safety (GRI19) are notably emphasized, with adoption rates of 47.00%. Furthermore, Anti-corruption (GRI5) and Diversity and Equal opportunities (GRI21) also hold significant importance, with adoption rates of 47.00% each. However, the sector places less emphasis on Local communities (GRI29) and Biodiversity (GRI11), with adoption rates of 21.00% and 5.00% respectively. This suggests a focus on ensuring employee and customer safety, coupled with efforts to promote ethical conduct and diversity, while community and biodiversity concerns receive comparatively less attention. Figure 18 exhibits GRI standards with more than 40% disclosure.

Several compelling reasons underpin this strong focus on health and safety within the ICT sector. First and foremost, the ICT sector is inherently consumer-centric (Choy & Park, 2016). It delivers products and services that directly impact consumers and end-users, such as smartphones, computers, software applications, and online platforms (Choy & Park, 2016). Ensuring the health and safety of customers is paramount in maintaining trust, safeguarding reputation, and remaining competitive in the market. Any safety issues or breaches can result in substantial legal, financial, and reputational consequences (Choy & Park, 2016).

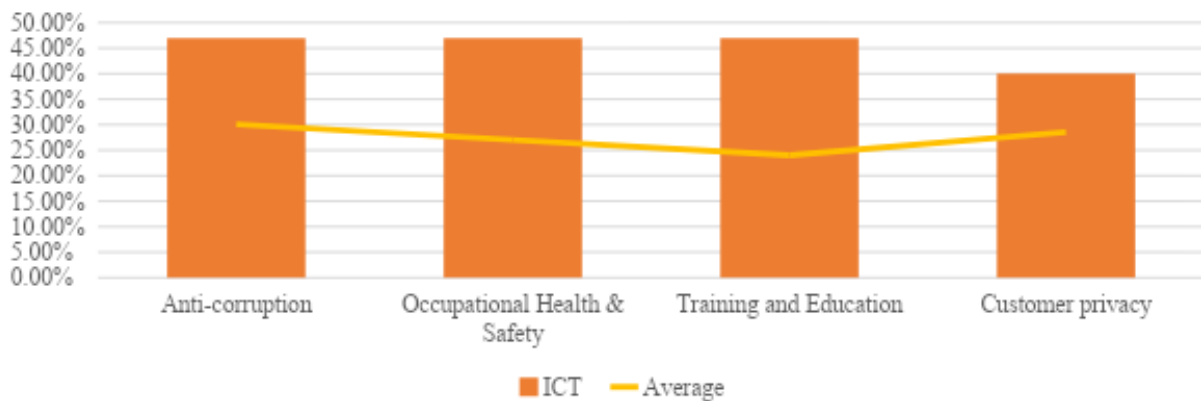
Moreover, the ICT sector operates within a highly regulated environment (ITU, 2021). Many countries have stringent regulations related to consumer safety and data protection. Compliance with these regulations is not just a legal requirement but also a fundamental way to build and maintain trust with customers. Failing to meet these standards can lead to severe penalties, lawsuits, and significant damage to a company's brand (ITU, 2021)

Occupational Health and Safety (GRI19) is also a vital consideration within the ICT sector. It encompasses the well-being of employees involved in the design, manufacturing, distribution, and maintenance of ICT products and services. Ensuring a safe working environment is not only a moral imperative but also contributes to increased productivity and employee satisfaction. Furthermore, the ICT sector often places a strong emphasis on corporate social responsibility (CSR) (Hasnaoui & Freeman 2010), demonstrating a commitment to customer and employee health and safety that aligns seamlessly with CSR objectives (Hasnaoui & Freeman 2010).

The ICT sector is characterized by intense market competition, with numerous players vying for market share (Zhu et al., 2023). In this context, emphasizing customer and occupational health and safety can serve as a powerful differentiating factor. Companies that prioritize these aspects can attract customers who place a premium on safety and well-being in their purchasing decisions.

Additionally, the ICT sector frequently relies on complex global supply chains, involving multiple suppliers and manufacturers (U.S. Department of Commerce, 2022). Ensuring health and safety standards are adhered to throughout these intricate supply chains is not only an ethical concern but also a strategic risk management approach. It helps prevent disruptions and potential liabilities that could arise from unsafe practices within the supply chain.

Figure 18. ICT– Most disclosure GRI practices (>=40%)



2.4.7 Manufacturing Sector

The Manufacturing sector exhibits a balanced distribution of emphasis on GRI standards. Notably, it demonstrates significant importance on Occupational Health and Safety (GRI19) and Anti-corruption (GRI15), with adoption rates of 86.00% and 59.00% respectively. Additionally, the sector places notable emphasis on Diversity and Equal opportunities (GRI21), with an adoption rate of 59.00% (see). However, the sector shows less focus on Biodiversity (GRI11) and Sustainable land use (GRI36), with adoption rates of 26.00% and 4.00% respectively. This reflects a commitment to employee well-being, ethical conduct, and diversity, while biodiversity and sustainable land use concerns receive less attention. Figure 19 exhibits GRI standards with more than 50% disclosure.

Several compelling reasons underpin this focus. First and foremost, the emphasis on Occupational Health and Safety (GRI19) underscores the sector's awareness of the importance of the health and safety of its workforce. Manufacturing operations often involve physically demanding tasks and potentially hazardous environments (Lean Suite, 2023). Manufacturing production technicians frequently stand for long periods; sit for long periods; and use their hands to handle, control, or feel objects, tools, or controls. Therefore, safeguarding employee well-being is essential to prevent accidents and maintain a healthy and productive workforce, in manufacturing firms (Jonathan & Mbogo, 2016).

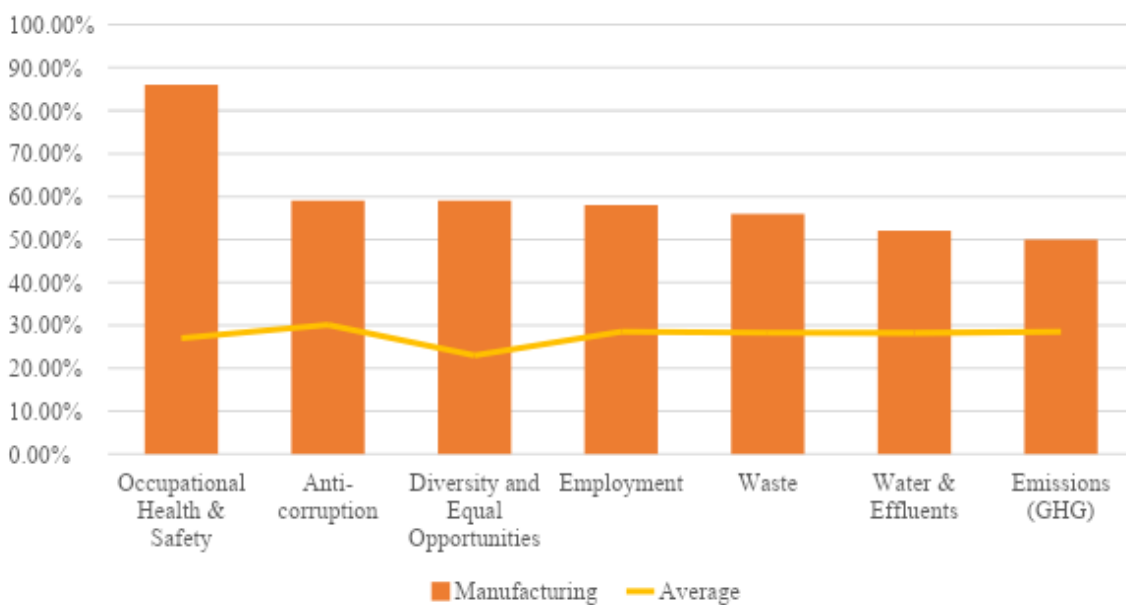
Additionally, according to the Chief Executive (n.d.), the manufacturing sector remains at high risk of exposure to bribery and corruption for myriad reasons. This happens for

different reasons. First, the manufacturing sector relies on decentralized operations and inventory storage in multiple areas. Second, the manufacturing sector relies on complex supply chains, which in turn rely on a network of distributors and agents. Third, these distributors and agents need contracts, licenses, permits, and clearances – often from government officials. Fourth, due to complex corporate structures, companies in the manufacturing sector may have difficulty ensuring they have proper oversight to follow their own anti-bribery and corruption policies.

For the above reasons, the manufacturing sector was ranked as the third highest in terms of cases of fraud, according to the Association of Certified Fraud Examiners' 2022 global study on occupational fraud. Given the possibilities of risk exposure, companies in the manufacturing sector must reinforce anti-corruption actions and international initiatives.

Equally noteworthy is the sector's emphasis on Diversity and Equal opportunities (GRI21) highlights the sector's proactive approach to fostering diverse and inclusive workplaces. Recognizing the value of diverse perspectives and talents, manufacturing companies strive to create environments where employees from all backgrounds can thrive, ultimately contributing to innovation and competitiveness. This is in line with a report from Deloitte.

Figure 19. Manufacturing– Most disclosure GRI practices (>=50%)



Deloitte's (n.d.) report states that organizations cannot have a robust talent strategy without a robust diversity strategy. Deloitte (n.d) stated that the manufacturing industry is already aware of this, as diversity has made its way to the top of the industry's list of priorities. Manufacturing companies of all sizes are taking the National Association of Manufacturers' Pledge for Action in the industry by 2030: a commitment to taking 50,000 tangible actions to increase equity and parity for underrepresented communities, creating 300,000 pathways to job opportunities for Black people and all people of colour.

2.4.8 Service Sector

The Services sector displays varying levels of emphasis on different GRI standards. Notably, Occupational Health & Safety (GRI19) is particularly significant, with an adoption rate of 80.00%. Similarly, Customer Health & Safety (GRI32) holds considerable importance, with an adoption rate of 56.00%. However, the sector exhibits limited focus on Biodiversity (GRI11) and Forced or Compulsory labour (GRI25), each having a 0.00% adoption rate. This suggests a strong commitment to ensuring the safety of both employees and customers, while concerns related to biodiversity and forced labour receive less attention. Figure 20 exhibits GRI standards with more than 50% disclosure.

Lucy Wright (2015) highlights that many organizations in the service sector recognize the value of offering occupational health services to their staff actively. Mental health problems and musculoskeletal issues rank high among the most common causes of both short- and long-term absences in the service sector.

Engaging in service jobs normally requires prolonged periods of sitting and immobility, which can actively have adverse effects on individual health (Wright, 2015). For these reasons, a lot of companies, in the service sector, try to incentive their workers to change their posture regularly. This can involve planning work so that movement is a part of their duties. Even the act of standing up and sitting down can actively contribute to improved health (Wright, 2015)

Additionally, being aware that sedentary workers often face significant physical fitness issues, as most of their working day is spent seated. Service companies try to call

attention to the dangers of not doing regular exercise outside of work, as sedentary employees are at risk of chronic conditions such as obesity, heart problems, and diabetes (Wright, 2015).

Moreover, concerning Customer Health & Safety, Service companies are increasingly conducting assessments of the health and safety impacts of services especially in healthcare services (Alotaibi & Federico, 2017). These increasing concerns are followed by a rise in the awareness of the potential benefits of a good service. A study conducted by Lonial & Raju (2015) shows that customer perceptions at the service attribute level can often be the key to the generation and management of customer satisfaction and loyalty.

Figure 20. Service– Most disclosure GRI practices (>=50%)



2.4.9 Comparison between sectors

In this section, we will conduct a comparative analysis of GRI standards adoption across different sectors. The data presented in **Appendix 4** illustrates the varying priorities and approaches embraced by different sectors.

Concerning environmental standards, the agri-food sector's leadership in Material (GR18) disclosure, indicated by a 56% rate, reflects its substantial impact on environmental and social issues. This high rate is not just a response to the sector's direct involvement in

these areas but also a result of growing demands from consumers and investors for greater transparency¹⁰. These stakeholders are increasingly concerned about sustainable practices, particularly in areas like packaging and production. The nature of the agri-food sector's products and supply chains, which are closely tied to environmental sustainability, further drives this trend.

In energy management (GRI9), the Engineering industry is notable for its 59% disclosure rate. This high level of disclosure is mainly due to the sector's significant energy requirements and its subsequent adoption of energy-efficient technologies, aligning with international standards such as EMAS¹¹ and ISO14001¹². Similarly, the Manufacturing sector demonstrates a strong commitment to energy efficiency. This focus is likely driven by a combination of factors, including the potential for cost savings and a growing awareness of environmental impacts.

For Water and effluent management (GRI10), the agri-food sector again leads with a 54% disclosure rate, significantly higher than the mere 20% in the Services sector. This discrepancy underscores the agricultural sector's heavy dependence on water resources. The importance of water sustainability is increasingly recognized, and supported by various governmental policies and programs, such as the Farm to Fork (F2F) strategy¹³. This strategy and similar initiatives highlight the critical role of water management in the sustainability of the agri-food sector.

Biodiversity disclosures (GRI11) are low across all sectors. The need for more robust policies to enhance disclosure is evident, considering the crucial role of biodiversity in maintaining ecological balance. In line with the UN's initiatives, the European Union is leading in implementing mandatory biodiversity reporting requirements for businesses. The Corporate Sustainability Reporting Directive (CSRD)¹⁴, approved by the European Council, requires firms to publish detailed information on their sustainability activities and impacts,

¹⁰ <https://phys.org/news/2021-02-consumers-demanding-sustainability-food-industry.html>

¹¹ https://green-business.ec.europa.eu/eco-management-and-audit-scheme-emas_en

¹²

<https://www.iso.org/iso-14001-environmental-management.html#:~:text=What%20does%20it%20do%20and%20an%20effective%20environmental%20management%20system>

¹³ F2F: https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

¹⁴

https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/comp-any-reporting/corporate-sustainability-reporting_en

including biodiversity. This legislative move indicates a shift towards recognizing and addressing the gap in biodiversity reporting.¹⁵

The Engineering and Manufacturing sectors exhibit higher levels of emissions disclosure (GRI12 and GRI13), illustrating their commitment to diminishing environmental footprints, a motivation largely influenced by regulatory pressures. This emphasis on emissions control is substantiated by research indicating significant energy use and greenhouse gas emissions within these sectors, necessitating a strategic focus on emissions management¹⁶. The Engineering sector, grappling with considerable industrial waste, leads in waste management disclosure (GRI14), reflecting an imperative for transparent strategies in waste reduction. This leadership in waste management is evidenced by the extensive, often dangerous waste produced by engineering firms, requiring adherence to rigorous government regulations and environmental laws¹⁷.

The Agri-food and Manufacturing sectors prominently feature in environmental compliance (GRI15), a likely consequence of their direct interaction with natural resources and the intricate nature of their supply chains. The agri-food supply chains, known for contributing to various environmental and social challenges, emphasize the need for sustainability standards to mitigate these issues, although these standards alone might not suffice for comprehensive sustainability (Meemken et al., 2021)

In Supplier Environmental Assessment (GRI16), the Manufacturing sector leads with a 36% disclosure rate, underscoring the complexities of its supply chains and the consequent environmental impact. This heightened focus on supplier environmental performance in manufacturing aligns with the sector's effort to integrate environmental considerations into its supply chain management. The integration of green supply chain practices, including the selection of environmentally responsible suppliers, is critical for manufacturing, reflecting its commitment to environmental stewardship (Zhang et al., 2020). The relatively lower disclosure rates in the agri-food and ICT sectors could be

¹⁵ <https://blog.protiviti.com/2023/03/07/biodiversity-reporting-requirements-have-arrived-is-your-firm-ready/>

¹⁶

<https://www.energy.gov/eere/amo/articles/us-manufacturing-energy-use-and-greenhouse-gas-emissions-analysis>

¹⁷ <https://www.recycling-magazine.com/2020/09/07/waste-management-in-engineering/>

attributed to their differing levels of direct environmental impact and the complexities inherent in their supply chains. It is expected an increase on the disclosure on the different environmental practices.

Looking ahead, the implementation of the Corporate Sustainability Due Diligence (CSDD) directive¹⁸ is poised to enhance disclosure levels among large companies. This directive will mandate comprehensive assessments and monitoring of supplier operations, thereby promoting greater transparency and accountability. In conjunction with other initiatives like the Farm to Fork (F2F) strategy, the CSDD directive signals a shift towards more sustainable business practices and increased environmental consciousness across various sectors. These developments highlight the growing importance for companies to adapt to evolving sustainability standards, both to maintain competitiveness and to contribute positively to global sustainability objectives.

Figure 21 GRI Environmental Standards (Sector analysis) – GRI8 to GRI16



Concerning environmental standards, in Employment (GRI17), Engineering stands out with a 62% disclosure rate, underscoring the sector's emphasis on transparent employment

¹⁸CSDD: https://commission.europa.eu/business-economy-euro/doing-business-eu/corporate-sustainability-due-diligence_en

practices. This could be due to Engineering's acute need for skilled labor in a competitive talent market, necessitating clear communication about employment conditions and opportunities.

In Labour/Management Relations (GRI18), Engineering again leads with a 43% disclosure rate, likely reflecting the sector's dedication to maintaining transparent and effective labor-management relations – a crucial aspect for project-based and team-centric work environments. Other sectors like Manufacturing show moderate levels of disclosure, suggesting a growing recognition of the importance of these relations, though they might not be as central to operations as in the Engineering sector.

These results are in line with the EY report on ESG reporting in the construction and engineering industry¹⁹ notes that social aspects, including health, safety, and labor, are high priorities for the engineering and construction industry, reflecting the industry's reliance on skilled labour and the importance of transparent employment practices. Additionally, the report mentions that 98% of investors evaluate ESG performance based on corporate disclosures, which includes employment practices. Furthermore, the report highlights that millennials are three times more likely to seek employment with companies that have strong stances on social and environmental issues, suggesting a need for clear communication about employment conditions.

Occupational Health & Safety (GRI19) sees the Agri-food sector leading with a 77% disclosure rate, highlighting its focus on safety due to the inherently physical nature of agricultural work. An Agri-food company, for instance, might extensively report on its health and safety protocols and employee wellness programs. This is significantly higher than ICT's 47% rate, where the nature of work is generally less physically demanding, possibly leading to less extensive health and safety measures.

In fact, according to ILO²⁰ agriculture is recognized as one of the most hazardous industries globally, with a significant number of agricultural workers suffering from

¹⁹ EY (n.d). The current state of ESG reporting in the engineering and construction industry.
https://www.ey.com/en_us/real-estate-hospitality-construction/esg-reporting-and-construction-industry

²⁰ ILO (n.d)
https://www.ilo.org/safework/info/standards-and-instruments/codes/WCMS_161135/lang--en/index.htm

occupational accidents and ill health each year. This high risk is attributed to the physical nature of agricultural work. Furthermore, the sector has established codes of practice and guidelines, such as the Safety and Health in Agriculture Convention 2001 (No. 184), to improve Occupational Safety and Health in agriculture. For the ICT sector, health and safety practices mostly revolve around working safely with computers and technology equipment. According to Safewell²¹, common hazards include poor postures, incorrect chairs, glare or poor lighting, trip hazards, and installation hazards. This suggests that while health and safety are important in ICT, the nature of risks is generally less physically demanding compared to the Agri-food sector.

In Training and Education (GRI20), Engineering shows a significant 59% rate, suggesting the sector's strong investment in employee development. According to 2023 trends report by Grid Dynamics²², there is a growing emphasis on investing in engineering talent and culture. This is driven by the need for business growth and innovation, with forward-thinking companies focusing on attracting and retaining top engineering talent. This talent is not only looking for competitive compensation but also values opportunities for growth, learning, and a positive work culture.

For Diversity and Equal Opportunities (GRI21), Manufacturing's 59% disclosure rate might reflect a sector looing to cultivate more diverse and inclusive workplaces. The manufacturing sector's focus on diversity and inclusion (D&I) might be driven by the broader trend of D&I becoming integral to ESG agendas in many organizations. According to Pitsent Masons²³, there's a growing emphasis on social value and what organizations are doing locally to foster D&I through their work and projects. This aligns with the increasing demand for data on diversity, culture, inclusion, and wellbeing from clients and stakeholders, as noted in a report on emerging trends for D&I in 2023. Additionally, the trend of broadening the definitions of diversity to include areas such as neurodiversity and

²¹ Safewell (n.d) <https://safewell.co.uk/what-is-health-and-safety-in-ict>

²² Griddynamics (n.d.)
<https://blog.griddynamics.com/2023-trends-increased-investments-in-engineering-talent-and-culture/>

²³ Pitsent Masons (n.d.)
<https://www.pitsentmasons.com/out-law/analysis/emerging-trends-for-diversity-and-inclusion-in-2023#:~:text=The%20year%20ahead%20will%20likely,current%20shortage%20of%20skilled%20labour>

socio-economic diversity supports the idea that the manufacturing sector is looking to cultivate more diverse and inclusive workplaces.

In Non-discrimination (GRI22), Engineering's 51% rate might be indicative of the sector's efforts to create and maintain an inclusive work environment, a key factor in attracting and retaining talent in a competitive field. According to Pinsent Masons, the shift in employee attitudes towards D&I from being passive to increasingly proactive and demanding real-time evidence of change in organizations supports the idea of engineering firms focusing on non-discrimination to attract and retain talent. Employees are no longer content with mere commitments to change; they want to see actual progress and evidence, which might be driving the Engineering sector's efforts to create and maintain inclusive work environments.

Figure 22 GRI Social Standards (Sector analysis) – GRI17 to GRI26



Freedom of Association and Collective Bargaining (GRI23) sees generally low rates across sectors, with Engineering slightly higher at 32%. Child Labour and Forced or Compulsory Labour (GRI24 and GRI25) witness low rates of disclosure across all sectors, indicating a

need for more robust reporting practices. This suggests areas where more disclosure and concerted effort for improvement are needed across the board.

In Security Practices (GRI26), the Services sector leads with a 40% disclosure rate. Service sector companies have adopted comprehensive security practices, emphasizing training in human rights policies and procedures for their security personnel. This training is designed to equip both company and private security staff, as well as public security forces, with the knowledge and understanding necessary to conduct their duties in compliance with human rights standards and ethical conduct.

In Rights of Indigenous People (GRI27) and Human Rights Assessment (GRI28), there are low disclosure rates across sectors. In fact, according to CIGI²⁴ a comprehensive disclosure on Indigenous relations is often missing from corporate reports, regardless of the sector. This lack of substantive disclosure is a gap in many organizations' sustainability reporting, especially for those operating in countries with Indigenous populations.

In the area of Local Communities (GRI29), higher disclosures in the Agri-food and Engineering sectors likely reflect their recognition of the impact on local communities. The Agri-food sector, for instance, might report on initiatives supporting local farming practices or environmental impact mitigation, acknowledging its direct interaction with local ecosystems. Similarly, Engineering might disclose its engagement with local communities affected by its projects. Supplier Social Assessment (GRI30) sees Manufacturing leading. In fact, according to US department of Commerce²⁵, the complexity and vulnerability of these supply chains necessitate a keen understanding of the social impact. Risks include overreliance on single-source suppliers and a lack of domestic production capacity, making supplier social assessment crucial for resilience and security in these supply chains. In Public Policy (GRI31), there is an overall low disclosure rate across all sectors. These can be attributed to various factors. A study on municipal transparency in Portugal, for instance, reveals that political ideology, financial

²⁴ CIGI (n.d):

<https://www.cigionline.org/articles/indigenous-relations-disclosure-critical-and-missing-most-corporate-reports/#:~:text=The%20risks%20to%20companies%20that.and%20performance%20on%20Indigenous%20relations>

²⁵ <https://www.commerce.gov/news/fact-sheets/2022/02/ict-supply-chain-assessment-fact-sheet>

independence, municipal wealth, and citizen involvement significantly influence public information disclosure (Tejedo-Romero & Araujo, 2023).

Customer Health & Safety (GRI32) is an area where the Agri-food sector's higher disclosure rate is likely a response to the direct health implications of food products. Successive food crises have heightened awareness of quality and food safety in the industry, driving the need for greater transparency. Consumer demands and the globalization of trade have also emphasized the necessity of ensuring quality and safety throughout the supply chain (Barbancho-Maya & López-Toro, 2022). In Marketing and Labelling (GRI33), the relatively low level of disclosure across all sectors indicates an area ripe for increased disclosure.

Customer Privacy (GRI34) sees a higher disclosure rate in the Services sector, reflecting the growing importance and regulatory focus on data privacy, particularly in industries with direct consumer interactions and sensitive data handling. Socio-economic Compliance (GRI35) reveals modest disclosure rates across sectors, suggesting a general area for improvement in disclosure regarding socio-economic impacts and compliance. Companies are increasingly accountable not just to shareholders, but to a wide range of stakeholders including employees, suppliers, community members, and governments. This shift demands greater accountability and transparency, especially in socio-economic aspects. According to Sustainalytics²⁶, Socio-economic impact reports are more comprehensive as they provide quantifiable evidence of a company's socio-economic impact on its stakeholders, focusing on social and economic rather than environmental aspects. This complexity requires a more nuanced approach to data collection and presentation, which could contribute to modest disclosure rates. Moreover, according to Crawford and Baid²⁷, effective socio-economic reporting with the GRI framework involves more than just summarizing current activities. It requires a materiality analysis to detect shared interests and issues between the company and its stakeholders.

²⁶

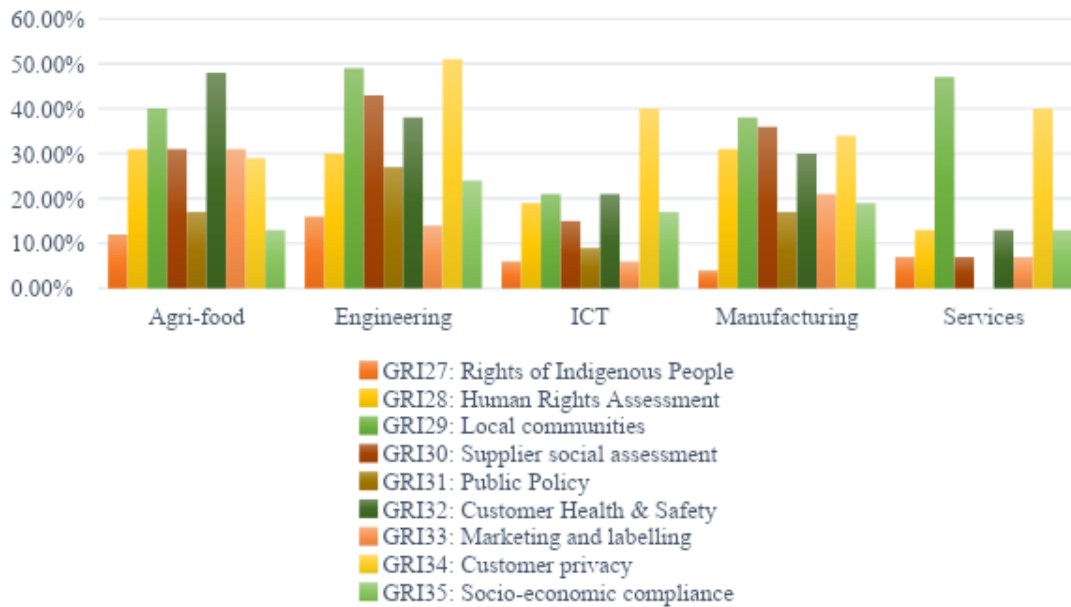
<https://www.sustainalytics.com/esg-research/resource/corporate-esg-blog/the-why-and-the-how-of-socio-economic-impact-reporting>

²⁷

<https://publications.gvsu.edu/seidman-business-review/2022-seidman-business-review/a-roadmap-for-using-the-gri-for-societal-impact-reporting>

This process can be challenging and time-consuming, potentially leading to lower rates of comprehensive reporting.

Figure 23 GRI Social Standards (Sector analysis) – GRI27 to GRI35



2.5 Sustainability Practices and GRI

In this section, we aim to clearly explain the relationship between sustainability practices and the GRI Framework. To achieve this, we will present a comprehensive list of sustainability practices currently being implemented by firms to enhance their sustainable performance. Alongside each practice, we will specify the relevant GRI standards, providing a clear linkage between practical actions and their reporting standards (Section 5.1).

Furthermore, to solidify this understanding, we will include real-world examples in section 5.2, showcasing how various companies have successfully applied some of these practices. These case studies will demonstrate the practical applications of sustainability practices in different business contexts, illustrating how adherence to GRI standards can lead to tangible improvements in sustainability performance.

2.5.1 Linking GRI and sustainability together

This subsection presents a comprehensive list of sustainability practices that firms are implementing to enhance their sustainable performance. This list serves as a crucial tool for businesses, providing a clear and structured roadmap for integrating sustainability into their operations. The list assists new businesses in identifying initial sustainability steps and goals, while helping more advanced companies benchmark their practices, identify gaps, and discover innovative strategies for further progress. Table 1 aligns key sustainability practices with relevant GRI standards. Each entry in the table represents a specific sustainability practice, along with the relevant GRI codes that apply to it. The sustainable practices encompass a wide range of areas, from market diversification strategies, like horizontal and vertical diversification, to more specific operational aspects such as investing in renewable energy and improving infrastructures. The table links these sustainable practices to the appropriate GRI codes, providing companies with a clear framework to report and improve their sustainability efforts. This contribution actively fosters a more responsible and sustainable global business environment.

Table 1. Sustainability practices and GRI

Sustainability Practices	GRI code
Market diversification through horizontal, concentric, conglomerate diversification, or vertical diversification considering anti-competitive practices.	GRI1, GRI6
Investing in sharing economy business models to have sustainable revenue.	GRI1, GRI2
Monitoring activities and information flows toward responsibility for corruption prevention.	GRI5, GRI7
Improving reliable infrastructures and services and improving automation.	GRI3
Implementing risk management system and conflict of interest's management.	GRI1, GRI2, GRI5
Managing competition commission assignment to implement anti-corruption and anti-competitive plans.	GRI5, GRI6
Auditing of Internal Control System and Compliance with Policies and Regulations besides.	GRI35
Using biodegradable packaging.	GRI8
Producing environmentally friendly products.	GRI8, GRI15
Developing recycling programs.	GRI14, GRI15

Sustainability Practices	GRI code
Investing in renewable energy.	GRI9
Reducing energy consumption per product/service.	GRI9
Reducing water consumption per product/service.	GRI10
Reducing carbon emissions per product/service.	GRI12, GRI13
Converting corporate fleets to hybrid or electric.	GRI9, GRI12, GRI13
Developing waste management programs.	GRI14
Assessing the suppliers and partners by devising environmental indicators.	GRI16
Improving labeling system to increase traceability for environmental issues.	GRI33
Reducing the impact of production activities on biodiversity.	GRI11
Investing in innovation management for product design.	GRI8, GRI9, GRI10, GRI11
Investing in innovation management for production design & planning.	GRI9, GRI10
Improving diversity by devising short-term and long-term plans and monitoring the indicators related to equal opportunities (education, proportion, salary, and health insurance) at workplace constantly.	GRI17, GRI18, GRI21, GRI22, GRI27, GRI28
Training employees to improve their knowledge in sustainability and disaster preparedness.	GRI20
Establishing the values that are important for nonprofit organizations considering where our company may be able to turn to for help.	GRI29
Continues analysis of the whole supply chain to assess the ethical indicators like preventing child and compulsory labor.	GRI24, GRI25, GRI30
Developing a data management plan and enforcing data privacy policies.	GRI26, GRI34
Simulating and analyzing production and logistics using new technologies such as digital twins to improve occupational health and safety management system.	GRI19, GRI32
Implementing occupational health and safety management system.	GRI19, GRI32
Monitoring the impact of the business model on the local communities (impacts on economic, health, welfare, etc.)	GRI29

2.5.2 Experiences of sustainability

In this section, we analyze real-world case studies that illustrate the practical application of sustainability practices in various business settings. These cases provide tangible examples of how companies across different industries successfully integrated sustainability into their operations have, adhering to the principles and standards outlined in the previous sections. By examining these real-life scenarios, we gain valuable insights into the challenges, strategies, and outcomes associated with implementing sustainability initiatives.

2.5.3 Unilever

Launched in 2010, Unilever's Sustainable Living Plan (USLP)²⁸ is a comprehensive framework that outlines the company's commitment to sustainable development. USLP is a clear example of how a company can align its profit with purpose through corporate social innovation. The plan comprises three main pillars: improving health and well-being, reducing environmental impact, and enhancing livelihoods. These pillars are deeply related with GRI standards, for instance:

- Health and Well-being Initiatives: Unilever's efforts in improving health and hygiene, reaching over a billion people by 2020, align with GRI standards related to health and safety (GRI19). Their commitment to reducing diseases through handwashing relates to GRI indicators focusing on hygiene promotion and disease prevention.
- Environmental Impact Reduction: Aligned with GRI standards on energy (GRI9), emissions (GRI12,13), and water (GRI14), Unilever targets to decrease the environmental footprint by 2030. Their strategies for reducing GHG impact, water consumption, waste generation, and promoting renewable energy strongly resonate with GRI's focus on environmental impact mitigation and resource management.
- Livelihood Enhancement: Unilever's dedication to sustainable sourcing of agricultural raw materials by 2020 links directly to GRI standards on responsible supply chains and fair labor practices. Their initiatives to empower women and

²⁸ Unilever's Sustainable Living Plan:
<https://www.unilever.com/files/92ui5egz/production/16cb778e4d31b81509dc5937001559f1f5c863ab.pdf>

support smallholder farmers and small-scale retailers align with GRI indicators on Employment (GRI17), Diversity (GRI21) and non-discrimination (GRI22).

Unilever recognizes that its success is linked to the well-being of the planet and its people, and it has embraced this philosophy in its business strategy. The comprehensive reporting by Unilever, documenting their progress towards these targets, echoes GRI's emphasis on transparent and accountable sustainability reporting. By adhering to GRI standards, Unilever not only communicates their commitments effectively but also enhances credibility and comparability in their sustainability efforts, showcasing a strong alignment with globally recognized reporting frameworks.

2.5.4 Patagonia

The case of Patagonia's Supply Chain Environmental Responsibility Program²⁹ is an example of how a company can infuse its core values with its business operations. Patagonia's dedication to transparency and environmental stewardship has long set the standard in the clothing industry, and their "Footprint Chronicles" initiative is a testament to their commitment to sustainability and ethical practices.

The Patagonia's Practices under this program, are very related GRI Standards:

- Supply Chain Transparency: Patagonia's "Footprint Chronicles" enables customers to follow the entire journey of products, reflecting an advanced level of supply chain transparency. This initiative aligns with GRI16: Supplier Environmental Assessment, which focuses on the environmental impact of suppliers and GRI30: Supplier Social Assessment, which addresses the social impacts associated with suppliers. As through this program, Patagonia not only advocates for better industry practices but also provides a model for monitoring supplier compliance with environmental and social standards.
- Environmental Responsibility: The environmental aspect of Patagonia's program aligns with several of the GRI standards, which guide companies on reporting their environmental footprint. Patagonia's commitment to understanding and minimizing the environmental impact in the lifecycle of its products reflects the

²⁹Patagonia's Supply Chain Environmental Responsibility Program:
<https://www.patagonia.com/our-footprint/supply-chain-environmental-responsibility-program.html>

ethos of GRI8: Materials, GRI9: Energy, GRI10: Water and Effluents, GRI12 and GRI13: Emissions, GRI14: Waste, and GRI15: Environmental Compliance.

- **Labor Practices:** The company's emphasis on fair labor practices and ethical treatment of workers corresponds with the GRI standards, particularly GRI23: Freedom of Association and Collective Bargaining, and GRI25: Forced or Compulsory Labor. Patagonia actively works to ensure that its supply chain is free from labor abuses, an effort that resonates with conscious consumers and stakeholders.
- **Product Responsibility:** Through the provision of detailed information about the sourcing and impact of its products, Patagonia addresses GRI32: Customer Health and Safety, ensuring that its customers are informed about the products they purchase, including their safety and impact on health.

The adoption of these practices and their alignment with GRI standards has positioned Patagonia as a leader in environmental and social responsibility in the apparel industry. The transparency provided by the "Footprint Chronicles" not only facilitates consumer awareness and education but also promotes an industry-wide shift toward greater accountability. Patagonia's initiative has enabled the company to closely monitor its environmental impact and to set goals for improvement. For example, their dedication to using recycled materials and organic cotton directly reduces their environmental footprint, showcasing their compliance with GRI standards regarding waste and materials.

2.5.5 Intel

Intel's commitment to global water³⁰ stewardship through its Global Water Policy reflects a significant and measurable initiative to sustainability. By aiming to restore 100% of its global water use by 2025, Intel not only showcases its dedication to environmental responsibility but also demonstrates how corporations can lead in solving global challenges.

Intel's Global Water Policy contributed to the better disclosure and compliance with GRI Standards:

³⁰ Intel's Global Water Policy: <https://www.intel.com/content/www/us/en/policy/policy-water.html>

- Water Restoration and Conservation: Intel's target to restore 100% of its global water use directly corresponds with GRI10: Water and Effluents, which focuses on water withdrawal, consumption, and discharge. By engaging in water restoration projects, Intel goes beyond minimizing negative impacts to actively contributing positively to the water cycle.
- Effluent and Waste Management: Intel's strategy also touches on GRI14: Waste Management, due to their efforts to reduce water pollution and improve water quality. These efforts are significant in preventing potential water-related impacts on natural environments and communities.
- Local Communities and Ecosystems: The policy emphasizes the importance of the local context and collaboration with local stakeholders, addressing GRI29: Local Communities. Moreover, through its water restoration projects, Intel contributes to local water security and supports the sustainability of local ecosystems, contributing to GRI11: Biodiversity.
- Climate Change: Intel's focus on water conservation is also intrinsically linked to climate action. By ensuring efficient water use and investing in restoration, the company acknowledges and acts upon the interdependencies between water management and climate resilience.

Intel's approach to water stewardship involves both direct action and collaborative efforts. By implementing water-saving technologies in its operations, Intel works to reduce its own consumption. Simultaneously, Intel collaborates on projects that contribute to local water restoration, such as replenishing aquifers, supporting conservation, and enhancing watershed health. These projects not only serve to offset Intel's water usage but also benefit the communities and ecosystems where Intel operates.

This strategy of balancing operational water reduction with external restoration initiatives ensures a comprehensive approach to water stewardship. The dual focus addresses the immediate need to reduce consumption while investing in longer-term sustainability projects that benefit the environment and local communities.

2.5.6 Google

Google's push towards 24/7 Carbon-Free Energy is a bold step in corporate environmental responsibility, showcasing the tech giant's commitment to leading the industry in sustainability practices. Google's journey from achieving carbon neutrality in 2007 to reaching 100% renewable energy procurement for its operations in 2017 underscores a firm dedication to innovation in renewable energy use and GHG emissions reduction.

The Google's 24/7 Carbon-Free Energy contributes to the disclosure of several GRI Standards:

- **Renewable Energy:** Google's attainment of 100% renewable energy for its operations directly aligns with GRI9: Energy, which calls for the disclosure of energy consumption within the organization and the energy intensity of operations. By transitioning to renewable energy sources and investing in renewable energy projects, Google demonstrates its commitment to reducing its energy footprint and promoting energy sustainability.
- **Emissions Reduction:** Google's carbon neutrality, along with its investment in high-quality carbon offsets, contributes to GRI13: Emissions, which focuses on the reduction of greenhouse gas emissions. The company's efforts are geared towards a future where every Google data center will operate on clean electricity every hour of every day, contributing to a significant reduction in carbon emissions in line with global efforts to mitigate climate change.
- **Innovation and Infrastructure:** Google's strategy to achieve 24/7 Carbon-Free Energy requires innovation in energy sourcing and infrastructure development. This approach is reflected in the GRI standards related to materials (GRI8), energy (GRI9), and emissions (GRI12 and GRI13), where the emphasis is on efficient use of resources and reduction of environmental impact.
- **Climate Change Mitigation:** Google's initiatives contribute to climate change mitigation by reducing emissions and supporting the transition to a low-carbon economy. This aligns with GRI13, which deals with the organization's approach to reducing greenhouse gas emissions and GRI2, which looks at economic performance, including the financial implications and other risks and opportunities for the organization's activities due to climate change.

Google's commitment to 24/7 carbon-free energy is more than an environmental statement; it is an operational transformation. The company's global data centers and offices operating on renewable energy have set a precedent for other companies to follow. Google's actions have ripple effects across the industry, driving demand for renewable energy and encouraging suppliers and partners to also increase their use of clean energy.

The adoption of renewable energy and carbon offsets by Google has immediate environmental benefits, such as reducing the company's carbon footprint and contributing to the health and sustainability of the planet. Additionally, by investing in renewable energy projects, Google supports economic growth in the clean energy sector, creating jobs and fostering innovation in green technologies.

2.5.7 Ikea

IKEA's "People & Planet Positive"³¹ sustainability strategy represents a comprehensive approach to environmental and social responsibility, encapsulating the company's vision for making a positive impact. The strategy is comprehensive, addressing various aspects of sustainability from resource use to customer empowerment, and is inherently aligned with the GRI standards:

- Renewable Energy Investment: IKEA's investment in renewable energy to power its stores and operations aligns with GRI9: Energy, which encourages reporting on energy consumption and reduction of energy requirements of products and services. IKEA's approach contributes to a decrease in energy intensity across its operations.
- Material Efficiency: The commitment to improving material efficiency corresponds to GRI8: Materials, which focuses on the use of materials that are sustainably sourced and managed. IKEA's strategy to source 100% of its wood, paper, and cardboard from more sustainable sources, specifically those certified by the Forest

³¹ Ikea's People & Planet Positive:
<https://www.ikea.com/global/en/our-business/reports/people-planet-positive-sustainability-strategy-220901/>

Stewardship Council (FSC), demonstrates adherence to responsible sourcing and conservation of natural resources.

- Carbon Footprint Reduction: IKEA's focus on reducing the carbon footprint of its products resonates with GRI12 and GRI13: Emissions, which details the disclosure of an organization's direct and indirect GHG emissions. Through the design of products to be more energy-efficient and the use of renewable energy, IKEA aims to minimize its climate impact.
- Sustainable Living: By inspiring and enabling customers to live more sustainably, IKEA addresses broader impacts covered by GRI standards such as GRI24: Child Labor and GRI25: Forced or Compulsory Labor, emphasizing the importance of social responsibility in its supply chain and business practices.

IKEA's "People & Planet Positive" strategy has made notable progress towards its sustainability goals, which has a ripple effect across its value chain. By focusing on sustainable materials and renewable energy, IKEA is not only reducing its environmental footprint but is also influencing its suppliers and customers to adopt more sustainable practices. The transparency in its sourcing of wood, paper, and cardboard fosters trust and sets a standard in the industry for responsible resource use.

The strategy is designed to create a circular and climate-positive business with an overall goal to reduce more greenhouse gas emissions than the IKEA value chain emits by 2030. This forward-thinking approach ensures that sustainability is embedded in every aspect of the business, from the sourcing of raw materials to product end-of-life.

2.5.8 Nestlé'

Nestlé's Creating Shared Value (CSV)³² concept is a central tenet of the company's business philosophy, which holds that for a business to be long-term successful, it must also create value for society. This approach is particularly resonant in the context of GRI

³²Nestlé's Creating Shared Value:
https://www.nestle.com/sites/default/files/asset-library/documents/library/documents/corporate_social_responsibility/nestle-csv-report-mar2008-en.pdf

reporting, as it embodies the multi-faceted nature of sustainability, addressing economic, environmental, and social impacts:

- **Local Community and Economic Performance:** Nestlé's commitment to improving access to clean water and enhancing the livelihoods of farmers aligns with GRI 3: Indirect Economic Impacts, which emphasizes the significance of indirect economic impacts on communities. Additionally, this commitment relates to GRI29: Local Communities, which focuses on the impact of operations on communities, particularly in terms of community engagement, impact assessments, and development programs.
- **Sustainable Sourcing:** Ensuring the sustainability of ingredients is in line with GRI8: Materials, calling for organizations to report on the use of recycled and non-recycled materials, and GRI11: Biodiversity, which covers the sourcing of materials from areas with high biodiversity value. Nestlé's focus on responsible sourcing from farmers emphasizes the integration of sustainable agricultural practices into their supply chain.
- **Water Stewardship:** By providing access to clean water, Nestlé addresses GRI10: Water and Effluents, which guides companies on reporting water withdrawal, consumption, and discharge. This standard underscores the importance of managing water sustainably and reducing water-related impacts.
- **Social Well-being:** The Nestlé Prize in Creating Shared Value, awarded to initiatives like IDE Cambodia's agricultural productivity project, demonstrates the company's commitment to GRI3: Indirect Economic Impacts. By fostering economic development in the communities where it operates, Nestlé directly contributes to enhancing social well-being and economic growth.

Nestlé's CSV approach, by integrating the business objectives with societal needs, has led to the development of various programs that have a tangible impact on communities and the environment. The CSV report, adhering to GRI standards, provides transparent data on the company's performance and the outcomes of its initiatives, thereby holding Nestlé accountable to its stakeholders and the broader public. The awarding of the Nestlé Prize in Creating Shared Value to organizations such as IDE Cambodia showcases Nestlé's

commitment to not only apply CSV principles internally but also to encourage and support external innovation that aligns with these values. This recognition promotes the scaling of impactful initiatives, further expanding the reach of shared value.

2.6 Resilience and GRI

In the literature, there are studies that show a positive correlation between firm resilience and the sustainable performance of its supply chain (Gani et al., 2023). On the one hand, some studies show that a sustainable supply chain is often more resilient, as it can adapt better to changing circumstances and minimize the impact of disruptions. On the other hand, some articles discuss that sustainability using the circular economy does not affect supply chain resilience (Júnior, et al., 2023) and there is a lack of success in bringing sustainability and resilience together in the industrial setting (Fiksel, 2006).

According to Fahimnia and Jabbarzadeh (2016), there is a trade-off between supply chain resilience and sustainability because it is not possible to make a sustainable supply chain resilient without an increase in costs associated with adjusting sourcing, production, and distribution strategies. Rajesh, (2021) confirms these results by demonstrating an objective contradiction between resilience and sustainability. Moreover, even though some studies have addressed the importance of integrating sustainability and resilience in supply chains, there is still very little investigation around the integration of the two concepts (Negri et al., 2021). The discordant results founded in the literature are since this relationship is still underexplored. Moreover, there is no indication of which practices can enable the simultaneous achievement of resilience and sustainability. Additionally, the measurement tools are limited and it is not clear which theories should be integrated to analyze the phenomenon, (Negri et al., 2021). So, in this section we provide some analysis regarding the relationships between GRI sustainability standards and resilience.

2.6.1 GRI and Economic Resilience

In this section, we provide some analysis about resilience by connecting the GRI standards of the secondary dataset to drivers that impact economic resilience. Based on the report

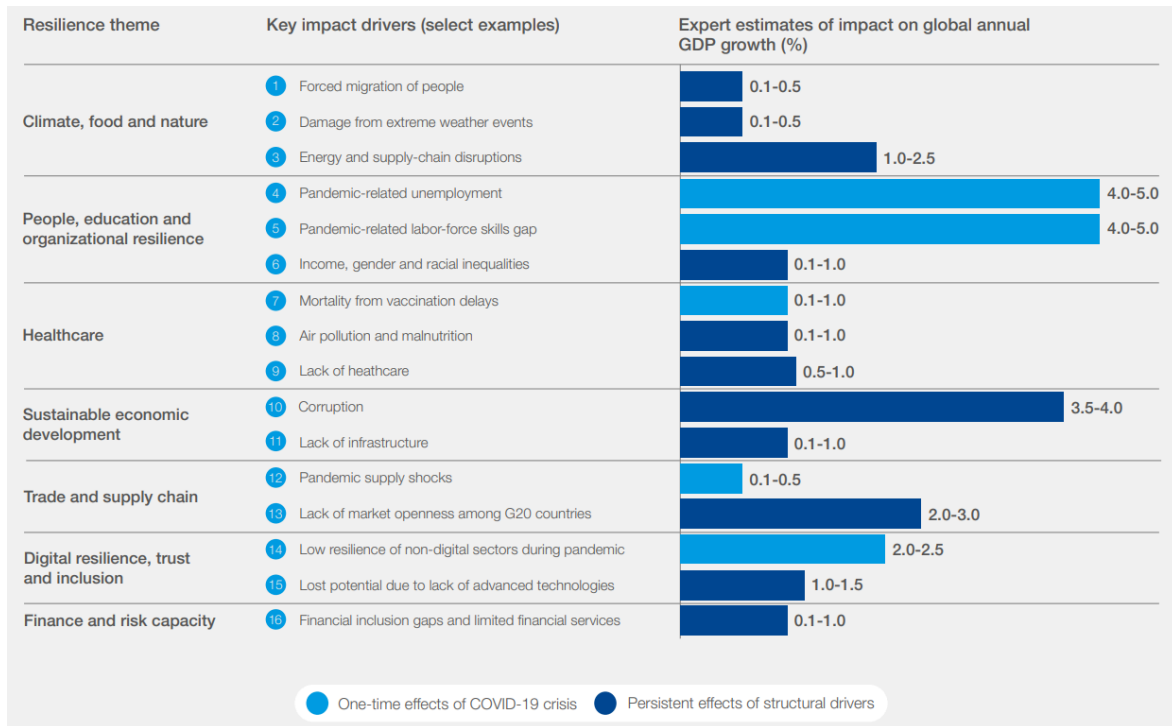
of the World Economic Forum (WEF) Resilience Consortium³³ the impact of resilience or lack of it on the annual GDP growth is between one to five percent. Accordingly, WEF defines some impact drivers that can affect different resilience themes and provides some estimations of their impacts on global GDP growth. In other words, WEF analyses the economic resilience (sustainable GDP growth) by defining the impact of relevant resilience drivers on GDP growth using a domain between 1% to 5%. Accordingly, we use the following steps to study the relationships between GRI standards and economic resilience:

- a) Choose the most relevant drivers from the report of WEF that can be connected to GRI standards.
- b) Normalize the estimated impact of the drivers to define their weights in terms of impacting on the GDP growth.
- c) Dedicate GRI standards to each of the resilience drivers defined by WEF. Consider each of the drivers as a group of GRI standards.
- d) Calculate the average disclosure of each group for SMEs and the leaders for each group.
- e) Calculate the average weighted resilience score of SMEs and the leaders for each group.
- f) Develop the same analysis based for different sectors.

Figure 24 shows the impact of different drivers of various resilience themes (based on the report of WEF) in two categories: onetime effect of COVID-19 crisis, and persistent effects of structural drivers. For our analysis we consider the latter category (See Table 2). Then among them we select the most relevant drivers that we can define a relationship between them and the GRI standards. Accordingly, Table 2 indicates the list of the most relevant drivers along with their impact on economic resilience in terms of GDP growth.

Figure 24. Impact on global GDP growth across resilience themes (Source: WEF).

³³ https://www3.weforum.org/docs/WEF_Resilience%20for_Sustainable_Inclusive_Growth_2022.pdf



According to Table 2, at this step there are 11 drivers with different range of estimated impact. The highest impact rate is related to corruption, and the lowest rates is 0.3 for forced migration of people and damage from extreme weather change. Moreover, later we will normalize average impact rates to calculate their weight of each driver for our analysis. The more the impact on GDP, the more the weight of the factors. The idea is to calculate an index using the GRI standards to have a better understanding of the resilience situation of SMEs and the leaders. Nota that, this is only a factor that we can use it as a general estimation of the impact of sustainability practices on the resilience and we need to do more accurate analysis by collecting data from companies to provide more useful analysis. In this section, we try do take the maximum advantages of the secondary data that currently we have access to it by providing different quantitative analysis a much as possible

Table 2. The average estimated impact of the relevant drivers.

The Relevant Drivers	Estimated Impact Domain	Average Estimate Impact
Forced migration of people	0.1 – 0.5	0.3
Damage from extreme weather change	0.1 – 0.5	0.3
Energy and supply chain disruption	1 – 2.5	1.75
Income, gender, and racial inequalities	0.1 – 1	0.55
Air pollution and malnutrition	0.1 – 1	0.55
Lack of healthcare	0.5 – 1	0.75
Corruption	3.5 – 4	3.75
Lack of infrastructure	0.1 – 1	0.55
Lack of market openness among G20 countries	2 – 3	2.5
Lost potential due to lack of advanced technologies	1 – 1.5	1.25
Financial inclusion gaps and limited financial services	0.1 – 1	0.55

In the next step, we categorize the GRI standards based on their connection with the proposed drivers. Table 3 shows the possible connection between the GRI standards and the selected drivers from the report of WEF.

Table 3. Resilience drivers and GRI.

Group	The Relevant Drivers	GRI Standards
L1	Forced migration of people	GRI3: Indirect economic impacts; GRI18: Labor/management relations; GRI29: Local communities
L2	Damage from extreme weather change	GRI14: Waste; GRI15: Environmental compliance; GRI16: Supplier environmental assessment; GRI33: Marketing and labelling; GRI36: Sustainable land use
L3	Energy and supply chain disruption	GRI4: Procurement practices; GRI8: Materials; GRI9: Energy; GRI10: Water & Effluents; GRI11: Biodiversity;
L4	Income, gender, and racial inequalities	GRI3: Indirect economic impacts; GRI17: Employment; GRI18: Labor/management relations; GRI20: Training and Education; GRI21: Diversity and Equal Opportunities; GRI22: Non-discrimination; GRI24: Child Labor; GRI25:

Group	The Relevant Drivers	GRI Standards
		Forced or Compulsory Labour; GRI23: Freedom of Association and Collective Bargaining; GRI27: Rights of Indigenous People; GRI28: Human Rights assessment; GRI30: Supplier social assessment; GRI35: Socio-economic compliance
L5	Air pollution and malnutrition	GRI12: Emissions (pollutants); GRI13: Emissions (GHG); GRI14: Waste; GRI15: Environmental compliance; GRI16: Supplier environmental assessment; GRI33: Marketing and labelling
L6	Lack of healthcare	GRI19: Occupational Health and Safety; GRI32: Customer Health & Safety; GRI33: Marketing and labelling
L7	Corruption	GRI5: Anti-corruption; GRI7: Tax; GRI31: Public Policy; GRI35: Socio-economic compliance; GRI6: Anti-competitive behavior
L8	Lack of infrastructure	GRI3: Indirect economic impacts
L9	Lack of market openness among G20 countries	GRI1: Market Presence; GRI2: Economic performance; GRI6: Anti-competitive behavior;
L10	Lost potential due to lack of advanced technologies	GRI26: Security practices; GRI34: Customer privacy; GRI37: Responsible data management
L11	Financial inclusion gaps and limited financial services	GRI2: Economic performance

As in our secondary dataset we do have access to the information regarding public policy, market presence, economic performance, and indirect economic impacts, we revise Table 2 to Table 3 considering the available GRI standards in the secondary data. In Table 4, we remove drivers: Lack of infrastructure; Lack of market openness among G20 countries; and financial inclusion gaps and limited financial services.

Table 4. Final groups for resilience practices and GRI.

Group	The Relevant Drivers	GRI Standards
S1	Forced migration of people	GRI18: Labor/management relations; GRI29: Local communities
S2	Damage from extreme weather change	GRI14: Waste; GRI15: Environmental compliance; GRI16: Supplier environmental assessment; GRI33: Marketing and labelling; GRI36: Sustainable land use

Group	The Relevant Drivers	GRI Standards
S3	Energy and supply chain disruption	GRI4: Procurement practices; GRI8: Materials; GRI9: Energy; GRI10: Water & Effluents; GRI11: Biodiversity;
S4	Income, gender, and racial inequalities	GRI17: Employment; GRI18: Labor/management relations; GRI20: Training and Education; GRI21: Diversity and Equal Opportunities; GRI22: Non-discrimination; GRI24: Child Labor; GRI25: Forced or Compulsory Labour; GRI23: Freedom of Association and Collective Bargaining; GRI27: Rights of Indigenous People; GRI28: Human Rights assessment; GRI30: Supplier social assessment; GRI35: Socio-economic compliance
S5	Air pollution and malnutrition	GRI12: Emissions (pollutants); GRI13: Emissions (GHG); GRI14: Waste; GRI15: Environmental compliance; GRI16: Supplier environmental assessment; GRI33: Marketing and labelling
S6	Lack of healthcare	GRI19: Occupational Health and Safety; GRI32: Customer Health & Safety; GRI33: Marketing and labelling
S7	Corruption	GRI5: Anti-corruption; GRI35: Socio-economic compliance; GRI6: Anti-competitive behavior
S8	Lost potential due to lack of advanced technologies	GRI26: Security practices; GRI34: Customer privacy; GRI37: Responsible data management

Now considering the average estimate impact of the groups we can calculate the weight of each of them in a domain between 0% and 100%. Moreover, we calculate the average disclosure rate of the GRI standards in each group as the disclosure rate. Table 5 and Table 6 show the results of the proposed calculations besides the final resilience index for the leaders and SMEs respectively.

Table 5. The average weights, average disclosure rate, and the resilience index for Leaders.

Group	Weight	Average disclosure rate	Resilience score (out of 100)
S1	0.033	0.520	1.7
S2	0.033	0.494	1.6
S3	0.190	0.598	11.4
S4	0.060	0.532	3.2
S5	0.060	0.613	3.7
S6	0.082	0.617	5.0

S7	0.408	0.537	21.9
S8	0.136	0.323	4.4
		Total Score (out of 100)	52.9

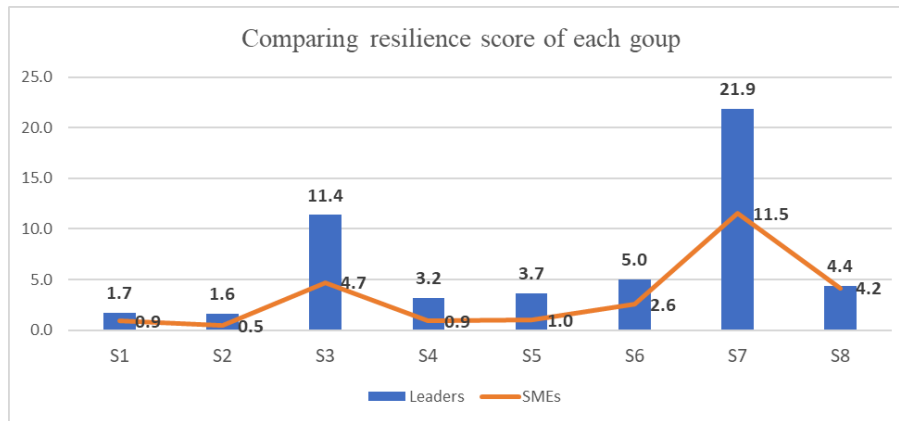
Table 6. The average weights, average disclosure rate, and the resilience index for SMEs.

Group	Weight	Average disclosure rate	Resilience score (out of 100)
S1	0.033	0.270	0.9
S2	0.033	0.144	0.5
S3	0.190	0.248	4.7
S4	0.060	0.150	0.9
S5	0.060	0.168	1.0
S6	0.082	0.317	2.6
S7	0.408	0.283	11.5
S8	0.136	0.307	4.2
		Total Score (out of 100)	26.3

2.6.2 Comparing SMEs and leaders

Overall, the results show the leader companies have a better performance in all groups and their aggregated score is almost doubled compared to SMEs aggregated score. To provide a better comparison between the leaders and SMEs, Figure 25 indicates the resilience score of different groups. Although leaders perform better, both leaders and SME's have similarities in terms of their performance in some of the drivers. For example, the highest resilience score is related to "S7: Corruption" for both because of having a good disclosure score (compared to other drivers) and the importance of this driver (it has the highest weight among all drivers). Similarly, their lowest resilience score of both is related to "S1: Forced migration of people" because of the lower weight of this driver.

Figure 25. Comparing the resilience score of the leaders and SMEs.



2.6.3 Forced Migration of people (S1)

Driver S1 "Forced migration of people" includes GRI 18 "Labor/management relations" and GRI29: "Local communities." "Forced migration" is also called "Forced misplacement" and refers to the international displacement of people with the use of force, compulsion, or coercion (McAuliffe and Khadria, 2020). The migration reasons include problematic phenomena for the country of arrival such as work, family reunification, and study besides the more challenging and tragic reasons such as conflict, persecution, and disaster (McAuliffe and Khadria, 2020). As a whole, the phenomenon of forced migration affects 3.5 percent of the world's population and it is increasing (The World Bank, 2023).

The data displayed in Table 7 show that leaders register a resilience score in this driver of 1.7 while SMEs of 0.9 with a gap in percentage terms of 47.05%. Comparing these results with the other drivers we find that both leaders and SMEs have a low performance demonstrating their lack of resilience facing migration flows (the maximum possible score is 3.3). However, migration of people should be carefully considered since it can create both opportunities and threats to businesses of all sizes. Migration flows provide both skilled and unskilled labour. It becomes crucial to understand what skills migrants have along with their work identity to develop a plan for integrating them into local firms or redirecting their work identity if needed (Nardon et al., 2021). However, when job opportunities are missing or there is a mismatch between supply and demand for job positions, social marginalization can emerge (Nardon et al., 2021). Companies identified as leaders in our sample outperform SMEs in this driver and can better exploit the migration flows advantages because they provide a greater variety of job vacancies and

relevant investments. It requires a greater effort from the SMEs to benefit from public and private institutions services to facilitate the matching of supply and demand in the job market.

Companies should increase their competencies in taking advantage of these opportunities while at the same time keeping a high attention on possible threats. The majority of migrants have a desire to start a new business based on their expertise and what they have been conducting in their own countries (Alexandre et al., 2019). Although, forced migration poses like refugees, asylum seekers, and internally displaced people causes social and economic challenges, the long-lasting presence of forcibly displaced might fill the unmet needs of the host communities by bringing skills, creating opportunities for local economies, and connectivity to broader markets.

Table 7. Resilience score comparison Leaders and SMEs.

Group	Maximum possible score based on the weights	Resilience score Leader's (out of 100)	Resilience score SME's (out of 100)	Gap (Leaders-SME's)	Gap in percentage compared to the Leaders Score (100*leader's score)/gap)
S1: Forced migration of people	3.3	1.7	0.9	0,8	47,05%
S2: Damage from extreme weather change	3.3	1.6	0.5	1,1	68,75%
S3: Energy and supply chain disruption	19	11.4	4.7	6,7	58,77%
S4: Income, gender, and racial inequalities	6	3.2	0.9	2,3	71,87%
S5: Air pollution and malnutrition	6	3.7	1.0	2,7	72,97%
S6: Lack of healthcare	8.2	5.0	2.6	2,4	48%
S7: Corruption	40.8	21.9	11.5	10,4	47,48%
S8: Lost potential due to lack of advanced technologies	13.6	4.4	4.2	0,2	4,54%
Total Score (out of 100)	100	52.9	26.3	26,6	50,28%

2.6.4 Damage from extreme weather change (S2)

Driver S2 "Damage from extreme weather change" includes GRI standards like GRI14 "Waste"; GRI15 "Environmental compliance"; GRI16 "Supplier environmental assessment"; GRI33 "Marketing and labeling"; GRI36 "Sustainable land use." This driver refers to the economic and social damage caused by extraordinary weather events that are difficult to

predict. Over the past 50 years, nearly 12 thousand disasters caused by extreme weather conditions and climate change resulting in more than 2 million deaths and an estimated \$4.3 trillion in economic damage (The World Meteorological Organization, 2023). The extreme weather events can adversely affect the entire value chain by causing difficulties to supply raw materials, mobilize goods and people, and may lead to temporarily shut down production facilities. Companies should be prepared in advance for the possible occurrence of extreme weather events by introducing preventive measures to avoid or minimize the organization collapse (Linnenluecke and Griffiths, 2010).

Our results show that leaders have a resilience score of 1.6 while SMEs have a score of 0.5 placing the S2 driver as one of the lowest score drivers (the maximum possible score is 3.3). This shows that both leaders and SMEs are not resilient toward disruptive and unexpected weather events and should improve their performance regarding this driver by devising appropriate procedures and innovative strategies to deal with these emergencies. Moreover, the difference between the performance index of leaders and SMEs (69%) is significant which shows SMEs need to invest more in improving their resilience performance to confront climate change issues. Leaders and SMEs should implement two types of actions to overcome extreme weather changes: immediate disaster response which includes short-term activities to respond to the immediate effects of disruption, and post-disaster reconstruction that covers long-term activities to absorb and recover post-disaster in addition to providing tools for improving resilience (Linnenluecke et al., 2012).

2.6.5 Energy and supply chain disruption (S3)

The S3 driver "Energy and supply chain disruption" includes GRI4 "Procurement practices"; GRI8 "Materials"; GRI9 "Energy"; GRI10 "Water & Effluents"; and GRI11 "Biodiversity." Nowadays, energy, oil and gas supply chains have a vital role in companies' resilience and the lack of having proper strategies like portfolio diversification, flexible contracts, transport capacity planning and safety stocks can intensify the negative impact of disruption on the supply chain (Urciuoli et al., 2014). These types of supply chain disruptions besides problems like sudden changes in the demand and material scarcity and affect the global trade and

take time for the companies to recover (Sztajerowska, 2023). The companies included in our sample demonstrate a moderate performance in terms of the average GRI disclosure and the relevant resilience score for leaders and a low performance for the SMEs despite they show a better performance in this driver compared to other drivers (leaders have a value of 11.4 while SMEs 4.7 while the maximum possible value is 19). The difference between Leaders and SMEs is 59% which again reveals a significant difference between them.

The impact of the energy and supply chain disruptions depends on the type of the crises as well as the supply chain characteristics (Ambulkar et al., 2015). Both the leaders and SMEs can improve their resilience performance to prevent and overcome the proposed challenges by enhancing their abilities to maintain control of logistics capacity, integrate with business partners, and implement risk management (Ponomarov and Holcomb, 2009). For example, in the case of large-impact events, resource reconfiguration proves to be a successful strategy for increasing resilience, while in the case of low-impact events, it is preferable to do risk management (Ambulkar et al., 2015). However, supply chains that are more dense, complex or have critical nodes are more prone to suffer major consequences from disruptive events (Craighead et al., 2007).

Moreover, increasing supply chain resilience is not an achievable goal without investment in various aspects of improving the supply chain (Chopra and Sodhi, 2014). Setting up risk management tools and preventing disruptive events are costly and can negatively affect business performance in the short-term (Chopra and Sodhi, 2014). This provides a possible explanation for the significant difference identified on this resilience indicator between leaders and SMEs in our sample. Leaders have more financial resources to invest in activities related to improving resilience compared to SMEs.

2.6.6 Income, gender, and racial inequalities (S4)

Driver S4 "Income, gender, and racial inequalities" includes GRI17 "Employment"; GRI18 "Labor/management relations"; GRI20 "Training and Education"; GRI21 "Diversity and Equal Opportunities"; GRI22 "Non-discrimination"; GRI24 "Child Labor"; GRI28 "Human Rights assessment." Inequality refers to a situation where resources or opportunities are not

shared equally between different groups in society (Kobayashi, 2020). One of the examples of inequality is gender discrimination where, although the situation is improving in the last few years, women on average earn less than men (OECD, 2017a). In addition, we are still facing racial discrimination based on the persistent racial wealth gap between blacks and whites in the U.S. (Noel et al., 2019). Gender inequalities are caused by macro-level factors such as cultural and religious factors; meso-level factors such as social and discriminatory preconceptions; and micro-levels factors such as social class or family affordability (Syed et al., 2018). Moreover, race inequality not only affects pay gap but also other aspects such as education, and chances of finding a job (OECD, 2017a) and increasing the likelihood of living below the poverty line. However, closing the racial gap represents a major economic opportunity for states and companies as the estimated cost of this gap in the United States is between \$1 and \$1.5 trillion (Noel et al., 2019). Therefore, firms should consider introducing ad hoc measures to reduce inequality by benefiting from skilled workforce that increase the resilience of the individual firm and the entire economic system.

The literature discusses how excessive inequality can be problematic and negatively affect the company's ability to face adversity (Tao et al., 2020). Interestingly, the same study indicates that small and medium-sized companies have a smaller pay gap among their employees and in contrast, leaders have larger gaps and should undertake greater efforts in this driver. In our data analysis, leaders included in our sample on this indicator have a score of 3.2 while SMEs have a score of 0.9 with a gap between the two of 72% (the maximum possible score is 6). These results show that both Leaders and SMEs have a low score, and the gap identifies that SMEs are far behind leaders and need invest more in this driver. This difference may be related to this fact that leaders have more challenges in inequalities like pay gap and they need to invest more to overcome the inequality. However, inequality is not only related to payment, and it includes other issues like education, health, promotion, gender, and racial equality. So, leaders and SMEs must improve their performance in these aspects. The ability to value all genders enables the effective use of all available resources resulting in improved performance.

2.6.7 Air pollution and malnutrition (S5)

Driver S5 "Air pollution and malnutrition" includes GRI12 "Emissions (pollutants)"; GRI13 "Emissions (GHG)"; GRI14 "Waste"; GRI15 "Environmental compliance"; GRI16 "Supplier environmental assessment"; and GRI33 "Marketing and labeling." Air pollution refers to the presence or release of chemical, physical, and biological substances that are harmful or poisonous to both the environment and the people into the air. Although many interventions have been planned to limit this issue, we expect an increment in pollutants in the coming years (OECD, 2017b). Malnutrition refers to a person's deficit and/or excessive consumption of nutrients. While there is a steady improvement regarding undernutrition over the past 25 years, obesity and overweight are steadily increasing as well as people affected by related diseases (Global Panel on Agriculture and Food Systems for Nutrition, 2016).

Our results find a resilience score for leaders of 3.7, while for SMEs 1.0 (the maximum possible score is 6). Overall, companies in our sample analysis show a weak performance regarding disruptive events related to air pollution and malnutrition. In addition, the gap between Leaders and SMEs is very high (73%) demonstrating that while leaders have limited consideration of the issue, SMEs are still very far from the problem recognition.

Air pollution is responsible for more than 300,000 deaths per year in G7 countries. The main consequences of air pollution are on population health and the natural environment; however, we should not overlook the economic consequences. In fact, air pollution leads to the change in health expenditures due to the increase in respiratory disease, productivity, as well as disruption on the agricultural sector due to the impact on the plants life cycle (OECD, 2016).

Malnutrition is responsible for diseases such as obesity, diabetes, and heart disease. Factors that lead to this condition include population growth and aging due to increased life expectancy, climate change affecting the ability to produce food, urbanization of the population, growth in earnings that while reducing under-nutrition fosters issues related to over-nutrition, globalization of diet, and competition for increasingly scarce natural resources (Global Panel on Agriculture and Food Systems for Nutrition, 2016). These trends represent a major opportunity for companies as they alter consumer consumption habits by their marketing and labelling strategies. Actions to consider include setting up proper

diets for infants and children, identifying guidelines for healthy and balanced diets, pragmatic, and planned use of animal-derived food, making plant-based foods more available and easier to consume, improving food-related communication, and refocusing global production toward healthier production.

2.6.8 Lack of healthcare (S6)

The S6 driver "Lack of healthcare" includes GRI19 "Occupational Health and Safety"; GRI32 "Customer Health & Safety"; and GRI33 "Marketing and labelling." The lack of healthcare is the lack of sufficient supply of healthcare services to meet demand due to a shortage of essential resources (Autran, 2022). Our data analysis shows a resilience score of 5.0 for the leaders in this driver while SMEs achieve a score of 2.6 (the maximum possible score is 8.2) which shows a moderate well performance for the leaders and a weak performance for the SMEs and a meaningful difference of 48% between them.

The literature has identified 12 capabilities needed by companies to overcome healthcare related disruptions such as the covid-19 pandemic (Betto and Garengo, 2023) and we explain the most relevant ones. The human resource management capability refers to personnel management and includes the capacity for collaboration, flexibility, and knowledge management. It is related to the organizational safety capability, which includes activities to improve safety within the organization like limiting the spread of disease, complying with more general workplace safety regulations, and developing appropriate safety management procedures and structures.

Customer Health & Safety (GRI32) is related with the company assessment of the health and safety impacts of product and service categories and disclosure of incidents of non-compliance concerning the health and safety impacts of products and services. Having these disclosures can be key for companies as it raises the awareness of potential flaws and helps them establishing procedures for improving both their product and services, avoiding potential problems in the future. This is even more important in healthcare industry as the impact of firm's actions is deeply connected with customer health. For instance, during Covid-19, the vulnerabilities of healthcare supply chains had

compromised the health and safety of both customers and healthcare professionals (Sawyer & Harrison, 2023).

Marketing and labelling (GRI33) are related with the disclosure of requirements for product and service information and labelling; disclosure of incidents of non-compliance concerning product and service information and labelling and/or marketing communications. Raising the customer awareness on the products and services provided with transparent labelling can foster the resilience within healthcare service.

2.6.8 Corruption (S7)

Driver S7 "Corruption" includes GRI5 "Anti-corruption"; GRI35 "Socio-economic compliance"; and GRI6 "Anti-competitive behaviour". Corruption can be defined as the abuse of entrusted power for private gain. Corruption has a noticeable annual global cost exceeding \$3.6 trillion and can take many forms including bribery, embezzlement, money laundering, tax evasion, and cronyism, to name a few (Johnson, 2018). Interestingly, one in four people say they have dealt with some form of corruption at least once, making it an extremely widespread phenomenon (Johnson, 2018). Accordingly, because of the widespread nature of the phenomenon this driver has the highest weight among other drivers in economic resilience. Based on the results of our data analysis, leaders and SMEs achieve a score of 21.9 and 11.5 respectively with a difference of 47% while the maximum possible resilience score for this driver is 40.8. So, although leaders and SMEs have a better performance for this driver compared to other available one, they achieved less than half of the possible score which again shows they need to invest more to improve their resilience score for this driver.

The governments are the main actors to implement anti-corruption actions such as strengthening institutions and monitoring budgets, decreasing the gap between anti-corruption laws and their implementation, incentivizing citizens to talk about it and take their complaints into account, and protecting the press when they talk about corruption (Moulds, 2019). The literature has explored five strategies that governments and companies can use to become more resilient in the face of corruption (Tunley et al., 2018). The first strategy involves increasing the effort required to implement acts of corruption. In

this direction, it is possible to create bureaucratic processes and procedures that make corruption more complicated. The second strategy concerns increasing the risk of being detected through the introduction of monitoring and reporting techniques, such as surprise audits, staff and system integrity tests, whistleblowing, data analysis and telecoms monitoring. The third strategy concerns the reduction of personal benefits associated with corruption such as inserting sanctions that limit the freedom, or career prospects of those who are discovered. The fourth category concerns the reduction of provocations and excuses and requires societal level intervention to limit the opportunities and justifications of these phenomena. The last involves the creation of ethical programs aimed at creating an ethical and values-oriented atmosphere that discourages the spread of corruption.

2.6.9 Lost potential due to lack of advanced technologies (S8)

Driver S8 "Lost potential due to lack of advanced technologies" includes GRI26 "Security practices"; GRI34 "Customer privacy"; and GRI37 "Responsible data management." Driver S8 refers to disadvantages due to lack of technology upgrades. Our results show a low resilience score of 4.4 for leaders and 4.2 for SMEs out of the maximum possible score which is 13.8. However, the difference between leaders and SMEs is negligible and equals 5%. This indicates that leaders have no advantage over SMEs on this indicator.

Technological obsolescence is a disruption capable of destroying the competencies of companies (Amankwah-Amoah, 2017). And its relevant risks include decreased production capacity and product quality; increased costs due to lower efficiency, increased frequency of defects, and the cost of maintaining machinery and technology; decreased competitiveness due to difficulty in performing like the competitors; security risks due to vulnerability to cyber-attacks, malfunctions, or downtime. To be more resilient in the face of technological advancement, companies can implement some practices: Do periodic monitoring of their technology level to identify technologies that are obsolete or no longer relevant and update them by investing in more advanced technologies. Undertake a culture of innovation by encouraging creativity and risk-taking. Team up with

technology experts who can provide advice and guidance regarding the latest technology trends (Zuckerman, 2001; Brettel et al., 2015; Saarikko et al., 2020)

2.7 Resilience Drivers and GRI

In this section, to discuss more about the relationships between the resilience drivers and GRI standards and provide further explanations about the performance of the leaders and SMEs, we use Sankey diagrams. The Sankey diagram is a graphical tool used to represent a flow from one series of values to another. The left-hand side of the Sankey diagrams in Figures 26 and 27, sorts the resilience groups from the lowest to the highest score. The thickness of the connecting lines from the drivers to the GRI standards show the impact of each GRI standard on the final total resilience score of drivers.

Looking at the left-hand side of the diagrams we can find out some similarities as well as some differences in the ranking of the drivers of the leaders and SMEs. In fact, the drivers with the highest resilience scores are S3 and S7 and the drivers with the lowest scores are S1 and S2 for both leaders and SMEs. However, the drivers with average performance have a different ranking for the two categories of companies.

Accordingly, for driver S7 "Corruption", GRI5 "Anti-corruption" and GRI6 "Anti-competitive behaviour" have the disclosure rates and consequently have the most impact of the resilience score of both leaders and SMEs. For driver S3 "Energy and supply chain disruption", the most impactful GRI in terms of disclosure rate is GRI9 "Energy" and GRI 10 "Water & Effluents" for leaders and is GRI4 "Procurement practices" and GRI8 "Materials" for SMEs which indicates their different priorities and approaches in improving energy and SC disruptions.

Figure 26. Sankey diagram for resilience groups and GRI standards (Leaders).

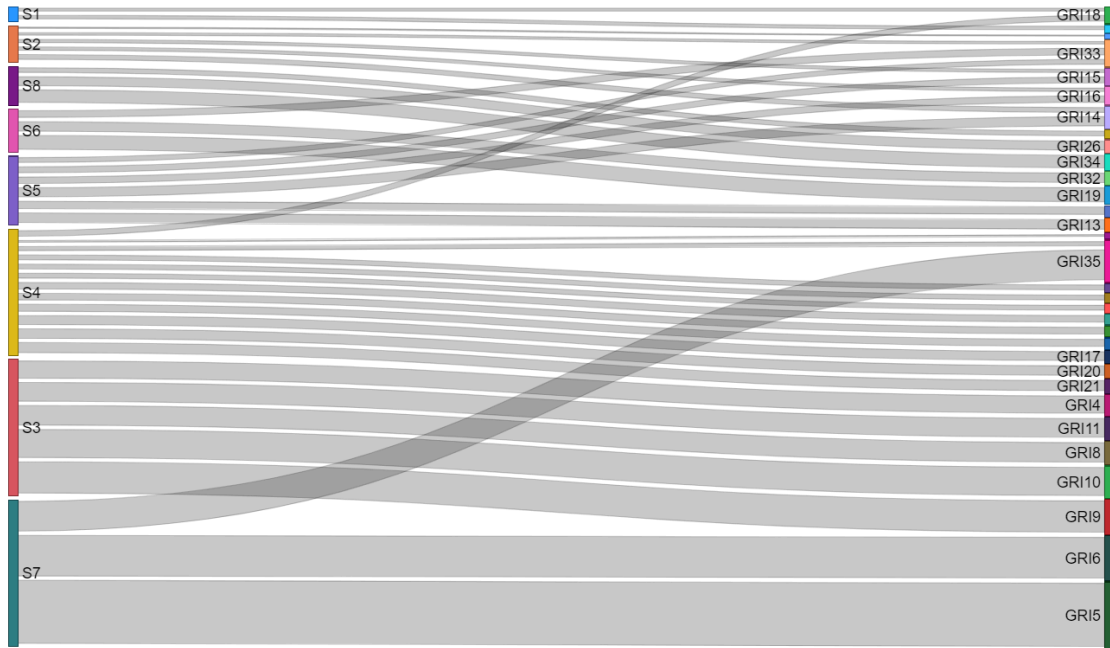
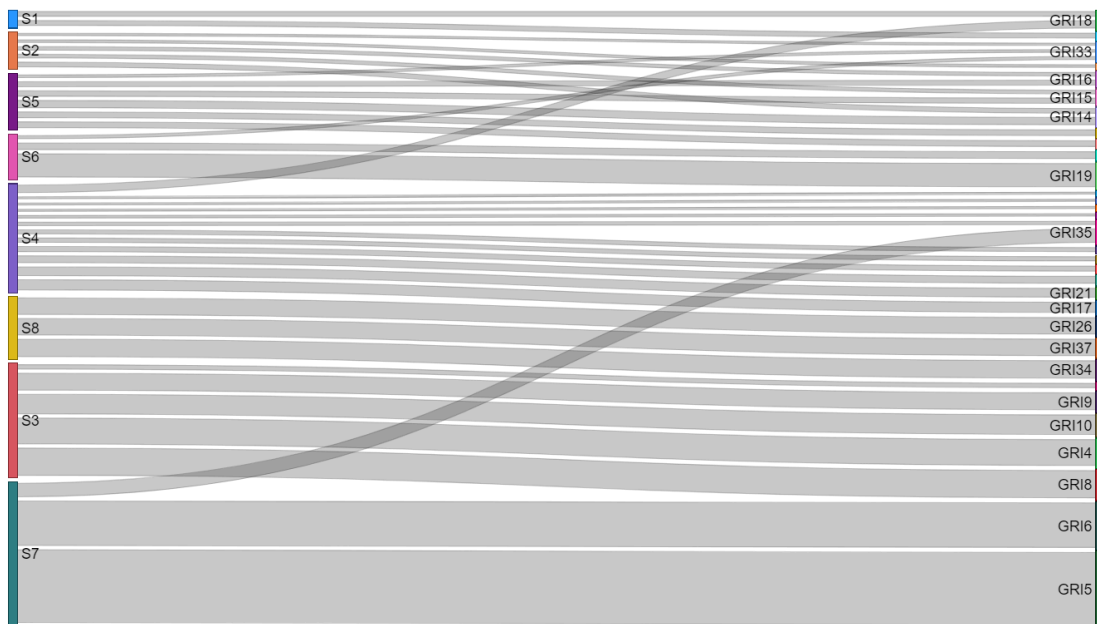


Figure 27. Sankey diagram for resilience groups and GRI standards (SMEs).



2.7.1 Resilience Score by Sectors: SMES and Leaders

In this section we analyze the resilience scores of leaders and SMEs by sector. Table 8 and Table 9 summarize the results of the resilience score analysis for the leaders and SMEs respectively.

Table 8. The resilience index for Leaders considering different sectors.

Group	Weight	Agri-Food	Engineering	Healthcare	ICT	Manufacturing	Services
S1	0.033	2.0	2.3	2.0	0.9	1.6	3.3
S2	0.033	2.3	2.0	1.4	0.7	1.7	1.3
S3	0.190	14.7	13.4	8.4	5.3	12.8	13.3
S4	0.060	4.2	3.8	3.1	1.7	3.3	2.0
S5	0.060	4.4	4.6	3.1	1.7	4.1	4.0
S6	0.082	7.0	5.1	6.5	2.2	5.3	4.1
S7	0.408	26.3	28.8	21.7	10.9	22.9	20.4
S8	0.136	4.8	6.4	5.4	3.2	3.9	2.3
	Total Score (out of 100)	65.83	66.39	51.63	26.48	55.47	50.58

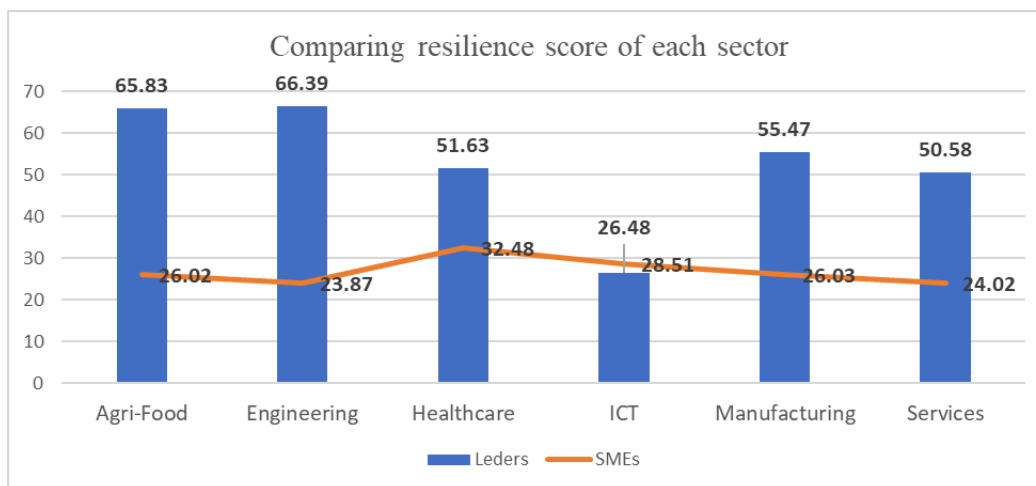
Table 9. The resilience index for SMEs considering different sectors.

Group	Weight	Agri-Food	Engineering	Healthcare	ICT	Manufacturing	Services
S1	0.033	0.8	0.8	1.3	0.7	0.9	1.4
S2	0.033	0.6	0.4	0.4	0.4	0.5	0.2
S3	0.190	6.0	4.6	6.8	3.0	5.0	3.2
S4	0.060	0.7	1.1	0.9	1.1	0.9	0.8
S5	0.060	1.1	1.1	0.6	0.8	1.2	0.6
S6	0.082	3.0	2.7	3.0	1.9	2.6	2.5
S7	0.408	10.6	8.8	16.6	14.6	11.5	9.4
S8	0.136	3.3	4.3	3.0	6.0	3.5	5.9
	Total Score (out of 100)	26.02	23.87	32.48	28.51	26.03	24.02

The comparative analysis of leaders and SMEs in Figure 28 shows a significant difference in performance between leaders and SMEs in which the leaders show a higher performance on almost every sector analyzed. Interestingly, leaders have an

inter-sectoral variability with resilience scores ranging from 66.39 in the Engineering sector to 26.48 in the ICT sector. These peaks show that among the leaders analyzed, the sector is a variable capable of influencing the resilience score. In contrast, SMEs record more stable inter-sectoral values ranging from 32.48 in healthcare to 23.87 in Engineering. This stability demonstrates a limited difference in the resilience score suggesting that for SMEs the sector is an irrelevant variable for predicting the firm's resilience score. Therefore, according to Figure 28, leaders record higher resilience scores than SMEs across all sectors except the ICT sector where SMEs have a slightly higher score.

Figure 28. Comparing the resilience score of the leaders and SMEs considering different sectors



2.7.2 Leader's and SME's resilience in the Agri-food Sector

In the Agri-food sector leaders have a resilience score of 65.83 while SMEs have a resilience score of 26.02. In this sector leaders outperforms SMEs being more resilient in all the drivers analyzed. According to FAO, the agri-food sector is resilient when it is capable over time to sustainably ensure access to sufficient, safe and nutritious food for all (FAO, 2021). However, the agri-food sector is increasingly affected by shocks that challenges its resilience. Among the disruptive events that most affect the sector, the literature cites the covid-19 pandemic, geo-political instability, climate change and natural disasters besides the population growth that increases the demand for food (Wei et al., 2023).

Creating resilient supply chains capable of withstanding unforeseen shocks through structured procurement, storage, and logistics capacity; and developing education programs to improve food habits and waste reduction are some of the helpful practices to improve this driver in agri-food industry (FAO, 2021). Given the interventions identified by FAO, it is not surprising that in this area leaders are more resilient as they are more structured and able to invest in the preventive tools. In addition, their greater economic availability and ease of access to financial resources makes them more resilient.

2.7.3 Leader's and SME's resilience in the Engineering Sector

In the Engineering sector the leaders have a resilience score of 66.39 while the SMEs have a resilience score of 23.87. In this sector leaders outperforms SMEs by proving to be more resilient in all drivers analyzed. This sector includes a various range of industrial, architectural, or urban planning operations and its resilience goals are achieved when systems continue to operate normally even in the event of a component failure (Lopez et al., 2023). Moreover, the human element has a critical role in this domain as it is responsible for the activities of designing and maintaining the systems (Woods and Allspaw, 2020).

2.7.4 Leader's and SME's resilience in the Healthcare Sector

In the Healthcare sector leaders have a resilience score of 51.63 while SMEs have a resilience score of 32.48 and the leaders outperforms SMEs in all drivers analyzed. Healthcare resilience is defined as "the ability to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required performance under both expected and unexpected conditions". The healthcare sector can be pressured by natural events such as natural disasters, hurricanes, and earthquakes or new pathogens such as EBOLA or COVID-19; or man-made causes such as crimes, wars, economic crises,

and cyber-attacks (Sayess et al., 2021). The determinants of a healthcare system's vulnerability include the difficulty of accessing medical care even under normal conditions; individuals' behaviors such as unhealthy diet, smoking rate etc.; the presence of chronic diseases in the population such as diabetes, or widespread respiratory problems that make the population more vulnerable; environmental conditions such as air and water quality; demographic factors such as the average age of the population; and economic factors such as lack of annual investments in health care (Sayess et al., 2021).

According to a BCG survey, in order to be more resilient, healthcare companies need to gain the ability to assess potential risks especially those related to the end-to-end supply chain and develop capabilities to mitigate such disruptions (Garro et al., 2023). The survey shows that resilient companies have three factors in common. First factor is integrating systems with the partners for identifying risks and mitigating them. Integration of systems with their partners is critical to identify risks quickly and respond promptly. Second factor is related to the use of advanced analytics to predict alternatives. For example, in the case of medicine production, pharmaceutical companies can predict alternative materials or suppliers to deal with supply disruption. Finally, the third factor emphasizes on assigning responsibility for resilience to each business unit.

2.7.5 Leader's and SME's resilience in the ICT

Sector

In the ICT sector, SMEs have a resilience score of 28.51 while leaders have a resilience score of 26.48. In this sector Leaders outperforms SMEs on drivers S1, S2, S3, S4, S5 while SMEs record a higher aggregate score due to high performance in drivers S7 and S8. ICTs are critical to elevate the resilience of an economic system as they enable information sharing, (re)connection, and resource acquisition (Chewning et al., 2013). However, the ICTs themselves need to be resilient to disruptive events. Resilience in the ICT sector is achieved when an information and communication system continue to function even in the event of a disruption such as a natural disaster, or a cyberattack, and can quickly

return to full functionality. Investment in technology and a commitment from management to ensure adequate financial support. As in other resilient systems, redundancy is required, which involves the introduction of multiple elements capable of performing the same function to increase reliability. The reliability of an ICT system can also be increased by providing backup strategies to recover from any data loss. System functionality, even in the face of disruption, can be ensured by testing the system under pressure to adjust any weaknesses that could emerge. Finally, training and education of internal staff throughout the enterprise in the proper use of systems increase resilience (Maurer and Lechner, 2014)..

2.7.6 Leader's and SME's resilience in the Manufacturing Sector

In the Manufacturing sector leaders have a resilience score of 54.47 while SMEs have a resilience score of 26.03 and the leaders outperforms SMEs by proving to be more resilient in all drivers analyzed. The manufacturing sector deals with the production of objects using equipment, labor, machines, tools, and chemical or biological processing or formulation. Disruptive events in this sector have the consequence of disrupting normal production processes resulting in a loss of production (Gu et al., 2015). There are some strategies such as building redundancy and increasing flexibility that can be helpful to increase the resilience of the manufacturing sector (Rajesh, 2021). Building redundancy involves placing multiple elements in a manufacturing system that can perform the same function. In case of malfunctions or breakdowns, production can continue without costly production interruptions. Similarly, flexibility refer to the ability of a systems to perform multiple functions by increasing responsiveness to unforeseen situations. Similarly, raw material inventory forecasting avoids downtime due to raw material shortages. Finally, industry 4.0 and digital technologies increase resilience of both leaders and SMEs by increasing flexibility, reliability, robustness, and responsiveness (Bianco et al., 2023). However, implementing and developing a more resilient manufacturing system is usually more expensive (Gu et al., 2015). This partially justifies our results where the leaders are

more resilient than SMEs. Leaders can benefit from economies of scale while, it is more difficult for SMEs to make large-scale investments.

2.7.7 Leader's and SME's resilience in the Services

Sector

In the Service sector, leaders have a resilience score of 50.58 while SMEs have a resilience score of 24.02 and the leaders outperforms SMEs in all drivers analyzed except S8 where SMEs have a higher score. The service sector includes all intellectual, complementary, and service activities such as maintenance and repairs, training, or consulting, housekeeping, tours, nursing, and teaching. Usually, the service sector is more resilient than other sectors to disruptions. Services are often carried out on the basis of long-term contracts that make the effect of demand fluctuations less powerful (Swinney and Netessine, 2009). Moreover, capabilities such as agility, flexibility, cooperation with other firms and visibility in the supply chain are pivotal (Revoredo-Giha and Dogbe, 2023).

According to the limitations that we had with the secondary dataset; the analysis of this section is only based on economic resilience. The resilience score we provided in this report is useful to have a better understanding of the connection between GRI standards and resilience performance. Besides, it helps to compare different sectors in terms of sustainability and resilience. However, it is not possible to provide additional discussions as we did not have access to some necessary data for further analysis. So, to develop additional analysis regarding resilience, we need to collect data and discuss different factors accordingly (Target #2, WP #2). This report (Milestone #1) can be a supplementary file for Target #2, and it is helpful to devise the questionnaire considering different variables.

3. Indicators based on data on the value chains of 500 Italian firms

In the modern era, disruptions have become a prevalent and formidable challenge, posing significant impacts on businesses and societies worldwide. The frequency of disruptions, ranging from natural disasters to economic crises, has intensified, testing the resilience of firms and industries alike (Ponomarov and Holcomb, 2009; Sheffi and Rice, 2005). Events like the COVID-19 pandemic have further highlighted the importance of understanding and managing disruptions effectively (Ivanov, 2020; Ivanov and Dolgui, 2020). These disruptions, occurring at an accelerated pace, have the potential to reshape industries, alter consumer behavior, and create unprecedented uncertainties for businesses. To navigate through this dynamic landscape, a comprehensive understanding of how disruptions influence firms' performance indicators is vital to reshaping strategies, supply chains, and networks (Craighead et al., 2007).

This report delves into the multifaceted world of disruptions and their impact on firms' performance indicators. In fact, disruptions are inevitable occurrences that can significantly impact firms' performance across various industries (Wilson, 2007; Yu et al., 2019). Any unexpected event, such as natural disasters or geopolitical tensions, can disrupt global supply chains. Shortages of raw materials, production delays, and distribution challenges can affect stock availability, customer service, and on-time delivery, leading to overall performance challenges (Macdonald and Corsi, 2013). Similarly, disruptions can cause shifts in consumer preferences, emerging technologies, or competitive pressures, which require deep modifications in the firms' operations and require adjustments to stay relevant in the market (Adner, 2002). Furthermore, labor shortages or technological failures can disrupt firms' workforce and operations and affect productivity, quality, and overall performance. Finally, regulatory and policy changes as

well as innovation and technological disruptions can create opportunities for firms, but also challenges in terms of adoption and implementation (Sood and Tellis, 2011).

The motivations mentioned above collectively influence firms' performance indicators during disruptive events, creating a complex landscape where certain indicators may be significantly impacted, while others show non-significant correlations with various support measures. Understanding these motivations is crucial for firms to build resilience and devise strategies that can withstand and navigate through future disruptions. A comprehensive report on firms' performance indicators during disruptive events offers valuable insights for decision-makers, policymakers, academics, and researchers to understand the multifaceted challenges faced by businesses during times of uncertainty and change.

This report focuses on the outbreak of the COVID-19 pandemic, which has severely disrupted global supply chains, posing unprecedented challenges for businesses. As supply chain dynamics evolved rapidly during the pandemic, the ability of companies to adapt and respond became paramount to their survival and success (Ambulkar et al., 2015; Bhamra et al., 2011). Therefore, this report aims to investigate the impact of the COVID-19 pandemic on supply chain structures, support provided by partners, and the associated changes in value chain indicators and vulnerability.

Accordingly, section 2 provides an overview of the sample used for this study, highlighting the diversity of industries and geographic locations included. The analysis of the sample ensures a comprehensive understanding of how supply chains were affected by the pandemic across various sectors and regions. Section 3 delves into the changes in supply chain structures that emerged as a response to the challenges posed by COVID-19. We examine how companies adjusted their supply chain configurations to enhance resilience and mitigate disruptions. Subsections include an exploration of the support received from supply chain partners through financial aids and commercial aids, as well as the adjustments of contractual terms made to navigate the crisis effectively. Section 4 focuses on analyzing key value chain indicators and assessing the vulnerability of firms during the pandemic. The value chain indicators examined include stock availability, customer service, sales, ROI, product quality, market share, and on-time delivery. This comprehensive analysis allows us to identify areas of strength and vulnerability in the

value chain. Section 5 establishes the connections between the performance indicators and the various aspects of the supply chain. We investigate how the performance indicators are influenced by the supply chain structure, the support from supply chain partners, and the adjustments of contractual terms. Furthermore, we explore how support to consumers through price reductions and promotions impacts the performance indicators. Section 6 analyzes the main technologies adopted during the first wave of COVID-19. The technologies include Big Data and Machine Learning, Artificial Intelligence, Blockchain, Drones, 3D Printing, Mobile Apps, Social Networks, Call centers, and Omni-channel (Koh et al., 2019). We find the main applications of these technologies for business purposes, their drawbacks, and disadvantages. At the end of each section, we assess the degree of adoption of these technologies by Italian companies by identifying those that are already widespread versus those that have not yet aroused particular interest. Section 7 assesses the amount invested by Italian companies on three items related to sustainability: Green Technologies; Green Practices, and Green Packaging. We assess the main drivers of these investments and give an overview of the situation in Italy with respect to these issues. Section 8 concludes the report with an analysis of resilience using different techniques that include correlation analysis, regression analysis, and Bayesian networks.

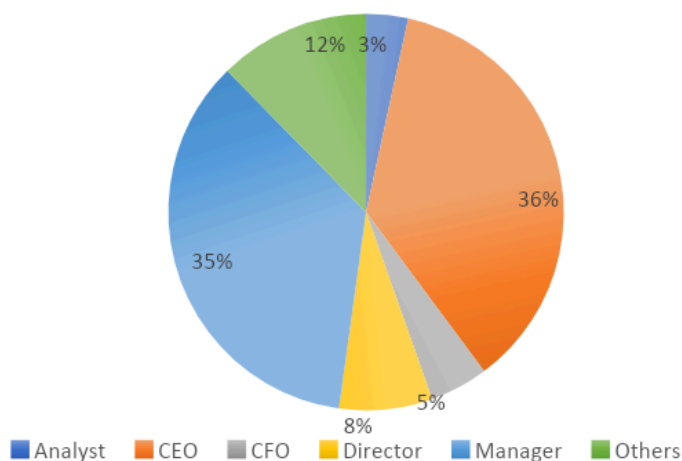
The findings from this report offer valuable insights for businesses seeking to enhance their supply chain resilience and improve performance indicators during periods of disruption. The analysis of the support provided by supply chain partners and its correlation with performance indicators can guide managerial decisions, helping companies navigate future uncertainties more effectively. The report encompasses a wide range of potential readers, including supply chain managers and professionals looking to enhance their understanding of supply chain dynamics during disruptive events like the COVID-19 pandemic. Researchers and academics, including PhD students, can find valuable insights to expand their knowledge in the fields of operations management and supply chain resilience. Public authorities and governments can benefit from the report's comprehensive analysis of supply chain structures and adjustments made during the pandemic. The findings can aid policymakers in developing strategies to strengthen supply chain resilience and prepare for future disruptions. Business leaders

and executives across industries can draw essential lessons from the report to adapt their supply chain strategies and mitigate risks during uncertain times. Industry associations and trade groups can leverage the report to foster collaboration and knowledge-sharing among their members, leading to collective resilience. Investors and financial analysts can make informed decisions by assessing companies' supply chain performance during the pandemic and evaluating their resilience to future crises. Consulting firms specializing in supply chain management can utilize the report to benchmark and develop tailored solutions for their clients, helping them navigate challenges and optimize their supply chain operations.

3.1 Description of the sample

The sample consists of 525 Italian companies, which have been interviewed after the first wave of COVID-19. The main motivations driving this research are: understanding the firms' capacity to achieve satisfactory levels of performance even during a disruptive event like COVID-19, identifying the managerial practices that companies adopted to face the disruptions, the investments made in sustainable practices during the period as well as their resilience in terms of time-to-recovery. In addition, this first questionnaire gathered insights for the preparation of a broader questionnaire related to PNRR.

Figure 29 The distribution of the professionals

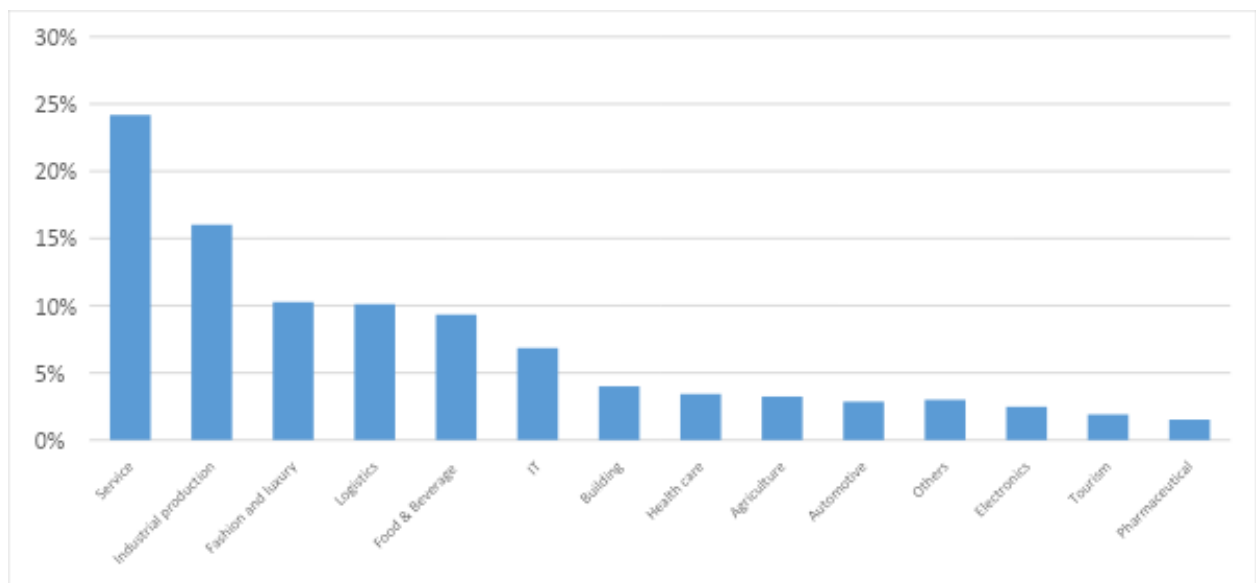


To pursue the objectives of this research project, several types of professional figures have been involved in the data collection, as displayed in Figure 29. Considering the job roles and positions covered within an organization, the sample is composed of 3% of analysts (professionals who perform analytical work, such as data analysis, market research, financial analysis, or any other specialized analytical tasks within the organization), 36% of CEO (the highest-ranking executives in a company, responsible for making strategic decisions, leading the organization, and managing overall operations), 5% of CFO (responsible for managing the financial affairs of an organization, including financial planning, budgeting, reporting, and overseeing financial operations), 8% of directors (hold a senior management position and are responsible for overseeing specific areas or departments within an organization; they provide leadership, guidance, and strategic direction to their respective teams), 35% of managers (responsible for supervising teams, coordinating work, ensuring productivity, and implementing strategies to achieve departmental or organizational goals), and 12% of others (include various roles within the organization that are not specifically listed, such as support staff, administrative personnel, or employees in specialized positions that do not fall into the aforementioned categories).

As displayed in Figure 30, the sample also includes several types of industries, giving insights into the representation of various Italian company frameworks. Considering the sectors, the sample is then composed of 24% of service companies (banking, consulting, hospitality, retail, education, and other service-oriented businesses), 16% of industrial manufacturing (automotive manufacturing, electronics, machinery, and other industrial sectors), 10 of fashion and luxury companies (fashion design, clothing manufacturing, luxury brands, accessories, and high-end retail), 10% of logistics companies (transportation, warehousing, supply chain management, and logistics services), 9% of food and beverage (food production, restaurants, catering, beverages, and food processing), 7% in IT (information technology, software development, hardware manufacturing, telecommunications, and related services), 4% in building (construction,

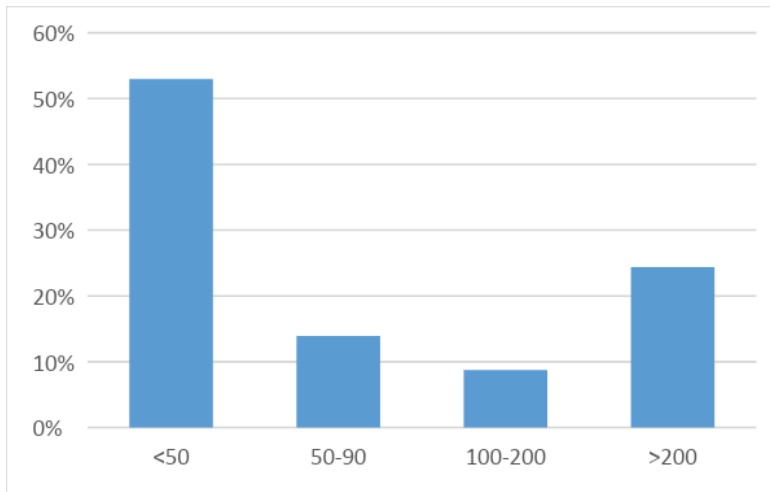
real estate development, architecture, and building materials), 5% in healthcare (hospitals, clinics, medical equipment manufacturers, pharmaceutical companies, and other healthcare-related businesses), 3% in agriculture (farming, crop production, livestock, forestry, and agricultural equipment), 3% in automotive (manufacturing, assembly, and distribution of automobiles and automotive parts), and 7% in other sectors.

Figure 30 Distribution of the sample among different sectors



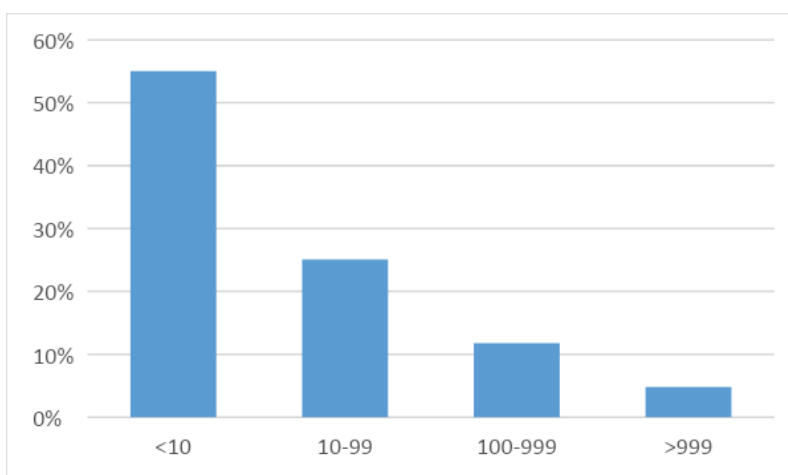
In Figure 31, the companies in the sample can be categorized according to the number of employees, which is a proxy of the companies' size. Accordingly, 53% of the sample is composed of companies with a number of employees lower than 50, indicating that more than half of the sample falls below the definition of SMEs (Montanari and Kocollari, 2020). Then, 14% of the sample falls in the category 50–90, 9% of the sample falls in the category 100–200, while 24% of the sample has more than 200 employees.

Figure 31 Distribution of the sample with respect to the number of employees



Finally, Figure 32 shows the dispersion of the sample with respect to the sales. The data was collected from a wide range of industries and sectors, providing a comprehensive representation of the business landscape. Among the Italian firms included in the sample, the majority, accounting for approximately 55%, reported sales revenue below 10 million euros. These firms represent a significant portion of the sample and likely comprise a mix of small and medium-sized enterprises (SMEs) as well as startups and businesses in their early stages of development. The second-largest segment in the sample comprises firms with sales revenue falling within the range of 10 to 99 million euros. Approximately 25% of the sample falls within this category, indicating a substantial presence of mid-sized companies that have achieved moderate levels of success and growth. The third category includes firms with sales revenue in the range of 100 to 999 million dollars, constituting about 12% of the sample. Lastly, the sample includes a smaller subset of firms with sales revenue exceeding 999 million dollars, accounting for approximately 5% of the total sample. These firms are likely to be major players in their industries, with significant market share and a strong track record of success.

Figure 32 Distribution of the sample with respect to the sales (in millions)



3.2 Supply chain structure and changes due to COVID-19

3.2.1 Supply chain structure

A supply chain is generally composed of various types of companies, including wholesalers, distributors, suppliers, retailers, and manufacturers, due to the interdependence and complexity of the process of bringing a product or service from its creation to the end consumer (John T. et al., 2001). The diverse composition of companies in a supply chain facilitates specialization, value addition, efficient resource allocation, market reach, customer satisfaction, and risk management (Chen and Paulraj, 2004). By working together, these entities collaborate to create and deliver products or services to consumers in a coordinated and effective manner. In terms of specialization and expertise, each type of company in the supply chain brings a specialized skill set and expertise to the process. Manufacturers focus on producing goods efficiently and at scale, while wholesalers specialize in bulk purchasing and storage (Cachon and Kök, 2010). Distributors excel in logistics and transportation, suppliers provide specific components or raw materials, and retailers excel in merchandising and meeting customer demands (John T. et al., 2001).

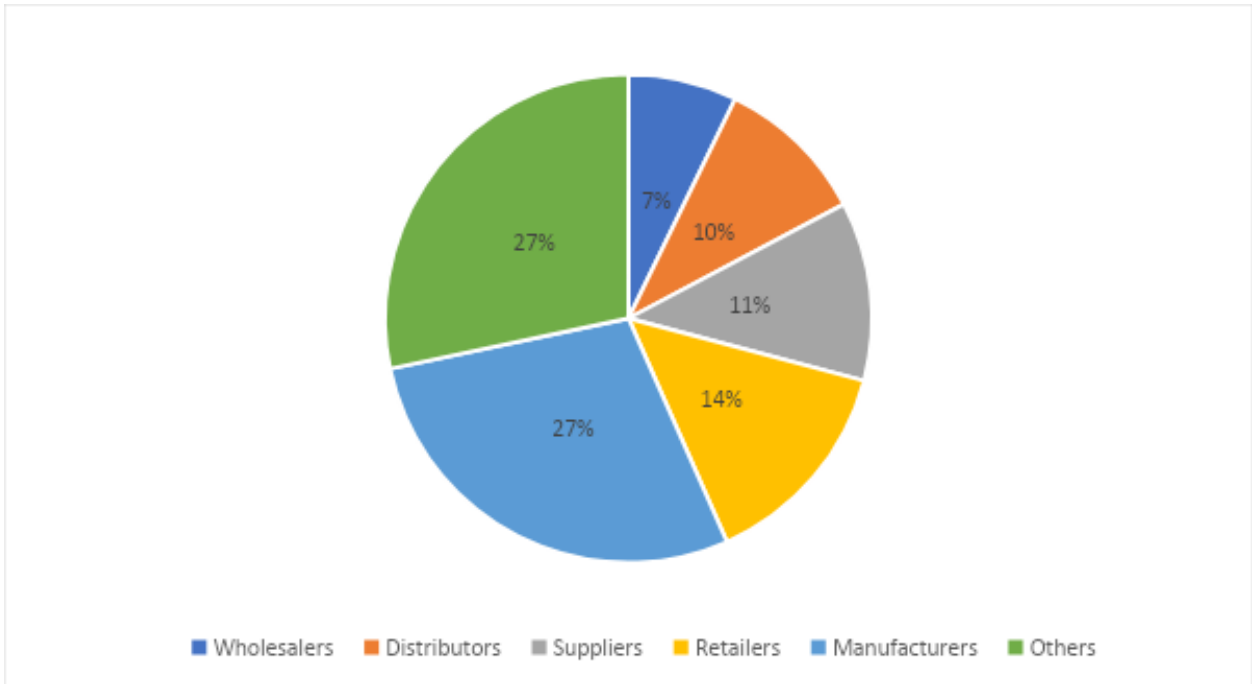
Similarly, companies in the supply chain add value to the product or service in their unique way (Horvath, 2001). Manufacturers transform raw materials into finished goods, ensuring quality and customization. Wholesalers and distributors handle the movement and storage of products, ensuring efficient distribution to retailers. Suppliers provide essential components or materials, contributing to the final product's functionality and quality. Retailers offer convenience, personalized experiences, and accessibility to consumers. Relatively to targets of efficiency, supply chain members specialize in specific tasks, allowing for efficient allocation of resources (Wu et al., 2013). For example,

manufacturers focus on optimizing their production processes, while wholesalers and distributors concentrate on efficient inventory management, warehousing, and transportation. This division of labor allows each company to streamline its operations and achieve economies of scale.

An important aspect that characterizes the firms in a supply chain is how each supply chain member reaches the market (Christopher and Towill, 2002; Iyer et al., 2014). Retailers, as the last link in the chain, have direct contact with customers and cater to their specific demands. Wholesalers and distributors ensure that products are available in various locations, while suppliers provide the necessary components or raw materials to meet manufacturing requirements. Hence, the complexity in managing the relationships with the upstream and the downstream change is inevitable (Touboullic et al., 2014). Finally, having multiple types of companies in the supply chain helps manage risks and uncertainties (Sreedevi and Saranga, 2017). If one company faces an issue or disruption, other companies in the chain can step in to mitigate the impact and ensure continuity. Additionally, diversifying the supply chain by involving multiple suppliers, distributors, and retailers reduces the dependency on a single entity and enhances resilience (Scholten et al., 2014).

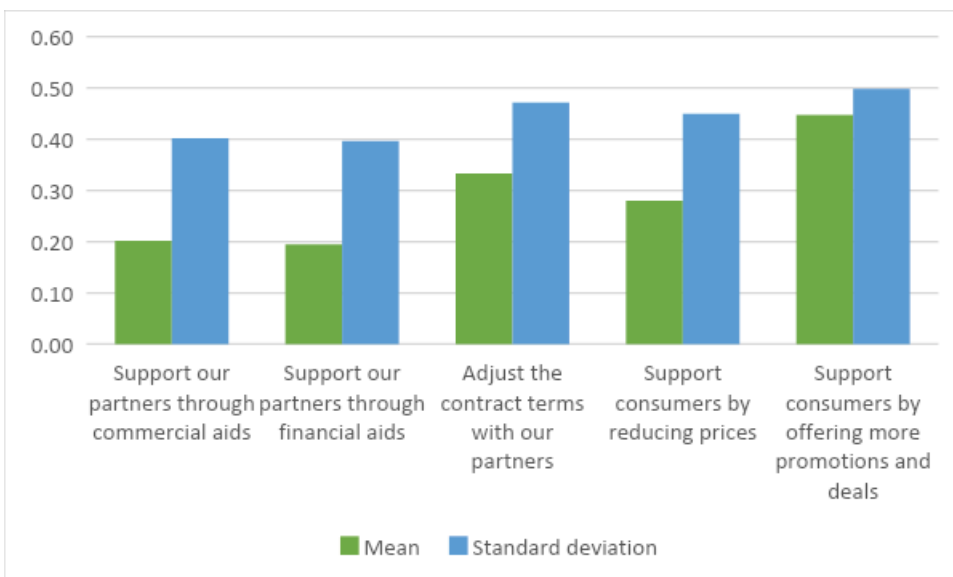
As displayed in Figure 33, within our sample, the firms composing the supply chains are distributed as follows: wholesalers 10%, distributors 7%, suppliers 11%, retailers 14%, and manufacturers and others, both covering 27% of the sample. Then, the sample exhibits a well-balanced representation across the different supply chain member categories, ensuring a comprehensive view of the entire supply chain ecosystem.

Figure 33 Composition of the sample with respect to the supply chain structure



Among the constellation of managerial practices that Italian firms can adopt, we focus our analysis on the information available regarding the following practices: support from the supply chain partners through financial and commercial aids, adjustment of contractual terms, as well as support for consumers by reducing the price and offering special deals or promotions. For each practice, Figure 34 displays the mean and the standard deviation, whose details are discussed in the next paragraphs.

Figure 34 Means and standard deviations of the managerial practices adopted by Italian firms



3.2.2 Support from supply chain partners through financial aids

In order to analyze how the value chain modified after a disruptive event like COVID-19, the dataset includes the variable "Support from supply chain partners through financial aids", which refers to the provision of financial assistance or support from partners within the supply chain to help mitigate the adverse effects of disruptions like the first wave of COVID-19 (Yu et al., 2022). This support can take the form of financial resources, loans, grants, or other monetary assistance (Lo Nigro et al., 2021; Silvestro and Lustrato, 2014). During the first wave of COVID-19, support from supply chain partners through financial aids became crucial for the success of supply chains since the whole system had important financial stability troubles (Sahoo and Thakur, 2023). The pandemic posed significant financial challenges for many businesses, including cash flow constraints, reduced revenue, and increased operational costs. Financial support from supply chain partners was a possible driver to help companies maintain financial stability, meet operational expenses, and sustain their operations during challenging times. At the same time, the disruptions caused by COVID-19, such as lockdowns, travel restrictions, and supply chain disruptions, can severely impact the ability of businesses to continue their operations (Rozhkov et al., 2022). Therefore, financial aids from supply chain partners could have provided the necessary resources to ensure business continuity, enabling companies to overcome financial hurdles and sustain their supply chain activities.

This discussion substantially links to the firms' resilience. In fact, in principle, financial support from supply chain partners can enhance the resilience of businesses. It allows companies to invest in necessary resources, adapt their operations, and explore alternative strategies to mitigate the negative impacts of disruptions. This support strengthens the overall resilience of the supply chain by helping individual businesses guarantee some levels of performance. This practice, then, supports the collaborative relationships among supply chain partners as it strengthens trust, builds stronger partnerships, and encourages a sense of solidarity within the supply chain. These collaborative relationships can lead to shared knowledge, resources, and joint problem-solving, ultimately benefiting the entire supply chain ecosystem.

However, disruptions like COVID-19 can influence the availability of support from supply chain partners through financial aids negatively (Dubey et al., 2022). The pandemic affected businesses across various industries, resulting in financial challenges for many organizations. Supply chain partners themselves may be facing their financial struggles, limiting their ability to provide significant financial support to other members of the supply chain. Furthermore, the uncertain business environment during a disruption like COVID-19 can make supply chain partners more risk-averse and cautious about extending financial aid (Trautrimis et al., 2020). They may prioritize safeguarding their financial stability and liquidity, which can reduce the availability of financial support for other partners. Finally, the disruptions caused by COVID-19 forced businesses to make difficult decisions regarding resource allocation. Supply chain partners may have had to prioritize their own survival and core operations, making it challenging to allocate significant financial aids to other partners.

According to the empirical analysis that we carried out and resulting from Figure 34, Italian companies were able to ensure "support from supply chain partners through financial aids" in only 20.19% of the cases, with a standard deviation of 40.18%, suggests a relatively low level of success in receiving financial support from their partners during the first wave of the pandemic period. Also, the high standard deviation indicates a wide range of variability in the data, reflecting significant differences among companies in terms of receiving financial aids. Accordingly, many Italian companies faced challenges in obtaining financial support from their supply chain partners during the first wave of COVID-19, which could have hindered their ability to navigate the financial challenges and maintain their supply chain operations. The high standard deviation suggests a significant variation in the availability of financial support among Italian companies. This variation could be attributed to factors such as the size and financial stability of the companies, their relationships with supply chain partners, and the specific circumstances and strategies employed during the pandemic. Overall, Italian companies encountered difficulties in accessing financial support from their supply chain partners during the first wave of COVID-19, informing that disruptions make supply chains vulnerable and unable to activate the financial support of the partners.

3.2.3 Support from supply chain partners through commercial aids

As for financial support, the companies can react to disruptions by getting support from supply chain partners through commercial aids; the latter refers to assistance or support provided by partners within the supply chain in the form of commercial benefits, collaborations, or business arrangements to mitigate the negative impacts of disruptions like the first wave of COVID-19 (Li et al., 2019). This support can consist of initiatives such as joint marketing campaigns, discounts, cooperative product development, or shared distribution networks. During the first wave of COVID-19, the support from supply chain partners through commercial aids expanded the market reach and activated new opportunities for customer access for businesses. In fact, collaborative marketing campaigns, joint promotions, or sharing of distribution networks can help companies reach a broader customer base, enhance brand visibility, and increase sales during challenging times (Greco et al., 2022). Furthermore, commercial aids enable supply chain partners to pool their resources, capabilities, and expertise. This collaboration can lead to shared costs, improved operational efficiency, and optimized resource utilization. By leveraging the strengths of each partner, businesses can navigate disruptions more effectively and sustain their supply chain activities.

The commercial support during value chain disruptions has an important role in improving the firms' resilience (Salam and Bajaba, 2023). Since commercial aids foster stronger relationships and interdependencies among supply chain partners, the related collaborations enhance the resilience of the entire supply chain network by promoting mutual support and shared responsibilities. By working together, partners can jointly respond to disruptions, adapt their operations, and find innovative solutions to maintain the flow of goods and services. It is important to also mention that disruptions like COVID-19 can create new demands and market dynamics. Commercial aids from supply chain partners can enable businesses to seize emerging opportunities and adapt their offerings to meet evolving customer needs. Through cooperative product development, joint ventures, or shared knowledge, companies can explore new business models and diversify their revenue streams.

However, disruptions like COVID-19 can negatively influence the availability of support from supply chain partners through commercial aids. Businesses may face financial constraints during disruptions, leading to reduced marketing budgets. Supply chain partners may be unable to allocate significant resources for joint marketing campaigns or promotional activities, limiting the availability of commercial aids. This negative framework also applies to operational challenges like production delays, supply chain disruptions, or capacity constraints. These challenges may limit the ability of supply chain partners to collaborate effectively or deliver on commercial aid commitments, reducing the availability of support. Finally, during disruptions, supply chains may need to prioritize immediate survival and core operations over collaborative commercial activities. Partners may focus on ensuring their continuity, redirecting resources, or adapting their strategies to the changing market conditions, potentially reducing the availability of commercial aids.

As displayed in Figure 32, the fact that Italian companies were able to ensure "support from supply chain partners through commercial aids" in only 19.42% of the cases, with a standard deviation of 39.60%, indicates a relatively low level of success in receiving commercial support from their partners during the specified period. The high standard deviation suggests significant variation among companies in accessing commercial aids. Therefore, many Italian companies encountered challenges in obtaining support from their supply chain partners through commercial aids during the first wave of COVID-19. The high standard deviation suggests a wide range of variability in the availability of commercial aids among Italian companies and could be attributed to factors such as the nature of business relationships, the willingness and capacity of partners to engage in commercial collaborations, the specific industry or market dynamics, and the strategies adopted by companies to adapt to the pandemic. Overall, Italian companies faced difficulties in accessing commercial support from their supply chain partners during the first wave of COVID-19, leading to a limited uptake of commercial during disruptions.

3.2.4 Adjustments of contractual terms

Considering the disruptions due to COVID-19, the study investigates whether firms adjusted the contractual terms of the supply chain partners. This information can be interpreted as modifications or changes made to the existing contractual agreements between different partners within a supply chain in response to disruptions like the first wave of COVID-19. These adjustments can involve renegotiating terms related to pricing, payment terms, delivery schedules, minimum order quantities, or other contractual obligations (Kemahlioglu-Ziya, 2015). The need to modify the contractual relationships was justified by the requirement of flexibility and adaptability imposed on business models; disruptions such as COVID-19 often introduce unforeseen challenges and uncertainties, which can require adjusting contractual terms to be flexible and adaptable in the business relationships and enabling to navigate the changing market conditions more effectively (Böckem and Schiller, 2008). These changes also provide an opportunity to align contractual obligations with the new reality, ensuring smoother operations and mitigating potential disruptions.

Furthermore, adjusting contractual terms can help alleviate financial burdens caused by disruptions. For example, revised payment terms or extended credit periods can provide relief to cash-strapped businesses. By easing financial pressures, supply chain partners can maintain their operations, secure necessary resources, and sustain their supply chain activities during challenging times. Partners are then asked to adopt a problem-solving approach by engaging in open discussions and renegotiations, addressing issues, and finding mutually beneficial solutions. This collaborative approach strengthens relationships, builds trust, and promotes cooperation, enhancing the overall resilience and performance of the supply chain, especially when new risks and uncertainties emerge (Chen et al., 2014). Adjusting contractual terms allows for a more equitable distribution of risks among supply chain partners. By sharing the burden of unforeseen circumstances, such as production delays, supply shortages, or changes in demand, partners can collectively manage and mitigate risks, reducing the negative impact on individual businesses and the overall supply chain.

Although changing the contracts appears simple in principle to make supply chains adaptive to new realities, legal and contractual constraints may have limited provisions for adjusting terms during exceptional circumstances. Strict contractual obligations, legal

restrictions, or lack of mechanisms for renegotiation can hinder the ability of supply chain partners to make necessary adjustments, reducing the availability of contractual support. Similarly, power imbalances within supply chain relationships can affect the willingness or ability of partners to make adjustments. Stronger partners may resist modifying contractual terms, leaving the burden of disruptions on the weaker or more vulnerable members of the supply chain. Power dynamics can impede the availability of adjustments, particularly if there is a lack of collaboration and shared responsibility among partners. Finally, businesses may lack the resources or liquidity required to accommodate adjustments in contractual terms, such as offering extended payment periods or absorbing additional costs. Financial constraints can limit the availability of adjustments, particularly if partners prioritize their financial stability and survival.

According to our results displayed in Figure 32, the fact that Italian companies were able to ensure "adjustments of contractual terms from the supply chain partners" in 33.33% of the cases, with a standard deviation of 47.18%, suggests a relatively low level of success in achieving contractual adjustments with their partners during the specified period. Therefore, the firms' ability to properly react to disruptions was prevented by a reluctance to change contractual terms.

3.2.5 Support consumers by reducing prices

Within the study under analysis, the reactions to COVID-19 were analyzed not only in terms of modifying the contractual conditions and financial aids, but also by aiming at favoring the consumers. In this sense, the variable "supporting the consumers by reducing the prices over the supply chain" refers to the practice of lowering prices across various stages of the supply chain to provide financial relief and support to consumers during the first wave of COVID-19 (Islam, 2021). This approach involves reducing the costs of products or services at different points in the supply chain, from manufacturers to distributors, retailers, and ultimately, the end consumers (Sacco and De Giovanni, 2019). By adjusting the prices, firms can guarantee the affordability of purchasing even during disruptions. This is very important to measure the social sustainability of a certain practice since disruptions caused by COVID-19, such as job losses and work accessibility, along with

reduced incomes and economic uncertainty: all these factors significantly affected consumer purchasing power (Sánchez Serrano, 2023). By reducing prices, supply chains can make products more affordable and accessible to consumers, allowing them to continue purchasing essential goods and services during challenging times. This helps maintain demand and sustains the flow of goods through the supply chain. Considering a well-known principle in economics according to which lowering prices can act as a stimulus for consumer demand, during a crisis like the first wave of COVID-19, consumer spending tends to reduce as individuals prioritize essential items and limit discretionary purchases. By reducing prices, supply chains can incentivize consumers to make purchases, promoting economic activity and supporting the recovery of the overall market. One should not forget, in fact, that consumers become more price-sensitive and may switch to lower-priced alternatives during disruptive events. By offering reduced prices, supply chain partners can attract and retain customers, potentially gaining market share and improving their position relative to competitors.

The literature in economics and marketing has, however, demonstrated that disruptions can negatively influence the ability to support consumers by reducing prices (He et al., 2016; JinYan et al., 2011). On the one hand, disruptions may increase costs for supply chain partners, making it challenging to reduce prices without compromising profitability. Factors such as increased production costs, supply shortages, transportation challenges, and higher operating expenses can limit the ability to pass on cost savings to consumers through price reductions. On the other hand, disruptions in the supply chain, such as production slowdowns, logistical challenges, or reduced availability of inputs, can limit the ability to adjust prices effectively. These constraints may prevent supply chain partners from implementing price reductions uniformly across the chain or in a timely manner, leading to inconsistencies and difficulties in supporting consumers.

As it results from Figure 32, considering that Italian companies were able to ensure "supporting the consumers by reducing the prices over the supply chain" in only 28% of the cases, with a high standard deviation of 44.94%, one can see a relatively low level of success in implementing this practice during the first wave of COVID-19. Therefore, the low percentage suggests that a significant proportion of companies were unable to provide price relief to consumers, potentially impacting their ability to maintain demand and

sustain market activity. This highlights even more the challenges and complexities involved in implementing such measures in a disruptive and uncertain environment.

3.2.6 Support consumers by offering promotions and deals

Along with analyzing the support for consumers through a price reduction, the study analyses the possible support offered through promotions and deals over the supply chain. These practices link to providing increased promotional activities, discounts, and special offers at different stages of the supply chain to benefit consumers during the first wave of COVID-19. This approach aims to provide financial relief, incentivize consumer spending, and maintain demand for products and services (Rini and Priyamvada, 2023). As a general principle in marketing, the promotion stimulates the consumer demand and, this effect should be easily replicable during disruptions. In fact, the disruptions caused by COVID-19, such as economic downturns, reduced consumer confidence, and changing purchasing behaviors, had a significant impact on consumer spending. By offering more promotions and deals, supply chains can create incentives for consumers to make purchases (Huang et al., 2018). These attractive offers can encourage spending, increase sales, and stimulate overall market demand, helping supply chains to recover and maintain their operations. Thinking in a more speculative manner, providing promotions and deals can allow supply chains to differentiate themselves from competitors and attract new customers, inducing sentiments of loyalty when provided with cost-saving opportunities. This can directly demonstrate a company's commitment to customer satisfaction and their willingness to adapt to changing market conditions, enhancing brand reputation, fostering positive customer relationships, and increasing brand loyalty in the long run.

Although the marketing principles apply greatly in normal contexts, disruptions like COVID-19 can influence this practice (Priyamvada and Kumar, 2022). In fact, the financial impact of disruptions may limit the ability of supply chain partners to provide extensive promotional offers and discounts. Similarly, disruptions may have caused new challenges in the supply chain, affecting the availability of products, logistical challenges, or

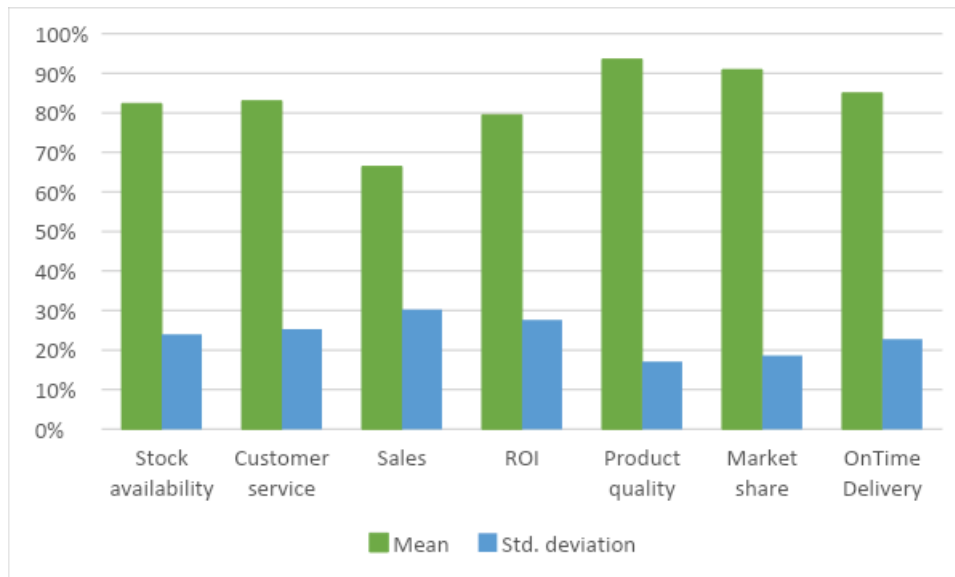
increased costs. These factors can limit the ability to offer promotions and deals consistently across the supply chain or hinder the execution of promotional strategies. Finally, the pandemic and its associated uncertainties have led to changes in consumer behavior, including shifting preferences, reduced purchasing power, and altered spending patterns. Predicting consumer response to promotions and deals during such times becomes challenging, potentially impacting the effectiveness and ROI of promotional efforts.

According to Figure 32, Italian companies were able to ensure "supporting the consumers by offering more promotions and deals over the supply chain" in only 44.76% of the cases, with a high standard deviation of 49.78%, which suggests a relatively moderate level of success in implementing this practice during the first wave of COVID-19. The high standard deviation reflects a wide variability among Italian companies in their ability to implement promotions and deals. This informs on the complex challenges faced by supply chains in adapting to disruptions and aligning their promotional efforts with the evolving needs and preferences of consumers during times of crisis.

3.3 Analysis of the value chain indicators and their vulnerabilities

In this section, we analyze the performance indicators registered in the value chain and linked to stock availability, customer service, sales, ROI, product quality, market share, and on-time delivery (Chae, 2009). The performance is analyzed in terms of vulnerability, that is, the performance loss because of the COVID-19 pandemic. For each performance indicator, the dataset reports information on the percentage of performance lost during the first wave of COVID-19. When a performance indicator is 100%, it means that the firms were not disrupted by COVID-19 and, therefore they were not vulnerable because their performance was not affected by COVID-19. In contrast, when a performance is 0%, it means that the firms completely lost that performance and, consequently, the level of vulnerability was very high. Figure 33 reports the means and the standard deviations for each performance indicator included in our analysis. The available information allows us to analyze the firms' capacity to guarantee some levels of performance even when the supply chain was disrupted by COVID-19.

Figure 33 Means and standard deviations of the firms' capacity to achieve certain performance during the first wave of Covid-19.



3.3.1 Stock availability

Stock availability during the first wave of COVID-19 refers to the ability of businesses to maintain a sufficient quantity of goods or products in their inventory to meet customer demand amidst the challenges posed by the pandemic (Zoller, 2005). It encompasses the availability even of essential items, like medical supplies and food, which experienced increased demand or supply chain disruptions during that time. The importance of stock availability during the first wave of COVID-19 was significant for two reasons (Priyamvada and Kumar, 2022). Firstly, there was a surge in demand for certain products, such as personal protective equipment (PPE), sanitizers, and medical supplies, as well as staple goods like food and household essentials. Ensuring stock availability in these critical categories was crucial to meet the needs of healthcare systems, essential workers, and the general population. Secondly, supply chains were disrupted due to lockdowns, transportation restrictions, factory closures, and shifts in global trade patterns. These disruptions led to delays, shortages, and difficulties in sourcing and replenishing inventory. Maintaining stock availability became a challenge as businesses had to adapt to

changing circumstances, find alternative suppliers, and manage inventory levels effectively.

As highlighted in Figure 33, Italian companies' ability to ensure stock availability in 82.33% of cases, with a standard deviation of 23.99%. Accordingly, the fact that Italian companies were able to maintain stock availability in 82.33% of cases indicates a relatively high success rate in meeting customer demand and ensuring product availability. This suggests that the majority of businesses were able to navigate the challenges posed by the first wave of COVID-19 and effectively manage their inventory to meet customer needs. The standard deviation of 23.99% indicates the variability or dispersion of stock availability among Italian companies, demonstrating that some businesses might have faced few difficulties in maintaining stock availability compared to others. Overall, the interpretation highlights the resilience and adaptability of Italian companies during a challenging period. While the majority were able to ensure stock availability, the standard deviation suggests that there were variations in performance, potentially due to factors such as industry sector, size of the company, supply chain dependencies, or proactive contingency planning.

3.3.2 Customer service

Customer service refers to the support and assistance provided to customers before, during, and after a purchase or interaction with a company. It involves addressing customer inquiries, resolving issues or complaints, and ensuring a positive customer experience. Customer service plays a crucial role in building and maintaining customer satisfaction, loyalty, and trust. During the first wave of the COVID-19 pandemic, customer service became even more critical. As businesses faced unprecedented challenges and disruptions, customers relied heavily on effective communication and support from companies (Afaq et al., 2023; Rabiul et al., 2022). Customer service teams had to adapt quickly to remote work environments and handle increased customer inquiries and concerns regarding product availability, delivery delays, safety measures, and policy changes.

Firms and supply chains pay great attention to customer service because of the connections with customer satisfaction and loyalty (JinYan et al., 2011; Williams and Naumann, 2011). Satisfied customers are more likely to continue purchasing from a company and recommend it to others. This loyalty contributes to maintaining a stable customer base and repeat business, which is crucial for the success and growth of supply chains. When customers receive prompt and helpful assistance, they develop a positive perception of the company and its commitment to their needs, along with positive word-of-mouth and online reviews to attract new customers and create a competitive advantage for the company within the supply chain (Chung et al., 2020).

One should not forget the value of customer service interactions with firms and supply chains when providing valuable insights into customer preferences, demands, and challenges. By closely monitoring customer inquiries and feedback, companies can gather data that helps improve demand forecasting accuracy and adjust inventory levels accordingly. The fact that Italian companies were able to ensure customer service in 83.01% of the cases, with a standard deviation of 25.28%, indicates a relatively high level of performance in customer service provision. The high percentage suggests that the majority of Italian companies prioritized customer service during the analyzed period. However, the relatively high standard deviation implies that there was variability among companies in their ability to maintain consistent customer service levels.

3.3.3 Sales

Sales are an essential aspect of business operations and refers to the revenue generated by selling products or services to customers. During the first wave of the COVID-19 pandemic, sales played a crucial role in the success of supply chains since the most important losses were directly related to the firms' inability to generate revenues due to lockdowns, shortage of goods, and lack of alternative options (Sharma et al., 2020). In general, sales directly contribute to a company's financial performance, to cover expenses, invest in growth opportunities, and sustain the business models (Sharma et al., 2020). Within a certain business strategy, markets and consumers to serve are selected according to the sales generated. By monitoring sales, supply chain managers can gain insights into customer preferences and adjust production and distribution accordingly.

When balancing marketing and operational strategies, sales can be considered as a proxy for customer satisfaction and loyalty. In fact, meeting customer needs, providing a positive buying experience led to repeat purchases and the development of long-term relationships. By fulfilling customer demands investing in closed loop supply chain, businesses can build trust and loyalty, creating a solid customer base that supports the success of the supply chain (De Giovanni et al., 2016).

Even though, during disruptions like the COVID-19 pandemic, sales can be directly affected by economic uncertainty, which causes changes in consumer behavior and often leads to a decrease in overall spending (Epler and Leach, 2021). This decline in consumer purchasing power affects sales as customers prioritize essential items and reduce discretionary spending, leading to a decline in demand for non-essential goods or services. Furthermore, disruptions lead to lockdowns, travel restrictions, or production halts, which can limit sales growth and development.

According to Figure 33, within the analyzed sample, the Italian companies were able to ensure sales in 66.42% of cases, with a standard deviation of 30.21%, suggesting that there was a significant variation in the ability of these companies to maintain sales during the specified period. The high standard deviation indicates that some companies were better equipped to adapt and sustain sales, while others struggled more significantly.

3.3.4 Return on Investment (ROI)

The Return on Investment (ROI), is a financial metric used to measure the profitability and efficiency of an investment, representing the ratio of the net profit or gain generated from an investment to the cost of that investment. During the first wave of COVID-19, businesses faced financial uncertainties and challenges. ROI serves as a tool to evaluate the effectiveness of investments made by companies to sustain their operations, adapt to the changing market conditions, and mitigate the impact of disruptions (Chowdhury et al., 2020). By evaluating the return on different investment options, businesses can prioritize and allocate resources to projects or initiatives that yield higher ROI. Therefore, during COVID-19, this indicator helped companies understand how to prioritize their investments and direct their portfolios. Furthermore, this enables supply chains to make informed

decisions regarding investment allocation, ensuring that resources are utilized effectively and efficiently. One should also mention that the ROI analysis allows businesses to assess the cost-effectiveness and efficiency of their operations. It helps in identifying areas of improvement and cost-saving opportunities within both the firms and the supply chains. Finally, ROI serves as a benchmarking tool for comparing the financial performance of different investments or projects. Therefore, during COVID-19, the indicator has been used as a comparative metric with respect to normal situations. This holds not only for the businesses to evaluate the success of their initiatives relative to industry standards or competitors, but also to monitor performance, sustainable growth, and enhanced positioning in the market.

Disruptions like COVID-19 can have a negative influence on ROI and impact success (Chowdhury et al., 2020). The causes can be of different types. On top, we should surely mention the revenue decline: Disruptions can lead to a decrease in sales or revenue, which directly affects the ROI calculation, making it challenging for businesses to achieve the expected targets. Furthermore, disruptions may necessitate additional costs for implementing safety measures, ensuring business continuity, or adapting operations to changing circumstances. These extra costs can reduce the net profit generated from investments, thereby impacting ROI. Indeed, the amplitude of the ROI is highly influenced by the amplitude of the disruptions. For example, market disruptions introduce uncertainty into the business, making it difficult for businesses to accurately forecast demand, costs, and investment outcomes. Uncertainty hampers decision-making and can result in suboptimal investments, affecting ROI negatively.

According to the empirical results displayed in Figure 33, Italian companies were able to ensure ROI in 79.49% of cases, with a standard deviation of 27.65%, indicating a varying performance among these companies in achieving their expected returns on investment during the specified period. Interpreting this data, the relatively high percentage of companies ensuring ROI suggests that a significant portion was able to generate positive returns on their investments despite the disruptions caused by COVID-19. The high standard deviation indicates that the performance varied among the companies shedding light on the importance of effective financial management, prudent investment

decisions, risk mitigation strategies, and agility in adapting to market changes to achieve positive ROI even in challenging times.

3.3.5 Product quality

Product quality refers to the characteristics, features, and performance of a product that meets or exceeds customer expectations and requirements. It encompasses various aspects such as durability, reliability, functionality, safety, and aesthetics. During the first wave of COVID-19, product quality became an indicator of great importance since the scarcity of materials and goods in general obliged companies, especially retailers, to sell most likely the goods that were available within supply chains rather than the goods connected with the corporate strategy (DeSingh and Prakash, 2023; Murmu et al., 2023). This was a very important aspect to consider since product quality directly affects customer satisfaction and loyalty, with an important reflection on reputation. In uncertain times like the COVID-19 pandemic, customers are more discerning and rely on high-quality products to meet their needs and expectations. However, delivering products with inferior quality did not help in building trust, enhancing customer satisfaction, and fostering long-term loyalty (Rauyruen and Miller, 2007). Rather, product quality plays a significant role in shaping a company's brand reputation. Brands known for consistently delivering high-quality products are often perceived as reliable and trustworthy even during disruptions (Ribbink et al., 2004). Furthermore, high product quality can differentiate a company's offerings from competitors and, most importantly, increase the amplitude of this differentiation during challenging periods like the COVID-19 pandemic. Interestingly, the quality of goods was extremely important during the COVID-19 period since it activated circular economy options like returns and repairs. During the disruptive period of COVID-19, the emphasis on product quality played a pivotal role in driving circular economy practices, particularly those centered around reparation and reuse. Companies that invested in maintaining high product quality ensured that their products were durable and reliable, reducing the frequency of replacements and mitigating potential supply chain disruptions. Moreover, by offering repair and refurbishment

services, they empowered customers to extend the useful life of their products, fostering a more sustainable consumption pattern.

Indeed, during disruptions like COVID-19, product quality can be definitely influenced by disruptions in the supply chain, such as raw material shortages, production shutdowns, or transportation challenges (Clemons and Slotnick, 2016). In fact, limited availability of inputs or compromised manufacturing processes can lead to substandard products. The same principles also apply to workforce limitations since COVID-19 restrictions and safety measures may lead to a reduced workforce or changes in working conditions. Insufficient staffing or altered production setups can impact product quality if proper training, supervision, or quality control measures are compromised. One cannot escape from mentioning that the pandemic-induced disruptions can strain supply chain operations, leading to rushed production schedules, compromised quality control processes, or changes in supplier relationships. These operational challenges may affect the consistency and reliability of product quality.

According to the results of our indicators, the fact that Italian companies were able to ensure product quality in 93.54% of cases, with a standard deviation of 17.11%, indicates a relatively high level of success in maintaining product quality during the specified period. Therefore, a majority of Italian companies prioritized and successfully maintained product quality despite the disruptions caused by COVID-19. The high percentage indicates a strong commitment to delivering high-quality products to meet customer expectations and ensure customer satisfaction. Furthermore, the relatively low standard deviation indicates a certain level of consistency in product quality management practices among the companies, which ensure companies uphold high standards, protect their brand reputation, and meet customer demands even during challenging circumstances.

3.3.6 Market share

In general, market share refers to the percentage or proportion of total sales or revenue that a company or brand captures within a specific market or industry. Therefore, it is a measure of a company's presence and competitiveness in relation to its competitors.

During the first wave of COVID-19, market share was particularly important considering the worldwide change of purchasing habits, the reduced scales for some industries and accessibility to the consumers, as well as different supply chain extensions that can compromise the market share substantially (Verhoef et al., 2023). In principle, disruptions cause a reduction of market share due to a lower share of customer spending and generate revenues. This can harm profitability and financial stability, providing minimal resources for future growth and investment. Companies with a significant market share often have more bargaining power with suppliers and customers. However, during COVID-19, negotiating favorable terms was not easy due to challenging market dynamics. Interestingly, during the pandemic, the company's ability to increase the market share was linked to the availability of goods, of whatever type. This is not in line with traditional market share dynamics, which have increasing trends when linked to brand visibility, trust and loyalty; all these ingredients lead to repeat purchases and positive word-of-mouth during normal time periods, while resulting in less important during a disruptive event. In such circumstances, in fact, disruptions can lead to a decline in overall market demand as consumer behavior changes, purchasing power decreases, or specific industries face challenges. This can result in a contraction of the market and impact the market share of all companies operating within it. Similarly, disruptions in the supply chain, such as production shutdowns, logistics challenges, or shortages of key inputs, can lead to product unavailability or delays. This can result in lost sales and customers turning to alternative sources, affecting a company's market share. Finally, disruptions can alter the competitive dynamics within a market. New players may enter the market or existing competitors may adjust their strategies to adapt to the changing environment. These shifts can impact a company's market share as it contends with intensified competition.

According to the results we obtained from the analysis of companies' indicators in Figure 33, Italian companies were able to ensure market share in 90.91% of cases, with a standard deviation of 18.57%. This indicates a relatively high level of success in maintaining their market position during the specified period. The relatively low standard deviation suggests a certain level of consistency in market share management practices among the companies. This likely indicates their ability to adapt to changing market conditions, meet customer needs, and differentiate themselves from competitors. Their ability to

ensure market share during this period reflects their resilience and vulnerability, strategic decision-making, and effective implementation of business strategies.

3.3.7 On-time delivery

In Operations Management, on-time delivery refers to the ability to deliver products or services to customers within the agreed-upon timeframe or the expected delivery date. It is a measure of reliability and efficiency in fulfilling customer orders. During the first wave of COVID-19, on-time delivery becomes particularly important for ensuring customer satisfaction and consumption experience (Bhattacharyya et al., 2023). Indeed, satisfied customers during disruptive events are more likely to develop loyalty afterwards, providing positive reviews on the web and generating repetitive purchasing. From the competitive side, on-time delivery can be a key differentiator for companies operating in a competitive market, especially with the advent of e-commerce (Sandoval et al., 2022). Hereby, meeting delivery expectations enhances the overall shopping experience and encourages customer loyalty, reduces customer complaints and returns, saving operational costs and maintains a good reputation. On-time delivery is a competitive advantage in the fast-paced e-commerce landscape, where customers value convenience and efficiency. Furthermore, on-time delivery reflects the efficiency of the supply chain's operations since it requires effective coordination and synchronization of various processes, including order processing, inventory management, production, and logistics. Therefore, a well-functioning supply chain with timely deliveries minimizes disruptions, reduces lead times, and optimizes resource utilization. From a partnership side, reliable on-time delivery builds trust and strengthens relationships, fosters positive collaboration, and facilitates long-term contracts.

The pandemic caused significant disruptions in global supply chains. Lockdowns, travel restrictions, and labor shortages affected transportation, production, and logistics operations. These disruptions led to delays, capacity constraints, and challenges in fulfilling customer orders on time. These challenges were also followed by shifts in demand patterns. Some industries experienced surges in demand for essential goods, while others faced a sharp decline in demand. These fluctuations created challenges in

managing inventory, production capacity, and fulfillment, impacting on-time delivery performance.

As resulting from the empirical analysis, the Italian companies were able to ensure on-time delivery in 85.02% of the cases, with a standard deviation of 22.78%; this indicates a relatively high level of success in meeting delivery deadlines during the specified period, meeting customer expectations and managing supply chain operations effectively. The relatively moderate standard deviation suggests that there was some variation in performance among the companies, indicating their ability to adapt to changing circumstances, implement effective operational measures, and prioritise customer satisfaction.

3.4 The connections between performance indicators and value chain indicators

This section connects the results obtained in section 3 with the indicators of performance to study the role of the supply chain in guaranteeing low vulnerability of business models and the related firms' capacity to resist a disruption like COVID-19. In principle, Supply Chains play a key role in enhanced resilience and performance during outbreak periods (Ivanov and Dolgui, 2020). The COVID-19 pandemic has brought unprecedented challenges to businesses worldwide, testing their resilience and adaptability. During such disruptive times, a well-optimized and efficient supply chain can prove to be a lifeline for firms, offering a range of benefits that minimize vulnerability and maintain high levels of performance (Ponomarov and Holcomb, 2009). First and foremost, a well-functioning supply chain ensures continuity of operations even during the most challenging circumstances. By establishing robust supply chain networks and diversified sourcing strategies, firms can mitigate the risks associated with disruptions in specific regions or suppliers (Pettit et al., 2010). The ability to quickly shift production or source materials from alternative locations enhances the supply chain's resilience, reducing the impact of disruptions on overall business operations. Moreover, a responsive supply chain allows

firms to adapt swiftly to changes in demand patterns and customer preferences during the pandemic. The COVID-19 outbreak significantly altered consumer behavior, leading to shifts in purchasing habits and preferences for certain products and services. Companies with agile supply chains can promptly adjust their production and distribution strategies to meet evolving demands, thereby ensuring a continuous flow of goods and services to customers.

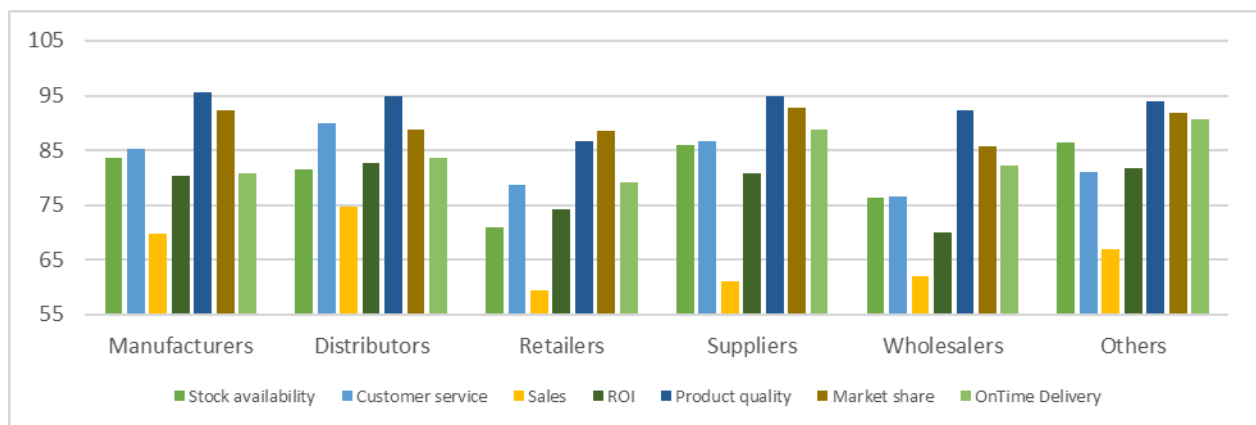
An optimized supply chain also fosters collaboration and communication among various stakeholders, including suppliers, manufacturers, distributors, and retailers (Scholten and Schilder, 2015). Effective communication and information sharing are vital during times of crisis, enabling supply chain partners to coordinate efforts, anticipate challenges, and respond collectively to disruptions. Collaborative partnerships enhance the supply chain's ability to swiftly address issues and devise innovative solutions, leading to improved overall performance. During the pandemic, disruptions in transportation and logistics posed significant challenges for many firms. However, a resilient supply chain can leverage advanced technologies, such as real-time tracking systems, IoT devices, and data analytics, to optimize transportation routes and enhance supply chain visibility (Min, 2019; Rajesh, 2017). These technologies enable firms to proactively identify potential disruptions, reroute shipments, and optimize inventory management, reducing the impact of transportation bottlenecks and ensuring the timely delivery of goods. Therefore, the COVID-19 pandemic has accentuated the significance and the need for a resilient and well-managed supply chain for firms seeking to face disruptions and maintain high performance levels. An agile supply chain that emphasizes continuity, responsiveness, collaboration, technology integration, and sustainability can enhance a firm's ability to navigate uncertainties and emerge stronger from challenges posed by the pandemic.

3.4.1 Performance Indicators and Supply Chain Structure

Supply chains' structures play a critical role in shaping firms' performance and resilience, especially during times of disruptions like the first wave of COVID-19. The structure of supply chains, comprising a complex network of manufacturers, wholesalers, suppliers,

retailers, distributors, and other stakeholders, influences how firms respond to challenges and opportunities (Sáenz et al., 2018). This section explores the critical associations between firms' capacity to perform on various performance dimensions and the structure of their supply chains. The COVID-19 pandemic exposed vulnerabilities in supply chains worldwide, leading to disruptions in production, distribution, and customer demand. According to our empirical results, each type of firm faced unique challenges that impacted their sales performance during the first wave of COVID-19. The disruptions caused by the pandemic, coupled with changes in consumer behavior and supply chain dynamics, presented significant hurdles that required adaptive strategies and resilience.

Figure 35 Performance indicators (on average) and the supply chain structure



During the first wave of COVID-19, manufacturers faced several challenges that affected their ability to perform sales (Bianco et al., 2023). Lockdown measures and restrictions disrupted production processes, leading to factory closures and reduced output. Supply chain disruptions and shortages of raw materials hindered manufacturing operations, causing delays in meeting customer demand. Furthermore, reduced consumer spending on non-essential items impacted manufacturers of luxury goods and other non-essential products. The uncertainty and economic downturn also led to a decrease in investments in capital projects, which could have otherwise driven sales for certain manufacturers (Song et al., 2022). Similarly, retail businesses faced closures and reduced customer mobility, as wholesalers had fewer orders from retailers, resulting in excess inventory and slow-moving stock. Social distancing measures and travel restrictions affected the ability

of wholesalers to meet with customers and engage in face-to-face sales activities. Furthermore, wholesalers who primarily supplied non-essential goods faced significant challenges as consumer spending shifted towards essential items during the pandemic. Suppliers, particularly those catering to non-essential industries, encountered challenges in generating sales during the first wave of COVID-19. Many industries, such as hospitality and entertainment, were severely impacted by lockdown measures and restrictions, leading to reduced demand for their products and services. Suppliers serving these industries faced declining orders and revenue. Additionally, supply chain disruptions affected the timely delivery of goods, further impacting sales for suppliers. Also, retailers faced some of the most significant challenges during the first wave of COVID-19. Lockdown measures forced the closure of physical stores, resulting in a sharp decline in in-store sales. While e-commerce and online sales saw growth, many retailers were not prepared for the rapid shift to digital platforms, leading to lost sales opportunities. Social distancing measures and consumer health concerns also deterred in-store shopping, impacting sales for brick-and-mortar retailers. Retailers of non-essential goods faced reduced customer spending, as people prioritized essential items amid economic uncertainties. With manufacturers and suppliers facing production delays and shortages, distributors had limited inventory to fulfill orders. Distribution channels were also disrupted due to transport restrictions and logistics challenges, affecting the timely delivery of goods (Butt, 2022). Additionally, distributors catering to non-essential industries faced reduced demand, leading to decreased sales during the pandemic. Finally, other firms, such as service providers and B2B businesses, also faced obstacles in performing sales during the first wave of COVID-19. Service-based industries, like hospitality, travel, and entertainment, were severely impacted by travel restrictions and social distancing measures, leading to cancellations and reduced bookings (Ferreira et al., 2021). B2B businesses saw a decline in demand as many companies reduced non-essential expenses and delayed capital investments.

Differently, firms that demonstrated agility, innovation, and a commitment to maintaining product quality during the first wave of COVID-19 were able to perform well and retain their market share. By adapting to changing consumer behaviors and leveraging technology, these firms effectively navigated the challenges posed by the pandemic and

emerged as resilient and competitive players in their respective industries (Remko, 2020). Some manufacturers were able to maintain their market share and product quality during the first wave of COVID-19 by adapting their production processes and product offerings to meet changing consumer demands. For instance, manufacturers of essential goods such as medical supplies, personal protective equipment, and hygiene products experienced an increase in demand, allowing them to capture a larger market share. By swiftly shifting production focus towards critical items, these manufacturers were able to maintain market share and contribute to public health efforts during the pandemic. Additionally, they emphasized product quality to meet stringent regulatory standards and consumer expectations, enhancing their reputation as reliable suppliers (Khan and Ali, 2023).

Similarly, wholesalers adapted their distribution strategies to maintain their market share during the first wave of COVID-19. Those who quickly transitioned to online platforms and e-commerce solutions capitalized on the increasing consumer shift to online shopping. By expanding their product range and offering competitive pricing, these wholesalers attracted more customers and secured market share (Reardon and Vos, 2023). In terms of product quality, wholesalers with stringent quality control processes ensured that their inventory consisted of genuine and high-quality products, enhancing their credibility as reliable partners to retailers. Relatively to suppliers and retailers, those who diversified their product offerings to include essential items, such as cleaning supplies and home office equipment, could cater to the evolving needs of consumers. By ensuring consistent product quality and timely deliveries, these suppliers were seen as reliable partners, contributing to their market share retention. Furthermore, those embracing e-commerce and omnichannel solutions were able to maintain their market share during the first wave of COVID-19. They provided customers with convenient online shopping experiences, offering various delivery options and easy returns.

Relatively to distributors, those who collaborated closely with manufacturers and suppliers to ensure consistent stock availability met customer demand and secured market share. Distributors that offered value-added services, such as product bundling or customized solutions, differentiated themselves from competitors and retained market share (Ghafour and Aljanabi, 2023). Product quality played a vital role in ensuring customer

satisfaction and repeat business, motivating distributors to maintain strict quality control measures. Service providers and B2B businesses that adapted their offerings to support remote working and virtual collaboration experienced market share growth during the first wave of COVID-19. Companies that provided technology solutions for virtual communication, online collaboration, and e-learning were in high demand, resulting in an expanded market share.

3.4.2 Performance indicators and financial aids from the Supply Chain Partners

In this section, we study the correlation between firms' capacity to perform on various performance dimensions during the first wave of COVID-19 and the financial support they receive from partners in the supply chain. This analysis endeavors to contribute valuable insights into the dynamics of financial support and its impact on firms' performance during times of disruption. The COVID-19 pandemic brought unprecedented challenges to businesses worldwide, disrupting supply chains, altering customer demands, and testing the resilience of organizations. During this period, firms had to navigate complexities, such as ensuring on-time delivery, maintaining product quality, sustaining market share, optimizing ROI, and providing exemplary customer service. Therefore, the financial support received from supply chain partners can shed light on the effectiveness of collaborative efforts during crises (Wang et al., 2023).

From an operations and supply chain management perspective, the non-significant correlation between the firms' capacity to perform availability of stock of goods during the first wave of COVID-19 and the financial support that firms receive from partners in the supply chain Table 10 can be attributed to a combination of factors. Firms might have implemented diverse inventory management strategies and operational practices to address the challenges posed by the pandemic. Some firms might have opted for lean inventory practices to reduce carrying costs, while others may have maintained higher stock levels to ensure continuity in the face of supply disruptions (De Giovanni and Cariola, 2021). These operational differences can lead to variations in financial support requirements and their correlation with stock availability. The risks associated with supply

chain disruptions during the pandemic could also impact the correlation. Firms might have encountered varying levels of disruptions, supply shortages, and demand fluctuations, leading to diverse financial support needs. Additionally, the uncertainties and rapidly changing business environment could have made it challenging for partners to accurately assess and align financial support with stock availability.

In these circumstances, managers may prioritize different strategies and recovery plans based on their risk appetite and long-term business goals. Some firms might focus on liquidity management and cost reduction, while others could emphasize building resilience through collaboration with partners. Such managerial choices can lead to varying financial support requirements, independent of stock availability. To address these complexities, supply chain professionals should focus on fostering strong collaboration and communication with partners. A shared understanding of each firm's operational capabilities, financial health, and risk exposure can help align financial support with actual needs while developing contingency plans and risk mitigation strategies that can enhance the resilience of supply chains, ensuring that firms receive appropriate support during times of disruption.

Table 10 Correlations between the performance indicators and managerial practices

	Support our partners through financial aids	Support our partners through commercial aids	Adjust the contract terms with our partners	Support consumers by reducing prices	Support consumers by offering more promotions and deals
Stock availability	-0.012	0.047	-0.029	-0.024	-0.057
Customer service	0.032	0.013	0.008	-0.102***	-0.085
Sales	0.077*	0.038	-0.059	-0.183***	-0.161***
ROI	0.033	-0.045	-0.108*	-0.084**	-0.071*
Product quality	0.046	0.018	0.039	-0.059	-0.079*
Market share	0.065	0.041	-0.006	0.011	-0.044
On Time Delivery	-0.010	0.026	0.018	0.072*	0.029
*significant with p-value<0.1; **significant with p-value<0.05; ***significant with p-value<0.01; italic values are not significant.					

A similar result is obtained when exploring the correlation between the firms' capacity to provide customer service during the COVID-19 period and the financial support received from partners in the supply chain. The customer service strategies during the pandemic were crucial to address the dynamic demands of consumers. While some prioritize digital customer experiences, others emphasize customer service through alternative channels. These operational distinctions contribute to the non-significant correlation, as financial support may not be directly linked to specific customer service initiatives. In fact, supply chain disruptions and uncertainties during the COVID-19 period expose firms to various risks. Demand fluctuations and supply chain disruptions may have led to varying financial pressures on firms, affecting their capacity to provide support. As financial assistance from partners is influenced by broader risk management and recovery efforts, the correlation with customer service capacity becomes less pronounced. In fact, firms prioritize diverse strategies during crises, such as the pandemic, leading to different resource allocations. Some may focus on financial stability and liquidity, while others emphasize customer-centric strategies.

In the midst of the unprecedented COVID-19 pandemic, firms have identified ways to maintain and even boost sales amidst economic uncertainties. Along this challenging landscape, a significant correlation between a firm's capacity to generate sales during the pandemic and the financial support received from supply chain partners has come to light, unveiling both economic advantages and operational considerations. The financial backing provided by supply chain partners proves to be a lifeline for many firms facing cash flow constraints during the pandemic. The significant correlation between sales capacity and financial support underscores the mutually beneficial nature of partnerships within the supply chain. Companies with strong sales performance gain increased credibility, becoming preferred partners for financial assistance from stakeholders who recognize the value of sustaining a resilient supply chain. A harmonious relationship between sales performance and financial support reveals the importance of seamless collaboration within the supply chain. While the correlation between sales capacity and financial support may seem advantageous, it comes with risks that sales managers must navigate strategically. A heightened reliance on supply chain support may impact a firm's

independence, and heavy reliance on partners for financial assistance could lead to potential compromises in decision-making autonomy. Firms must strike a delicate balance between leveraging support and maintaining financial autonomy to safeguard the firm's long-term interests.

Differently, the empirical analysis demonstrates the perplexing relationship between a firm's ROI and the financial support it receives from supply chain partners. Surprisingly, a non-significant correlation has emerged, sparking intrigue and prompting financial analysts to delve deeper into the economic implications and potential risks associated with this unique scenario. Contrary to conventional wisdom, the COVID-19 period has stirred discussions within the community of firms and supply chains, challenging the traditional assumptions about the interplay between ROI and financial backing. Furthermore, the pandemic compelled supply chain partners to prioritize their financial stability, often necessitating prudent allocation of financial resources. As a result, direct financial support to other firms may have been tempered, resulting in a less pronounced correlation between ROI and partner funding. The non-significant correlation presents certain financial risks: the lack of a direct correlation could potentially strain liquidity and impact the capacity to invest in growth initiatives or capital-intensive projects. Moreover, reduced immediate financial backing from partners may hinder a firm's ability to optimize resources and capitalize on market opportunities during challenging economic conditions. This scenario emphasizes the significance of cultivating robust financial strategies that can withstand fluctuations in external funding and support self-sufficiency in achieving ROI.

Amidst the disruptive landscape of COVID-19, firms have grappled with the non-significant correlation between a firm's ability to manufacture high-quality goods and the financial backing extended by supply chain partners. This enigma has sparked interest among engineering minds, who strive to unearth the underlying factors contributing to this intricate interplay. COVID-19 triggered unprecedented challenges for operations management across industries, affecting production capacities, supply chain logistics, and workforce dynamics. As firms adapted to the new normal, the divergence in operational trajectories may have impacted the nature and extent of financial support from supply chain partners. High-quality goods manufacturing often necessitates

intricate production processes, specialized resources, and stringent quality control measures. During the pandemic, firms prioritized operational continuity and adaptation to changing market demands. This priority may have led to a relatively lower emphasis on financial support for high-quality production, contributing to the non-significant correlation observed. Furthermore, the economic turbulence brought on by COVID-19 prompted supply chain partners to reevaluate their financial strategies and prioritize their stability. The resultant impact on the availability of financial support for high-quality production may have contributed to the weakened correlation between production quality and financial backing. In fact, the COVID-19 economic landscape prompted firms to focus on cost optimization and financial prudence. For some firms, the pursuit of high-quality goods production may have taken a back seat in favor of maintaining financial viability. This shift in priorities may have influenced the link between production quality and financial support.

Throughout the COVID-19 crisis, firms have strived to expand their market share as a means of survival and resilience. However, our empirical analysis reveals that this pursuit of market dominance does not necessarily translate into a significant increase in financial support from supply chain partners. In fact, supply chain partners, grappling with their own financial stability amidst unprecedented uncertainties, may have directed their resources toward safeguarding their core operations, rather than offering extensive financial support to boost market share for partner firms. Additionally, COVID-19 has led to dynamic shifts in consumer behavior and market demands, forcing firms to realign their strategies to meet immediate needs. Consequently, the emphasis on market share growth may have diverted resources away from activities that would traditionally attract financial support from partners. Probably, the unpredictable and prolonged nature of the pandemic has necessitated conservative financial strategies among supply chain partners. The prudence to conserve financial resources may limit the extent of support offered to partner firms, affecting the correlation between market share growth and financial backing. The supply chain partners, as a steward of financial sustainability, must tactfully weigh risks and rewards and chart a prudent course of action that safeguards both market share aspirations and supply chain partnerships. In these intricate financial analyses, the expertise in risk management, financial planning, and strategic foresight

become the guiding light that illuminates a path towards resilience, profitability, and lasting financial success amidst the uncertainties of disruptions like COVID-19.

As the world faces the challenges of COVID-19, logistics management emerges as a critical focal point for firms seeking to optimize their supply chains. However, our empirical analysis shows a non-significant correlation between a firm's capacity to deliver goods on time and the financial support it receives from supply chain partners. This result is probably linked to the disruptions caused by the COVID-19 pandemic, which tested the resilience of logistics management worldwide. Amidst fluctuating demand patterns, transportation restrictions, and workforce disruptions, ensuring on-time delivery has become a complex target. The pandemic has sparked an exponential rise in e-commerce, making timely deliveries a critical success factor for firms. E-commerce platforms have emerged as key channels for businesses, leading to a surge in online orders and last-mile delivery challenges. However, the economic uncertainties arising from COVID-19 have driven firms and supply chain partners to adopt cost-conscious strategies. Balancing the financial pressures of maintaining efficient logistics operations with on-time delivery targets becomes a delicate balancing act for firms. Supply chain disruptions and delivery delays during the pandemic led to financial penalties and a lack of suppliers' support, highlighting a misalignment between financial support expectations with partner firms and the beneficial logistics strategies, operations managers can strike a balance between on-time delivery and financial sustainability.

3.4.3 Performance indicators and commercial aids from the Supply Chain Partners

This section analyses the correlation between the firms' capacity to achieve some performance indicators during the first wave of COVID-19 and the commercial aids received from supply chain partners. The latter refer to the assistance or resources provided by one business entity to another within the supply chain to enhance their commercial activities and achieve common objectives (Boehme et al., 2021). This support can take various forms, such as offering discounts or promotions on products, sharing marketing resources, providing co-branding opportunities, assisting with sales and distribution, or even collaborating on joint marketing campaigns. In general, the goal of

commercial support is to strengthen the competitiveness and market position of both partners, fostering a mutually beneficial relationship that drives growth and success in the marketplace. Surprisingly, we find that all correlations between the firms' capacity to achieve performance and such aids are not significant.

The non-significant relationship between firms' capacity to perform stock availability and the commercial support they receive from supply chain partners during the COVID-19 period is influenced by a combination of uncertain factors. First of all, disruptions like the COVID-19 pandemic have introduced unprecedented uncertainties in demand patterns and supply chain dynamics. As firms grappled with rapidly changing market conditions, it became challenging to accurately forecast and plan inventory levels. The volatile nature of demand during the pandemic might have led to fluctuations in stock availability, making it difficult to establish a consistent correlation with commercial support from supply chain partners. Furthermore, the pandemic brought forth disruptions in logistics, transportation, and production capabilities, impacting the flow of goods throughout the supply chain. Hence, inventory managers have probably understood that these disruptions might have created bottlenecks, leading to stockouts for essential goods or excess inventory for non-essential goods. Such fluctuations can obscure the correlation between stock availability and commercial support, as the focus shifts to addressing immediate operational challenges.

Regarding service management, the correlation between a firm's capacity to provide exceptional customer service during the COVID-19 period and commercial support has been demonstrated to be non-significant. This is most likely due to the amplitude of the disruptions linked to COVID-19: with the incredible disruptions in supply chains and market demands due to the pandemic, firms may have faced constraints in meeting customer expectations and maintaining service levels. Consequently, the economic uncertainties stemming from the pandemic might have destroyed the correlation between customer service performance and commercial support from supply chain partners. This might have resulted in firms seeking commercial support from partners as a secondary response, while customer service performance might have been influenced by various external factors beyond their immediate control. From a managerial perspective, the pandemic necessitated agile and innovative strategies to navigate through

unprecedented challenges. Unfortunately, firms might have had to realign their resources and priorities to address urgent needs.

Interestingly, during the COVID-19 pandemic, the elusive correlation between a firm's capacity to generate sales and the commercial support received from supply chain partners can be seen as a very peculiar empirical result. The COVID-19 pandemic brought forth an economic whirlwind, disrupting markets and reshaping consumer behavior. Hence, firms learned how businesses navigated through unprecedented challenges. The economic disturbance may have directed commercial support from supply chain partners towards a non-significant correlation with sales performance. This can be due to the supply chain disruptions, remote work, and logistical hurdles affecting daily operations: these operational complexities may have hindered firms from fully leveraging their sales capacity, contributing to the intriguing divergence between sales performance and commercial support. One should not forget that the COVID-19 landscape was fraught with risks at every turn. As sales managers assessing the risks, suppliers understood the need for prudent decision-making, allocating more importance to risk mitigation and crisis management rather than directly bolstering sales through commercial aids.

The previous results are also confirmed when analyzing the correlation between a firm's capacity to achieve ROI and the commercial support received from supply chain partners. In principle, the economic disorder caused by the COVID-19 pandemic may have prompted commercial support from supply chain partners to be channeled. However, the suppliers have seen the delicate balance between investment decisions and risk management. Firms, seeking to safeguard their financial future amidst uncertainty, may have allocated commercial support towards other practices rather than directly impacting ROI, giving rise to the non-significant correlation. For example, investments in safety measures and employee welfare rather than focusing solely on immediate financial gains. Finally, our findings suggest that firms' capacity to perform the ROI does not depend on commercial aids, at least during disruptive periods. Overall, companies can achieve high ROI during disruptive periods without relying on commercial support from suppliers for several reasons. Diversified revenue streams, cost optimization, and strategic investments contribute to profitability as well as a strong market position, in-house expertise, and efficient supply chain management.

In the domain of operations management, the observation of a non-significant correlation between a firm's capacity to produce high-quality goods during the COVID-19 period and the commercial support received from supply chain partners reveals the high-quality standards of Italian firms embedded in the production processes, which are independent of any commercial support. In the literature, it is well documented that challenges such as supply chain disruptions, labor constraints, and demand volatility have potentially diverted the focus of commercial support towards operational efficiency and continuity, potentially overshadowing the direct influence on product quality. However, the economic exigencies during the pandemic have necessitated prudence in the operational decisions where optimization of quality has been always guaranteed even in case of adverse suppliers' willingness to provide commercial help. In fact, to face the uncertainties of the COVID-19 period, firms have been driven to mitigate risks associated with product quality, safeguard reputation and minimize potential consequences of poor quality. Indeed, decisions made by supply chain partners could indirectly influence product quality. Variations in supplier capabilities or delays in material delivery may have impacted the commercial support changes, contributing to the non-significant correlation with firms' willingness to increase quality. Overall, there are several reasons to explain this result. Certain companies have well-established in-house quality control processes and dedicated quality assurance teams. These internal mechanisms enable them to uphold stringent quality standards without significant reliance on external commercial support. Also, companies with strong supplier partnerships may have already established reliable and high-quality sources for their raw materials and components. These suppliers consistently deliver goods that meet the company's quality requirements, reducing the need for additional commercial support, while being interested in the continuous supply of quality materials even during disruptions. Moreover, some companies invest in advanced technology and automation that improve the precision and consistency of their manufacturing processes. By relying on technology, they can maintain product quality without significant reliance on commercial support. For example, companies with well-established quality management systems, such as ISO certifications or Six Sigma practices, have ingrained a culture of quality in their operations. These systems provide a framework for maintaining quality even during challenging times.

From the empirical results, one can observe that there is a non-significant correlation between the firms' capacity to increase market share during the COVID-19 period and the commercial support received from supply chain partners. This independence links to the fact that some firms may have invested in innovative marketing and sales strategies, enabling them to gain market share independently. Alternatively, companies with well-established brands and loyal customer bases might have experienced steady demand even without substantial commercial aid while the unique market conditions during the pandemic might have necessitated tailored approaches that differed from the traditional commercial support provided by partners.

From a risk perspective, firms that heavily rely on commercial support from supply chain partners may face vulnerability if disruptions in the supply chain occur. Depending solely on external support might hinder a company's adaptability and resilience during unforeseen crises. Additionally, partnerships could be subject to renegotiations or disruptions, impacting market share initiatives; hence, maintaining independence in expanding market share offers a buffer against potential risks associated with external dependencies. Finally, existing contractual agreements between suppliers and their partners might not include provisions for extensive commercial support. Suppliers may need to adhere to the terms of these contracts, limiting their ability to provide additional support. Similarly, suppliers and firms may have different strategies and objectives during the pandemic, being inclined not to offer commercial support.

While on-time delivery has always been a crucial performance metric, the extent of commercial support from partners in the supply chain during this pandemic remains non-significant. Probably, meeting customer expectations is vital while with disruptions and uncertainties abound, customers rely heavily on the timely receipt of goods and services. Fulfilling these expectations becomes essential for customer satisfaction and loyalty while depending solely on commercial support from suppliers may not be practical during disruptions, as suppliers themselves may face challenges. Firms that can maintain control over their delivery operations can respond more flexibly to uncertainties and ensure a smoother supply chain flow.

To address this non-significant correlation, operations management strategies must be implemented to enhance on-time delivery capabilities and encourage commercial

support from partners. Leveraging data-driven analytics, firms can optimize logistics and develop real-time visibility to mitigate disruptions. Collaborative planning with partners and leveraging technology for supply chain integration can create synergies and bolster on-time delivery performance.

3.4.4 Performance indicators and modification of contractual agreements during disruption

In this section, we investigate the correlation between firms' performance on various dimensions during the first wave of the COVID-19 pandemic and the willingness of supply chain partners to adjust contractual agreements. Several factors contributed to this lack of correlation, highlighting the complexities and challenges faced by supply chain management during the pandemic (Sharma et al., 2021). One primary reason is the diversity of supply chain partner priorities. Each partner may have distinct objectives during times of disruption, ranging from agility and flexibility to cost reduction or risk mitigation. These varying priorities could lead to differences in their willingness to adapt contractual agreements, resulting in a lack of consistent correlation with firms' performance. Moreover, existing contractual obligations and legal constraints played a significant role. Long-term contracts with fixed terms and conditions limited the flexibility required to respond promptly to changing market conditions. As a result, supply chain partners faced challenges in making immediate adjustments to agreements during the crisis.

Another critical aspect was information asymmetry (Tai et al., 2022). In some cases, supply chain partners lacked comprehensive information about each other's performance and capabilities during the pandemic. This information gap hindered effective collaboration and may have contributed to less willingness to modify contracts based on incomplete or inaccurate data. Furthermore, the uncertainty brought about by the pandemic prompted supply chain partners to adopt a cautious approach to protect their interests. Fear of potential negative consequences from contractual adjustments might have deterred them from actively changing agreements, irrespective of firms'

performance. Considering the long-term relationship dynamics, established supply chain partnerships often extend beyond immediate crises, leading partners to prioritize preserving trust and relationships built over time. This emphasis on the long-term may have limited the extent of contractual changes based on short-term fluctuations in firms' performance. Supply chain partners faced their own operational and financial difficulties during the pandemic: limited resources and capacity to manage contractual changes may have hindered their ability to accommodate adjustments, regardless of firms' performance. Finally, market conditions and industry variations played a role in the lack of correlation. The impact of COVID-19 on different industries and markets varied significantly, leading to diverse effects on supply chains. Factors such as demand fluctuations, disruptions in production, and government regulations had varying consequences across sectors, influencing partners' willingness to modify agreements differently.

Going more into detail, the correlation between a firm's capacity to maintain stock availability and the supply chain partners' willingness to alter contractual agreements has shown intriguing complexities from an operations and supply chain management perspective (Urciuoli et al., 2014). In principle, the pandemic induced fluctuations in demand and supply, making inventory management a daunting task. As firms grappled with volatile market conditions, maintaining an optimal level of stock became critical for business continuity and to avoid supply chain disruptions. However, supply chain partners, facing disruptions and uncertainties, have demonstrated to be reluctant to modify contractual agreements, probably fearing additional risks and operational complexities. In fact, the pandemic has exposed vulnerabilities in supply chain networks. While firms strive to enhance stock availability to cater to fluctuating demand, supply chain partners may encounter difficulties in meeting contractual obligations due to production constraints, transportation disruptions, or limited access to raw materials. Consequently, contractual adjustments might not have been a feasible option for some partners amidst the operational challenges. From a legal perspective, in fact, both firms and supply chain partners must assess the potential repercussions of changes, including financial, legal, and reputational risks. Balancing the need for stock availability with the uncertainties

surrounding contractual adjustments may have led to a non-significant correlation between the two aspects.

Regarding customer service, the non-significant correlation between a firm's capacity for customer service during the COVID-19 period and the supply chain partners' willingness to change contractual agreements links to the necessity to guarantee a swift response to meet changing customer demands. Firms had to prioritize ensuring customer satisfaction and maintaining service levels, often focusing on immediate customer needs rather than renegotiating contractual terms with supply chain partners. The latter could harm both the service and the business continuity, resulting in unstable relationships and collaboration. During the COVID-19 pandemic, the dynamics of service management required immediate solutions to customer needs whose intervention was not aligned with the time needed to modify the contractual agreements among parties.

Similar results emerge when evaluating sales since the correlation between a firm's sales capacity during the COVID-19 period and the willingness of supply chain partners to amend contractual agreements was not significant. Interestingly, the pandemic unleashed a wave of uncertainty, compelling businesses to prioritize immediate revenue generation. Sales managers had to focus on adapting to rapidly shifting market demands and ensuring sales continuity, leaving less scope for extensive contractual renegotiations with partners. Therefore, the firms' priority was optimizing sales operations to cope with disruptions, rather than diverting resources towards contractual modifications. The latter practice could have been very risky; for example, altering contractual terms might impact the stability of the business relationships with suppliers, distributors, or customers and, consequently, parties may become apprehensive about the changes, leading to a loss of trust and cooperation. This, in turn, could hamper collaborative efforts and adversely affect the overall supply chain dynamics.

Surprisingly, a significant and negative correlation has emerged between a company's capacity to achieve higher ROI and the supply chain partners' willingness to modify contractual agreements. Economically, this intriguing phenomenon can be attributed to the financial incentives that arise when a firm demonstrates improved ROI. As a company's profitability increases, suppliers perceive it as a sign of stability and reliability, enhancing their confidence in the firm's ability to fulfill contractual commitments.

Consequently, suppliers become less inclined to seek changes to the agreements, as they are more assured of consistent and timely payments. In fact, from a financial perspective, a firm that exhibits higher ROI signals strong financial health, which resonates positively with supply chain partners. In contrast, if a firm is experiencing financial challenges, suppliers may seek contractual modifications to safeguard their interests and mitigate potential risks of non-payment or delayed payments. From a managerial perspective, the correlation underscores the importance of financial performance in fostering stable and collaborative relationships with supply chain partners. Companies with strong ROI records are better positioned to negotiate mutually beneficial agreements, as they have trust and confidence in the supply chain network.

Ensuring high-performance, stylish, durable, and conforming products during the COVID-19 period is crucial for businesses seeking to maintain a competitive edge. However, it is noteworthy that a non-significant correlation exists between a firm's capacity to deliver superior product quality and the supply chain partners' willingness to modify contractual agreements. Operationally speaking, this phenomenon may arise due to the recognition that product quality is a fundamental aspect of any business, regardless of the prevailing conditions, even during a disruptive event like the COVID-19 pandemic. Companies committed to upholding stringent quality standards prioritize operational excellence and invest in research, technology, and quality assurance measures to deliver exceptional products consistently. Therefore, supply chain partners may perceive a stable commitment to quality from the focal firm, reducing the immediate necessity to change contractual terms related to quality performance. Furthermore, the non-significant correlation reflects the intrinsic value of maintaining quality standards under all circumstances. High-quality products bolster a company's reputation, enhance customer loyalty, and contribute to long-term financial success. With a strong focus on quality, firms demonstrate their commitment to delivering value to customers and stakeholders. Consequently, supply chain partners may perceive this dedication and consider it less necessary to renegotiate existing agreements related to quality. Considering the impact of quality on risk management, altering contractual terms related to product quality could add further complexities and costs, potentially impacting the financial stability of both the focal firm and its supply chain partners.

The absence of a significant correlation between a firm's capacity to increase market share during the COVID-19 period and the supply chain partners' willingness to change contractual agreements can be attributed to the reduced consumer demand and operational restrictions causing a significant decline in sales. In such uncertain and economically challenging times, both firms and supply chain partners were compelled to prioritize stability and continuity over radical contractual changes. Modifying contractual agreements during the pandemic might have introduced additional risks and complexities to an already vulnerable supply chain. Industries were grappling with unforeseen challenges, such as disruptions in production, distribution, and logistics, which made it difficult to focus on market share expansion. Instead, businesses were more inclined to preserve financial viability and ensure operational continuity by upholding existing contractual agreements. Furthermore, the unprecedented nature of the pandemic made it challenging for companies to predict market dynamics accurately. As a result, many firms adopted a cautious approach, favoring stability and incremental growth over aggressive market share expansion through contractual changes.

In the same vein, the insignificant correlation between a firm's capacity to deliver goods on time during the COVID-19 period and the supply chain partners' willingness to change contractual agreements can be understood by examining the critical importance of on-time delivery during the pandemic. The COVID-19 pandemic disrupted traditional sales channels and consumer behavior. Physical retail outlets were either closed or faced severe restrictions, pushing companies to adopt alternative strategies. With limited options to reach consumers, businesses increasingly relied on omnichannel solutions and e-commerce platforms to engage customers and ensure continuity in sales. On-time delivery became a lifeline for firms seeking to maintain customer loyalty and competitive advantage during the pandemic. As traditional channels faltered, timely delivery of goods through e-commerce became the primary way to serve customers' needs and expectations. In this context, companies had to adapt rapidly to meet the surge in online demand. Supply chain partners played a crucial role in enabling efficient logistics operations and ensuring that products reached customers on time. These partners recognized the significance of on-time delivery as a key driver of customer satisfaction and retention, making it imperative to uphold delivery commitments despite the

challenges posed by the pandemic. The reluctance to change contractual agreements may have been influenced by the understanding that on-time delivery was the only opportunity to reach consumers effectively. Firms and supply chain partners recognized the strategic importance of maintaining smooth logistics operations, as any disruptions could lead to dissatisfied customers and potential loss of market share.

3.4.5 Performance indicators and modification of the selling price to support the consumers

The COVID-19 pandemic posed unprecedented challenges to businesses worldwide, leading companies to adopt various strategies to navigate the disruptions and support their customers. Among these strategies, offering price reductions to consumers emerged as a significant approach to maintaining market share and sustaining customer loyalty during the crisis. This section investigates the correlation between firms' capacity to perform on different performance dimensions and the support offered to consumers in terms of price reduction during the first wave of COVID-19.

During the COVID-19 disruption, businesses faced unique challenges in managing their inventory and pricing strategies (Fonseca, 2020). Some companies chose a speculative approach, increasing prices when the available stock of goods decreased due to heightened demand. However, a distinct group of socially oriented firms adopted a different approach, ensuring the availability of goods without resorting to price hikes. Surprisingly, these socially conscious companies refrained from decreasing the price of available stock as well. However, according to our empirical analysis, firms decided to maintain stock availability while avoiding price reductions since they prioritized customer satisfaction and loyalty, aiming to offer stability and support during uncertain times. Their ability to maintain stock levels amidst the challenges of the pandemic showcased their operational resilience and efficient inventory management practices. Despite the non-significant correlation between stock availability and price reductions, these companies demonstrated their commitment to social responsibility. By not increasing prices during the crisis, they provided a sense of reliability and trustworthiness to their

customers, establishing stronger relationships that may prove beneficial in the long run. The risks associated with this approach were primarily centered around financial considerations. By not adjusting prices, these firms might have faced profitability challenges due to increased operational costs and potential revenue loss. However, their emphasis on social orientation and customer-centricity likely outweighed the financial risks, leading to a strategic decision to maintain stable pricing.

During the first wave of the COVID-19 pandemic, some firms chose to provide support to consumers by reducing prices, aiming to alleviate financial burdens and attract customers during a time of crisis (Henkel et al., 2023). However, this approach led to an unexpected consequence: an exaggerated increase in service demand that companies struggled to manage effectively. From a service management perspective, the significant and negative correlation between the firms' capacity to provide customer service and the support offered through price reductions underscores the challenges posed by such a strategy. By reducing prices, firms inadvertently generated a surge in demand that exceeded their operational capacity during the disruptions caused by the pandemic. This surge strained resources, logistics, and customer service systems, resulting in diminished service quality and customer dissatisfaction. The economic motivation behind offering price support was to demonstrate empathy and solidarity with consumers facing financial hardships during the pandemic. However, the risks associated with this approach quickly became evident as service levels fell short of expectations due to overwhelming demand. On the other hand, firms that chose not to provide price support experienced a more manageable and sustainable demand for service. Without the exaggerated increase in demand, they were better equipped to allocate resources efficiently and maintain service quality during the disruptions. The managerial motivations for this approach were rooted in the desire to strike a balance between supporting consumers and ensuring operational effectiveness. Companies had to make difficult decisions about pricing and service capabilities, understanding that providing support could lead to unmanageable demand spikes.

Considering the challenges posed by the COVID-19 pandemic, companies faced a critical dilemma regarding customer support through price reductions. Offering lower prices during this period resulted in an unprecedented surge in demand for goods and services

(Henkel et al., 2023). However, this overwhelming increase in demand often exceeded the companies' operational capacity, leading to shortages and logistical bottlenecks that could not be managed effectively during disruptions. The motivation behind providing price support was socially sustainable and aiming to alleviate the burden on consumers facing financial constraints and demonstrate solidarity in difficult times. Sales managers believed that reduced prices would attract more customers and foster loyalty. However, the unintended consequence was an incredible increase in demand that strained the supply chain. The operational risks were evident as companies struggled to keep up with the unexpected influx of orders. The inability to manage this heightened demand resulted in inventory shortages, delayed deliveries, and compromised customer service. This led to frustrations among customers and posed a significant challenge to maintaining service levels and meeting customer expectations. On the other hand, companies that refrained from offering price support experienced a more stable demand for goods and services, aligning with their operational capacity. While this approach might have resulted in lower sales figures, it allowed for better management of resources and ensured a more sustainable and balanced supply chain. Interestingly, the decision to provide or not provide price support during the COVID-19 period required careful consideration of both economic and operational aspects. While offering lower prices demonstrated social responsibility and customer empathy, it also posed considerable risks to the supply chain and overall business performance.

During the first wave of the COVID-19 pandemic, Italian firms navigated the dilemma of extending customer support through price reductions while preserving their own financial viability. A financial lens delves into the reasons behind the noteworthy and negative correlation between firms' capacity to achieve ROI and the support provided to consumers by reducing prices. Economically, the decision to lower prices seemed like a savvy strategy to stimulate demand and attract customers during the unprecedented crisis. However, unforeseen consequences soon surfaced as the price cuts triggered an overwhelming surge in demand for goods and services. The resulting strain on operational capacity forced companies to employ costly and unconventional measures to cope with the increase in orders. In turn, this gave rise to operational risks, with companies struggling to maintain quality and efficiency under intense pressure. The need

for swift responses strained resources, increased production costs, and disrupted supply chains. Consequently, the firms' capacity to attain the desired ROI suffered a setback, leading to the observed negative correlation between price support and financial performance. Although the motivations behind price reductions were driven by a genuine desire to support customers and foster enduring relationships during the pandemic, the increase in demand and the operational complexities forced a reevaluation of this approach. These arguments explain the negative correlation between firms' capacity to achieve ROI and the support offered to consumers through price reductions.

During the first wave of COVID-19, one aspect that remained non-negotiable for firms was their commitment to ensuring high-quality goods, especially for essential items like food that directly impacted consumers' health. Despite offering support through price reductions during the first wave of COVID-19, firms were steadfast in upholding their capacity to produce and deliver goods of uncompromising quality. The absence of a significant correlation between the firms' capacity to guarantee high-quality goods and the support they offer to consumers through price reductions is a signal of their unwavering dedication to quality. While economic support was extended to alleviate the financial burden on consumers, firms understood that compromising on product quality was not an option, particularly for essential goods. The importance of maintaining quality during this critical period was magnified by the crucial role these goods played in safeguarding public health. Consumers prioritized health and safety concerns, making the assurance of quality an imperative for firms operating in the food and healthcare sectors. Even as firms extended support through price reductions, they recognized that any reduction in the capacity to deliver high-quality goods would have severe repercussions on their reputation, customer trust, and long-term success. Thus, they navigated the complexities of the pandemic with resilience, ensuring that quality remained at the forefront of their operations.

From a financial perspective, the decision of firms to provide support to consumers by reducing prices during the first wave of the COVID-19 pandemic did not significantly impact their capacity to perform in terms of market share. This is the main result that we obtain from our empirical analysis. In fact, many sectors were severely impacted and paralyzed by the pandemic, hindering firms' ability to expand or capture a larger market

share easily. The reduction of prices, while aimed at supporting consumers, did not necessarily lead to a substantial increase in sales or market share growth, as the overall demand was limited during the crisis. Furthermore, the limited stock availability further constrained the impact of price reductions on market share. Even if firms reduced prices to attract customers, they faced challenges in meeting the increased demand due to supply chain disruptions and production limitations. Consequently, the reduced prices did not translate into a significant market share gain. Finally, the competitive landscape played a crucial role in nullifying the effects of price reductions on market share. As one firm lowered prices to support consumers, competitors in the same industry would often follow, maintaining a level playing field and keeping the market share dynamics relatively stable. In light of these considerations, the correlation between firms' capacity to perform in terms of market share and the support provided to consumers through price reductions being non-significant has managerial and economic justifications.

According to our empirical results, there is a significant and positive correlation between the firms' capacity to deliver goods and the support offered to consumers through price reductions. From an operations management perspective, this alignment was fueled by substantial investments in their logistics fleet, recognizing that home delivery and omnichannel services were the primary means to reach consumers during the pandemic. The motivations for this correlation were rooted in the understanding that reduced prices would attract more consumers and increase demand. Consequently, companies realized the importance of bolstering their logistics capabilities to meet the surge in online orders efficiently. These investments in the logistics fleet not only enabled them to handle higher delivery volumes but also improved their overall capacity for on-time delivery. In principle, companies strategically expanded their logistics fleet, utilizing modern technologies and data-driven solutions to optimize delivery routes and minimize lead times. This proactive approach ensured that price reductions would not compromise their ability to meet customer expectations for swift and reliable deliveries.

3.4.5 Performance indicators and promotions and deals to support the consumers

This study section investigates the correlation between firms' capacity to perform across multiple dimensions and the support they extended to consumers through distinctive promotions and compelling deals during the first wave of COVID-19 (Gan et al., 2021). Therefore, it will scrutinize the inherent risks and managerial motivations underlying the implementation of these promotional strategies amidst the challenges posed by the COVID-19 crisis.

Amidst the disruptions and uncertainties, firms encountered the formidable challenge of ensuring the availability of stock of goods to meet consumer expectations while concurrently devising innovative strategies to attract and retain customers through alluring promotions and deals. In fact, we observe a non-significant correlation between firms' inventory capacity and the support they offer to consumers through promotions. This can be explained by the sudden surge in demand for specific products induced inventory shortages, thereby hampering firms' ability to maintain a steady supply. As a consequence, these supply chain disruptions compelled firms to resort to promotional offers as a means to manage consumer expectations and mitigate the negative repercussions on customer satisfaction. In such a context, Italian firms showed a great ability to effectively synchronize inventory levels with actual demand. Consequently, firms found themselves relying heavily on promotional initiatives to incentivize consumers to purchase available goods. Although these promotional activities induced a sense of corporate social responsibility in a very difficult moment, the demand generated by the promotions and deals has had no impact on firms' ability to replenish inventory promptly. The first wave of the COVID-19 pandemic ushered in a challenging landscape for businesses aiming to maintain exemplary customer service (Rabiul et al., 2022). As firms grappled with the economic repercussions of the pandemic, their capacity to provide seamless customer service became inextricably linked to the support they offered through particular promotions and intriguing deals to entice consumers. As the pandemic instigated economic uncertainty, firms sought innovative ways to retain customer loyalty and stimulate demand. To achieve this, they introduced appealing promotions and captivating deals to entice consumers and drive sales. The allure of these offers resulted in an unprecedented increase in demand, which put significant strain on the systems and processes that support customer service. In fact, firms found themselves ill-prepared to

manage the sudden surge in customer inquiries, order processing, and delivery logistics brought on by the increased demand due to promotional offerings. The inadequacy of systems and processes to cope with such atypical spikes in demand led to disruptions in customer service, negatively impacting the overall customer experience. While the primary motivation behind offering promotions and deals was to enhance customer satisfaction, the reality of their implementation exposed risks and challenges. The surge in demand overwhelmed the capacity of firms to meet customer expectations promptly and efficiently, leading to delays and customer dissatisfaction. The unanticipated disruptions highlight the need for a carefully balanced approach: businesses should proactively evaluate and fortify their systems and processes to withstand the pressures of sudden demand fluctuations during times of disruption due to promotions.

The dynamic between promotions and pricing, while seemingly complementary, revealed intriguing trade-offs that manifested as a significant and negative correlation with sales (Henkel et al., 2023). During the unprecedented challenges of the first wave of the COVID-19 pandemic, firms grappled with the delicate balance of offering promotions and deals to support consumers while maintaining their sales performance. On one hand, promotions and enticing deals were deployed as a means to provide support to consumers during tumultuous times. These initiatives aimed to capture consumer interest, stimulate demand, and alleviate the impact of the pandemic on purchasing power. However, this surge in demand triggered by promotions, often outpaced the firms' capacity to fulfill orders and maintain adequate inventory levels. As a result, operational challenges arose, including disruptions in supply chains, logistics, and distribution. The rapid increase in sales posed a strain on the resources and capabilities of the firms, leading to bottlenecks, stockouts, and logistical inefficiencies. Economically, the trade-off between offering promotions to support consumers and sustaining sales performance became evident. While promotions aimed to bolster short-term demand, the operational challenges hampered the firms' capacity to capitalize on the surge in interest, leading to missed revenue opportunities.

While offering promotions and deals were aimed at alleviating the economic challenges faced by consumers, the correlation between these promotions and the firms' capacity to achieve ROI turned out to be significant and negative, revealing intriguing insights. These

promotions aimed to attract consumers, stimulate demand, and drive sales amidst the uncertainties. These well-intentioned efforts were intended to establish goodwill with customers and retain their loyalty during difficult times. As promotions enticed consumers, it was anticipated that revenues would witness an upswing, leading to enhanced ROI. However, the path to positive ROI proved to be arduous due to the inherent risks associated with promotions. In fact, the rapid increase in sales could outpace the firms' capacity to efficiently manage inventory and deliver products in a timely manner. As a consequence, operational costs surged, potentially eroding profit margins and impacting the overall ROI.

The negative correlation between a firm's capacity to produce high-quality goods and the support offered to consumers through promotions and deals during the first wave of COVID-19 highlights a set of trade-offs between quality and promotion. It is evident that higher promotions resulted in a substantial increase in sales, leading to a surge in production to meet the heightened demand. However, this rapid scaling up of production came at the cost of meticulous quality control. From an operational standpoint, the upsurge in demand triggered by promotions necessitated an immediate boost in production volumes. In their quest to meet consumer demands, firms amplified production rates and expedited processes. Unfortunately, this accelerated pace might have compromised the rigorous quality control measures that were previously in place. Such a trade-off between speed and precision posed significant risks to the integrity of the final product. This result is highly risky for firms and requires a deep understanding during disruptions: the surge in sales driven by promotions seemed promising at first glance, as it generated higher revenues for the firm. In fact, rushed production processes driven by emergencies might have led to oversight and lapses in quality checks, undermining the firm's ability to deliver goods that consistently meet high standards.

In analyzing the significant and negative correlation between a firm's capacity to increase market share and the support offered to consumers through promotions and interesting deals during the first wave of COVID-19, firms recognize the importance of modifying strategies according to the disruptions. In fact, promotions and deals during the pandemic were strategic moves to boost sales and gain a competitive edge in a highly challenging market. However, some companies might have run promotions on goods that

were not entirely aligned with consumers' needs during the COVID-19 period. This disconnect between the promotional offers and consumers' actual requirements had adverse repercussions on market share. Consumers' priorities and preferences shifted significantly: products that once held high demand might have lost relevance during the pandemic, leading to decreased interest and reduced market share.

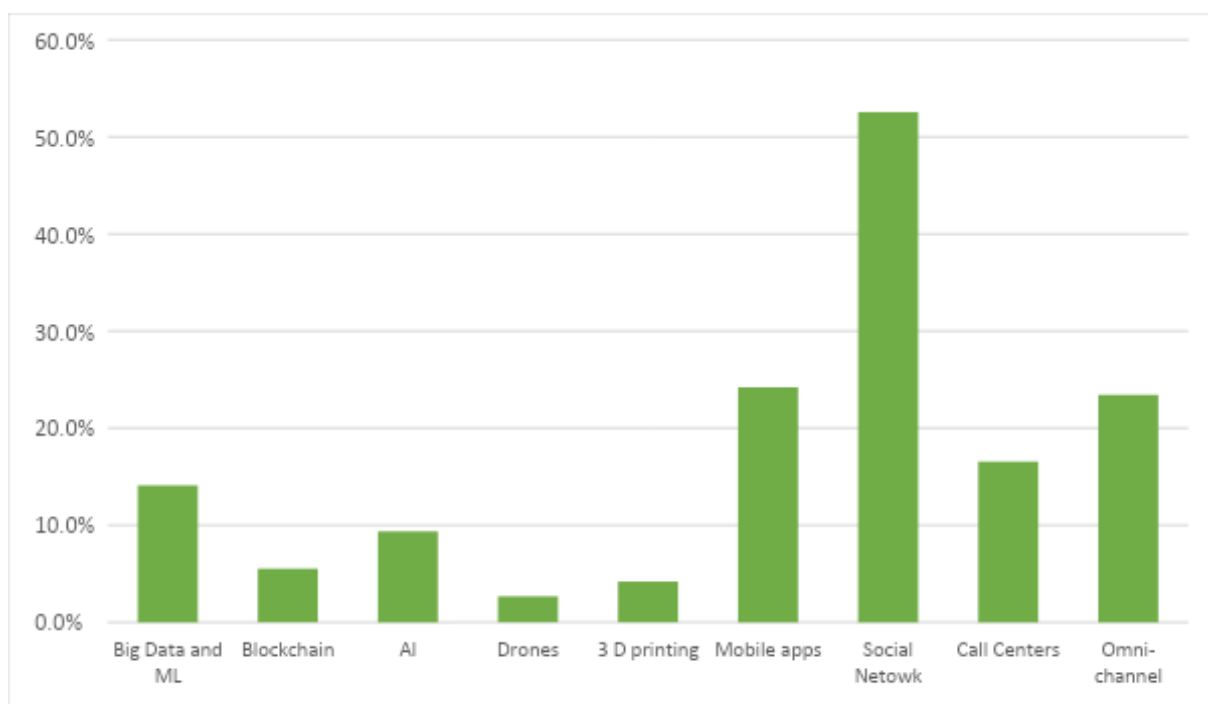
Logistics played a crucial role during the pandemic as disruptions to supply chains and transportation systems were rampant. While some companies focused on promotion to support consumers, they encountered challenges in ensuring the timely delivery of goods. The surge in demand driven by attractive deals put immense strain on logistics operations, leading to delays in deliveries and logistical bottlenecks. The need to fulfill the increased orders while delivering on the promised promotions required meticulous planning and efficient execution, including revisiting the logistics fleet. The adoption of omnichannel strategies added another layer of complexity. Companies sought to reach consumers through various channels integrated with e-commerce, including physical stores, online platforms, and home deliveries. Overall, the Italian companies show a great capacity to manage the disruptions since the on-time delivery was not at all influenced by promotional strategies.

3.5 The technologies adopted during the first wave of COVID-19

In this section, we analyze the technologies adopted during the first wave of COVID-19: big data and machine learning, blockchain, artificial intelligence, drones, 3D printing, mobile apps, social network, call centers, omnichannel (Alghamdi and Alghamdi, 2022; Zafar and Ahamed, 2022). For each technology, the dataset reports information on the percentage of companies that adopt these technologies during the first wave of COVID-19. Therefore, the technology adoption is measured in terms of the percentage of companies that adopt the specific technology in the analyzed sample. When an indicator is 100%, it means

that all the firms in the sample adopt that technology. In contrast, when the indicator is 0%, it means that the analyzed firms didn't use that technology. Figure 34 reports the percentage for each technology included in our analysis.

Figure 35 Technologies percentage of adoption in the Italian firms



3.5.1 Big Data & Machine Learning

Big Data refers to a quantity of computer data large enough to be impossible to capture, store, manage, and analyze in a reasonable time with traditional hardware and software tools. There is no predetermined size of data to talk about big data, but the amount of data must be placed concerning the capacity of the systems available. Big data can be defined through the 3Vs developed by Doug Laney in the early 2000s: i) Volume, which refers to the amount of data that could come from multiple sources such as IoT systems, social media, commercial data, other databases etc; ii) Velocity, refers to the speed of

data generation and analysis; iii) Variety, refers to the multiplicity of data types available such as numeric, text, video, audio, images, etc. Later other dimensions have been considered such as Veracity, which refers to the reliability of the data; Value, which refers to the usefulness that can be derived from the data; and Variability, which refers to the unpredictability of the data. The availability of Big Data has opened the possibility of training machine learning algorithms. Machine learning refers to the construction of algorithms that can learn and improve from the data made available to them to create models capable of making predictions about the data itself.

During the first wave of COVID-19 big data and machine learning found applications for both business purposes and pandemic control. From the perspective of business marketing, big data is a valuable tool for improving customer acquisition and retention (Singh and Singh, 2019). The digital footprint left by customers is useful for understanding their needs, preferences, and tastes and designing personalized products, services, and experiences, accordingly, elevating brand loyalty and increasing sales. In a context of uncertainty such as COVID-19, this information has made it possible to keep track of customers in the absence of them in the physical stores. In addition, big data analytics makes it possible to identify potential risks and devise a strategy to address them before they occur. The disruption brought by the pandemic has led to the emergence of new and unpredictable risks capable of causing threats throughout the value chain. Companies that have been able to leverage the data to predict the risks have optimized the decision-making process gaining a significant competitive advantage. Moreover, big data analysis is a valuable tool to develop new products and improve the current products by intercepting customer preferences and tastes. For the supply chain, analyzing and sharing data within the supplier network to manage the relationships more precisely makes the supply chain more resilient to disruptive events such as COVID-19. For instance, the proper use of big data analytics reduces the risk of returning products and alleviates inventory inefficiencies.

Furthermore, big data provides an analytical landscape for the supply chain to improve planning and decision-making processes by enabling more useful analytical approaches related to automatic analysis of contracts, cost modeling, demand balancing, operations planning, real-time roadmap in delivery planning, automatic delivery scheduling, efficient

warehouse management, automatic allocation and stock planning, fraud detection, energy consumption scheduling, customer rating, and product recommendation (Bag et al., 2021). For instance, implementing big data analysis for improving delivery fleet management during a crisis like the pandemic which made many of the online ordering platforms overwhelmed, can help to cut costs and delivery time by using up-to-date shipping information and optimizing route deployment, resource allocation, and delivery schedules. Looking at our sample, the data suggest that only 14% of the Italian companies were using big data and machine learning technologies during the first wave of COVID-19, indicating a relatively low rate of adoption.

3.5.2 Blockchain

Blockchain is a distributed, encrypted database shared among multiple nodes in a network that allows data to be recorded securely and immutably. Since blockchain was first introduced in 2008, several types of blockchain have been created that differ in technical features and practical applications. However, they have some common advantages that include transparency, privacy, security, immutability of information, and decentralization, which made it a viable alternative to traditional centralized databases during the COVID-19 pandemic (Min, 2019). Indeed, digitizing the flow of information through blockchain helps all partners in the supply chain to have access to accurate data and trace the products, services, and financial transactions in real-time. The modern global supply chains usually include many partners and each of them often knows only its direct stakeholders. So, blockchain enhances trust and traceability by sharing data and implementing smart contracts which lead to facilitating the material, cash, and information along the whole supply chain (Biswas et al., 2023).

Blockchain proves to be effective in value chain tracking, product quality monitoring, and product originality control. During the pandemic, it was a valuable technology for tracking drugs and vaccines by ensuring the proper and fair allocation of resources to the countries by promoting supply chain coordination. Accordingly, some of the British hospitals adopted blockchain technology to secure the processes of distribution, storage, and administration of vaccines with a focus on the cold chain. In fact, some medicines such as the Pfizer-Biontech COVID-19 vaccine require specific storage so as not to lose its

characteristics. Moreover, the food sector is one of the main beneficiaries of the traceability characteristic of blockchain to enable tracking and certifying the food origin, processing, transportation, and storage conditions. Borrowing from these applications.

Furthermore, blockchain is an efficient technology to ensure the implementation of product life cycle assessment steps including waste disposal analysis. With the emergence of the sharing economy and subscription business models, the companies remain the main owner of the products which help them create a circular supply chain (Dubey et al., 2020). In that case, blockchain technology is useful for tracing the products' location, materials, maintenance information, etc. So, blockchain technology provides the opportunity to implement different circular economy practices and conduct life cycle assessments to improve sustainability performance. Besides, it enhances business resilience by having an agile organization in tracing products and services as well as the source of disruptions.

Looking at our sample, 6% of the companies used blockchain during the first wave of COVID-19. Despite the potential benefits of blockchain during crises, the results show that it has the lowest adoption rate among the considered technologies. The main reasons may be related to the lack of knowledge about the benefits of blockchain as a recent technology, its high adoption costs, and the required skill for implementing it. This indicates the necessity of a greater effort to investigate the challenges of implementing this technology that promises to make value chains more resilient in crisis conditions.

3.5.3 Artificial Intelligence

Artificial intelligence (AI) is the ability of a machine with a real-time connection to the environment, to understand it and act toward a predetermined goal by exhibiting human capabilities such as reasoning, learning, planning, and creativity (Belhadi et al., 2022). AI was invented in the 1950s, however, its adoption is increasing due to the large amount of data available to train artificial intelligence algorithms and provide the inputs to obtain satisfactory outputs. AI has various applications like the creation of dialogues; face and motion recognition; image and video making; task planning; and automated reasoning. Its versatility has made it a valuable tool for managing the disruptions in the COVID-19 pandemic and monitoring activities were a successful application (Modgil et al., 2022). AI

developed predictions and simulations of the spread of the virus to be used by policymakers. Some countries such as China have applied AI by integrating it with drones and sensors to monitor the population rules compliance. Telemedicine services integrated with AI such as Self-checker services, AI Chatbots, and teleconsultation have ensured a quick and effective response to citizen questions while minimizing the risk of contagion from direct contact with a human operator. Finally, a valuable contribution of AI concerns drug research and development. Amazon web services have launched an AI capable of analyzing 128,000 publications related to drug and vaccine development to select those most useful in identifying a cure or vaccine for COVID-19. Other applications include molecule scoring process, biomarker discovery, and prediction of virus protein structures. One of the main advantages of AI is the ability to improve the decision-making process by making decisions quicker and with a smaller margin of error (Belhadi et al., 2022). In fact, unlike humans, AI, when fed with adequate data, has a very limited margin of error in repetitive tasks. Moreover, it provides greater fairness by not being influenced by personal evaluations, making it an important tool for applications such as funding approval, personnel selection, and resource allocation. AI is also effective in providing 24/7 digital assistance by answering customer questions and reducing the human staff workload. In addition to the decision-making process, AI allows the analysis of a large amount in a limited time by identifying patterns. COVID-19 had a significant impact on the supply chain procurement, manufacturing, and go-to-market activities. In this context, AI can be applied to inventory management where it ensures the proper flow of items in and out of the warehouse through order management, shipment planning, and demand forecasting. It enhances safety in the supply chain by analyzing and assessing risks and suggesting corrective actions in real-time. It also reduces operational costs by increasing speed, and accuracy and reducing errors. However, despite all these advantages, the initial investment is huge in terms of expertise and systems development. Moreover, the training costs are not only for specialized personnel but also for training the algorithms themselves, which requires sufficient data and information to improve themselves. Although the system is very scalable and once fully deployed provides attractive results, at first the benefits may not seem to repay the investment made.

AI is useful for improving the resilience performance of companies during crises like COVID-19. AI is capable of automating various processes such as demand forecasting, production planning, transportation scheduling, and predictive maintenance to face various disruptions and sudden changes in the demand and market (Naz et al., 2022). Some companies are implementing AI to ship the products before the customers place their orders. The customer order will be later matched with the shipment that is already in the logistic network and then the system reroutes the shipment to the exact customer destination. These capabilities of AI will cut operational costs by providing an accurate real-time resource allocation. Moreover, AI learns from offline and online data to offer solutions to managers and firms for facilitating their decision-making procedure and being more agile during disruptions.

According to Figure 36, 9% of the Italian firms included in our sample used AI during the first wave of COVID-19. This identifies a low adoption of AI technology despite its potential to deal with issues during crises and unexpected disruptions. The limited application is likely due to the high initial implementation costs that this technology requires currently.

3.5.4 Drones

Drones are unmanned vehicles remotely controlled by human operators or automated computers. Drones can come in different types and sizes. They can be as large as actual airplanes or as small as to be held in the palm. Their applications are very versatile and include military applications where they have an established presence, business applications for last-mile delivery or moving goods in warehouses, collecting video or audio information in dangerous or inaccessible places, rescuing people, and recreational activities. During the COVID-19 pandemic, drones found three main applications: i) Monitoring of public spaces; ii) Disinfection of public areas; and iii) Transportation and delivery of medical supplies and commodities (Shishkov et al., 2021).

These days, there are several use cases for drones adopted by governments and companies. In France and Belgium, police have applied loudspeakers to drones flying over areas subject to mass gatherings to communicate necessary precautions to citizens. In Austria, drones are equipped with cameras to monitor traffic and detect unauthorized gatherings. In Norway and Spain, a special drone called the Mavic 2 Enterprise Dual

enables remote temperature checks. The application of drones for the disinfection of public areas has seen its application in the most acute moments of the pandemic in China, the United Arab Emirates, Spain, South Korea, and other countries. Drones were useful for the delivery and transportation of medicines and essential products. One interesting application is the one implemented by United Parcel Service (UPS), which developed a special tool for drones to maintain the cold chain to carry vaccines, clinical trials, and heat-sensitive medicines. This technology has allowed UPS to integrate drone transportation into the highly specialized cold chain business even after the pandemic.

Some of the main advantages of using drones are the high speed of delivery, the extended delivery network especially in the final stage of the supply chain for last mile delivery, and the limited physical contact resulting in reduced spread of infection. However, not all companies and countries had access to drone technologies and expertise to mobilize them since the beginning of the pandemic. Many specific applications have been developed on an ad hoc basis as in the case of UPS. In addition, positive results seem to be content specific and have mixed results based on each country's regulations, socio-cultural context, people's habits, and the country's level of technology. Finally, to have a relevant impact in terms of effectiveness and efficiency, drones must involve a very large number of vehicles and be used at a relevant scale. The use cases detected are mostly pilot projects or short-term applications. In our sample drones are the least widespread, adopted by 3% of the sample. This indicates that drone technology is not yet widely deployed and only first adopters are exploring it for business applications.

3.5.5 3D Printing

3D printing refers to the creation of three-dimensional physical objects from 3D digital models. The feature of 3D printing, which distinguishes it from other ways to create three-dimensional objects, is the use of additive techniques by adding material layer by layer. For this reason, it has also acquired the name additive manufacturing. 3D printing includes a wide range of software and hardware solutions that allow the use of various techniques for numerous applications. These include "material jetting" involving the use of hot-melt inks in the form of wax, plastic material, or metal to create objects. "Material

extrusion" involves the use of a filament that is melted to be deposited in layers to create the desired object, while "Powder bed fusion" involves the use of powders.

The COVID-19 pandemic creates an unanticipated demand for goods and medical equipment. Among the objects that have been produced through 3D printers for medical purposes, we can mention: i) Hospital respiratory support apparatus, such as valves for respirators, or other disposable components; ii) Personal protective equipment, such as masks or face shields; iii) Environmental solutions, to avoid direct contact with surfaces or objects that could have promoted the spread of the virus; and iv) Printed equipment disinfection .

A common element of all these objects is the use of 3D printing to increase production and fulfill the temporary product shortage. The versatility of 3D printing provides various advantages that can be useful for improving resilience (Alexopoulos et al., 2022). This technology has a high degree of customization, and the ability to speed up and simplify production processes which results in reducing lead time as well as decreasing the operating and tooling costs of printers compared to traditional industrial solutions. In addition, thanks to additive manufacturing, material waste is minimized by decreasing the raw material needed (Bouchenine and Abdel-Aal, 2023). However, this technology has evident limitations on large-scale production where, despite continuous improvements, many shortcomings remain. In fact, the accuracy of 3D printers does not yet reach those of the most developed industrial manufacturing. Consequently, for devices that require greater precision in the manufacturing and inspection process, we need other production techniques rather than using 3D printing. Moreover, although 3D printing has a good performance in terms of costs for producing one-off or limited number parts, for large-scale production, this technology does not guarantee the exploitation of the economies of scale achieved with traditional manufacturing. We also identify a limitation concerning the size of printable objects since most printers available to date are rather small.

Looking at our sample, the 3D printing technology is used by 4% of the companies. This is a very low percentage which shows that Italian companies do not yet consider it an attractive technology. This is probably due to the aforementioned limitations. However,

during the pandemic of COVID-19, some use cases that highlight the advantages have emerged, so in the coming years, we could expect an increment in its adoption.

3.5.6 Mobile Apps

Mobile apps are software applications that are simplified by eliminating unnecessary functionalities. They are faster, lighter, and essential for use on mobile devices such as smartphones, tablets, and smartwatches. During the COVID-19 pandemic, apps were developed specifically to try to limit the spread of infection or to support the patients (De Pablos et al., 2022). Among these, the most popular were contagion-tracking apps. These apps use the mobile device hardware to track the user's movement. The most used technologies are GPS, camera images, credit card transactions, Bluetooth, and Wi-Fi connections. These applications after detecting a proximity with an infected person anonymously alert the user. Very similar technology has been applied by some countries to develop quarantine apps. Using the same technologies, authorities can verify that the infected user complied with home confinement measures. Some countries included the use of additional devices such as electronic ankle monitors connected to the app for greater control. Another category of mobile apps involves symptom monitoring apps. These applications, by asking users precise questions or collecting biometric data from wearable devices, indicated to the user the likelihood of being affected by the virus. Finally, extensive use was made of information providing apps, using both preexisting applications such as major social networks and specially developed apps. The goal is to communicate important information and prevent the proliferation of fake news.

Besides the mobile apps applied for pandemic management, the mobile applications have given many advantages to the companies that integrated them into their business model (Bama and Abrahams, 2023). They are faster and more responsive compared to the company's website because they are specially designed and optimized for use on mobile devices. During the pandemic, there was an increment in online traffic and mobile apps made it possible for companies to provide their products with a better online service. Firms personalize these apps according to the user's preferences and collect required data from the user to offer and support them with additional services. This has enabled customers to save time and carry out their operations easier. For example, preferred to

purchase their favorite products directly from the app, view their desired information faster, and access their favorite entertainment during the lockdowns. They have greater accessibility and usability because these apps are simple and intuitive and even less experienced users can use them.

Furthermore, they can be integrated with the hardware of the device in which they are installed by leveraging camera, GPS, and NFC sensors ensuring a more immersive experience for the consumer and at the same time allowing the company to collect valuable data for customer profiling and service personalization. However, many of these advantages imply some challenges. The need to be fast and responsive limits the number of functions that a mobile app can support. Therefore, for more complex tasks, the customers must be redirected to the company's website, negatively affecting the user experience and creating a feeling of dissatisfaction. They may not be compatible with all devices and companies should invest in app compatibility with most of the devices available on the market avoiding limiting the user base. Moreover, they often have bugs or problems that require frequent updates without which they may not work properly. Besides, they raise security and privacy concerns since they have access to user data. Privacy concerns have led many users to give up using them, which in many cases has resulted in the application itself being less effective due to the reduced network effect.

As displayed in Figure 35, in Italy 24% of the companies in our sample had developed mobile apps. Although in absolute numbers this is not a high percentage, it ranks among the most widely used technologies analyses. Therefore, Italian companies have perceived the advantages and usefulness of this technology. However, significant investments are still needed to increase its diffusion.

3.5.7 Social Network

A social network is an Internet service for managing social relationships by exchanging messages, sharing information, and other shared activities. The most popular platforms are Facebook and its entire ecosystem, Twitter, LinkedIn, TikTok, and WeChat. Since their introduction in the early 2000s, social networks have steadily spread and today they are used by more than 60% of the world's population. Their widespread use has made them one of the most effective tools for disseminating information and consequently, they were

a valuable tool during the COVID-19 pandemic (Jo et al., 2021). In addition, the limited face-to-face sociality imposed by the regulations has increased the use of social networks for socializing. Given the number of people who use them daily, during the pandemic social networks have been used for the rapid dissemination of educational content or preventive behavior. National authorities in different countries shared on institutional social profiles the rules and regulations introduced as well as updates regarding the spread of the virus. This has improved interaction between citizens and authorities, thanks in part to the ability to ask questions or request explanations with comment or private message features.

From a business perspective during the pandemic, social networks provided a valuable point of contact between companies and consumers (Pham et al., 2021). This opportunity allowed companies to apply communication strategies to increase brand reputation, communicating promotions or discounts, gathering feedback from consumers, promoting online sales channels, and sharing company efforts to support the population and authorities. For example, some companies in Italy have provided new products to cover the required medical items in the market, such as respirator valves produced by Ferrari, or masks produced by Gucci and Prada. These initiatives have been shared on social channels, bouncing from one page to another and ensuring great visibility for the brands, as well as identifying them as engaged in social initiatives and close to the population. These types of initiatives improve brand awareness and brand recognition resulting in increased traffic on the company's websites and e-commerce, and increased sales and revenue.

However, because of the dual impact of the visibility that social networks provide, there are potential drawbacks that require careful monitoring. Companies need to consider the possibility of receiving negative comments or reviews and have a strategy to limit and manage their possible damage. During the pandemic, companies that did not comply with standards for pandemic control, or did not adequately protect their workers, were exposed to public judgment with a negative impact on their reputation and brand perception. Social networks give anyone the ability to create content, therefore both users and companies must consider the possibility of fake and inaccurate news (Bermes, 2021). Such news goes viral, polarizing public opinion, creating unfounded fears, and impacting

political processes. Companies must devise strategies to respond to these situations to limit their dissemination, rectify information, or exploit the visibility gained by the viral fake news to take advantage of it. Finally, during COVID-19 the social network has experienced an unusual growth. Companies should be aware of it to avoid a superficial approach. So, a social network strategy requires targeted investment in expertise and content. Moreover, the results are often not immediate but take time to be appreciated.

As displayed in Figure 35, social network is the most widespread technology adopted by 53% of the companies. This shows that it is a familiar technology among Italian companies probably due to limited up-front costs.

3.5.8 Call centers

A call center is the set of devices and human resources used to manage a large number of incoming calls (inbound call center) and/or outgoing calls (outbound call center) from a company. The minimum requirement for a call center is a telephone line and a specialized operator, but from a technological point of view, much more advanced technologies can be used such as chatbots and artificial intelligence. Call centers have numerous applications, including sales and telemarketing purposes, market research, and customer service. During the COVID-19 pandemic, call centers were widely used to answer questions from the population in a new and unknown situation. They provided the possibility of managing a large number of requests and questions (rules relating to home confinement, travel restrictions, symptoms, medical requests, and advice) in a short time. In terms of business applications, call centers play a fundamental role in maintaining relationships with consumers to offer them an effective service. This leads to an increment in customer satisfaction and an improvement in competitive advantage. Furthermore, they improve customer loyalty by reducing the costs of acquiring new customers and offering a more personalized service based on customer needs compared to other remote interaction systems. During the crises, these services are essential to provide pre-and post-sales assistance to customers due to the restricted face-to-face interactions. However, when the service is not effective, it has negative implications,

negatively affecting the purchasing and/or use experience and customer satisfaction. Therefore, companies should carefully design the service by making strategic decisions such as the choice to outsource the call center service or internalize it.

Despite being an established technology only 17% of the companies included in our sample use call centers. This is an unexpected result considering that it was one of the few channels available during the first wave of COVID-19 to have an interaction with a person in charge of the company. Probably this result is due to companies' preference for other up-to-date communication channels such as social networks.

3.5.9 Omni-channel

Omnichannel refers to the use of multiple offline and online sales channels with the goal of ensuring an integrated and cohesive customer shopping experience. Omnichannel is a valuable tool for increasing customer satisfaction, as improving the shopping experience increases customer trust in the brand and enhances customer loyalty (Zhang et al., 2021). It provides a consistent experience across multiple touchpoints and it allows customers to save time by selecting the best channel based on their needs like prices, return options, and support during and after-sales.

However, implementing an omnichannel strategy requires updating the organizational structure (Zhang et al., 2021). An omnichannel strategy aims to integrate physical and digital touchpoints seamlessly by providing a seamless customer experience across various channels (brick-and-mortar stores, online platforms, and mobile applications). Some competencies to effectively implement an omnichannel strategy are the ability to forecast, effective information flow among the business functions, inventory planning, warehouse and logistics management, and fast and lean manufacturing strategies (Naclerio and De Giovanni, 2022).

During the pandemic, companies that were already adopting an omnichannel strategy had a clear competitive advantage over the traditional brick-and-mortar business model because they had active sales channels even after the physical stores were forced to shut down. However, the pandemic brought unexpected challenges. The lockdowns led to a sudden increase in the users' flow to online channels, resulting in overwhelmed web pages that slow down and with applications and websites malfunctioning. Inventory and

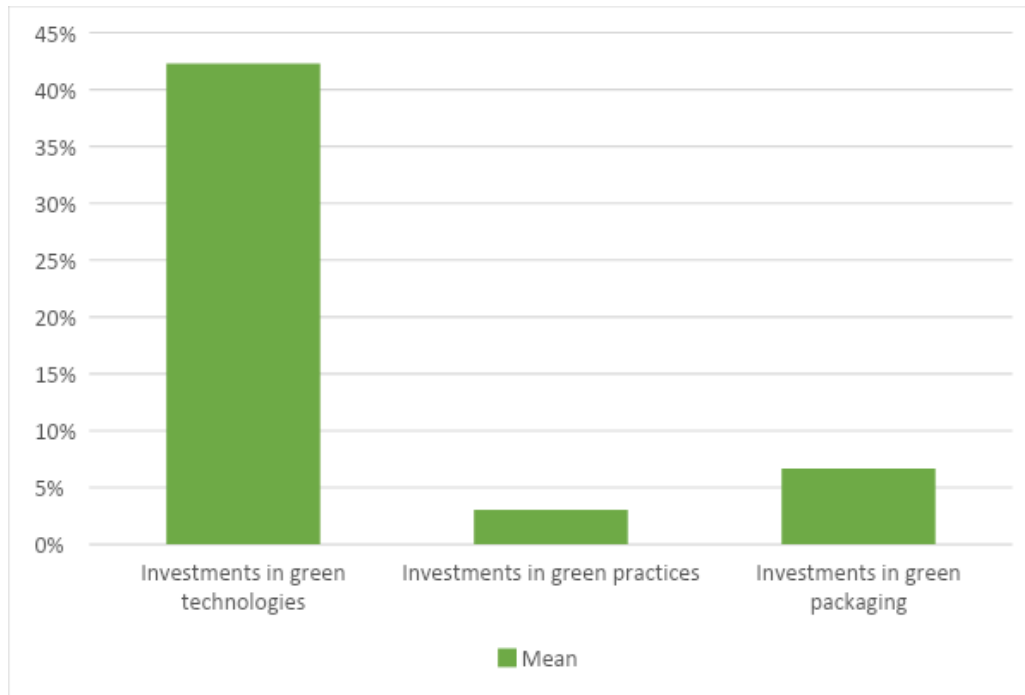
warehouse management have been strained. In fact, the overload of orders combined with the difficulty of obtaining supplies resulted in the reduction of products in stock, some products out of stock, delays in deliveries, and difficulties in the return or replacement of defective products. Product quality was also challenged due to the difficult supply of raw materials or the limited availability of production facilities. Finally, in a ripple effect, customer services had to handle a large number of complaints and refund requests, as well as replace physical stores for product-related information and questions, decreasing the quality of service provided.

The 23% percent of the Italian companies included in our sample used an omnichannel strategy during the first wave of the COVID-19 pandemic. This result shows that most companies are not prepared to approach the customer with multiple channels indicating the need for more investment in this direction.

3.6 Green investments, practices, and packaging

In this section, we analyze green investment, green practices and green packaging during the first wave of COVID-19. For each sustainability initiative, the dataset reports information on the percentage of companies that adopted it during the first wave of COVID-19 and allows us to analyze the firms' sustainability commitment during the proposed disruption. Therefore, green adoption is measured in terms of the percentage of companies that adopt the specific item on the analyzed sample. When an indicator is 100%, it means that all the firms in the sample invest in that sustainability initiative. In contrast, when a performance is 0%, it means that the analyzed firms didn't use it at all. Figure 36 displays the results included in our analysis.

Figure 36 Green technologies, practices, and packaging investment percentage in the Italian firms



3.6.1 Investment in green technologies

Green technologies refer to the use of technology to preserve the natural environment. Green technologies make it possible to reduce CO2 emissions, create green products, reduce material consumption, increase digital sustainability, produce clean energy, and manage waste (Borah et al., 2023; Trabucco and De Giovanni, 2021). For more explanations, we provide a few examples of the relevant technologies for different sectors. The energy sector is the one that attracts most of the investments in solar panels, wind turbines, hydrogen for energy production, carbon capture and storage systems, and energy-saving technologies. The mobility and transportation sector focuses on electric cars and trucks, electric or hydrogen public transport, connected cars, and car-sharing applications. The construction sector is investing in green and sustainable materials in addition to the energy efficiency of structures. Besides, the food sector is limiting the use of pollutants, hydroponic cultures, and synthetic meat to follow the goals of organic farming.

Looking at the literature, it appears that COVID-19 has increased the adoption of green technologies in both public and private firms. However, the literature shows a strong correlation between the development and use of green technologies and the amount

invested by national and supranational public institutions through subsidies and/or tax reductions (Krass et al., 2013; Xu et al., 2017). Despite the uncertainty of demand, when subsidies are present, the cost of uncertainty is shared between the company and the government decreasing the risk. In addition, since COVID-19 there are more investments to stimulate economic recovery and many of them are aimed at implementing green technologies. Overall, it appears that investment by governments is the main stimulus for the green technologies extension.

According to our results displayed in Figure 36, 43% of the companies adopted green technologies during the first wave of COVID-19. Green technology is ranked in the first place among the green items analyzed in our sample uncovering that sustainability investments are focused mainly on green technologies. However, the results show that it is still far from a widespread green technology investment given that more than 50% of the companies are not investing in that.

3.6.2 Investment in green practices

Green practices are a set of actions to reduce the impact on the environment and conduct a strategy oriented toward environmental sustainability. Green practices can cover activities undertaken directly by the organization itself or those carried out by other actors in the supply chain such as suppliers or customers (Vachon and Klassen, 2006). For the suppliers, the company can collaborate and monitor suppliers' behavior to incentivize them to apply green practices by providing technical and environmental specifications, establishing green partnerships, working on packaging and shipping methods, and applying for green certifications such as ISO 14000. Collaboration can also be toward customers by gathering suggestions and guidance from them to create more sustainable products, reducing packaging, developing reverse logistics policies, and providing suggestions for proper product recycling. Moreover, there are practices that the company can implement internally like designing environmentally friendly products which include using green raw materials, recycling, and disassembling for repair. The development of internal green operations includes saving energy, setting up procedures to avoid possible environmental damage, using standardized tools and components to facilitate repair, and decreasing internal consumption of both material and energy (Azevedo et al., 2011).

The introduction of green practices requires targeted investment and a long-term strategy to adjust internal and external procedures besides good relationships with supply chain partners to collaborate with them in this direction (De Giovanni and Esposito Vinzi, 2012). Just like what we mentioned in the previous section regarding green technologies, there is a positive correlation between investments in green practices and government subsidies through tax credits or grant funding as well. As a result, following the increment in funds invested by national and supranational governments in this direction during and after the pandemic, the adoption of green practices is increasing.

According to our results displayed in Figure 36, the fact that 3% of the companies adopted green practices during the first wave of COVID-19 indicates that only a marginal share of Italian companies are implementing these sustainability practices. Therefore, it requires more effort from the government and companies to extend the range of green practices in Italy.

3.6.3 Investment in green packaging

Green packaging is the use of packaging with the least environmental impact and includes the use of sustainable materials, reduction of packaging waste, and the use of renewable energy during manufacturing. Green packaging can be categorized into recycled packaging, reusable packaging, and degradable packaging and each of the segments requires its own materials, technologies and manufacturing procedures. The challenges of COVID-19 impacted green packaging from a dual perspective. On the one hand, numerous production plants stopped working or ran out of raw materials which decreased the usage of packaging. On the other hand, the demand for vaccines, drugs, and medical devices increased the demand for sustainable packaging. In addition, lockdown measures caused an increment in in-home delivery services for goods and foods, and raising consumer awareness of the packaging issues forced companies to revise their strategies regarding it (Agerup et al., 2019).

The two main drivers of investment in green packaging are consumer preferences and government regulations either by introducing taxes or through subsidies (Rokka and Uusitalo, 2008). During and after COVID-19 these two drivers increased investment in green packaging. Companies are developing innovative sustainable materials that meet

the technical performance requirements such as strength, flexibility, and durability for packaging applications. These include materials such as glass which provides significant savings in raw materials and energy if properly recycled as well as recycled cardboard and the more innovative materials made from natural waste such as fruit peels. Further investments concern the production phase with the reduction of energy for packaging production the use of sustainable energy, and the development of modular production facilities that can be adapted to types and sizes of packaging. Finally, another approach is investing in logistics design and supply chain integration to reduce the weight and size of packaging by avoiding overpackaging and promoting savings on waste, and energy consumption for transport. In addition, private and public institutions should support communication and marketing investments to raise awareness for recycling and waste management.

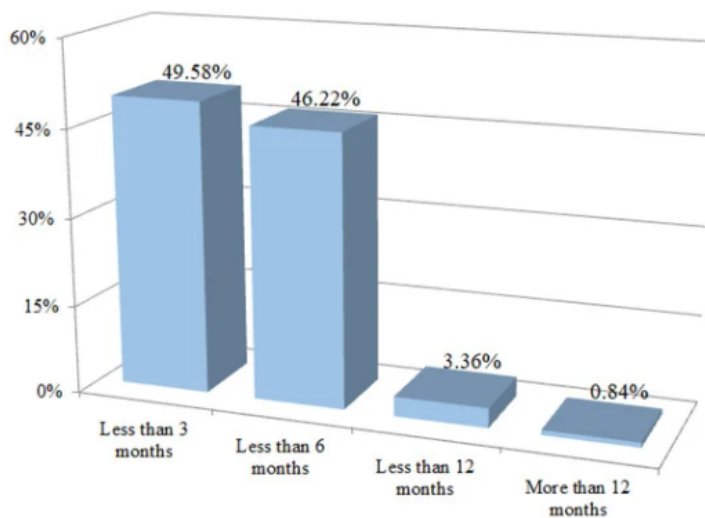
As results from Figure 36, only 7% of the Italian companies were investing in green packaging during the first wave of COVID-19. This shows relatively low interest and investment limited to a few early adopters who are exploring green packaging.

3.7 Analysis of resilience

This section examines the resilience of firms, drawing on extant literature. Hollnagel et al. (2006) delineate resilience as the capacity of an organization to counteract and recuperate from perturbations while maintaining its dynamic equilibrium. Similarly, Vugrin et al. (2010) postulate a tripartite framework for system resilience, categorized as absorptive, restorative, and adaptive capabilities. The absorptive capacity underscores a system's innate ability to neutralize systemic perturbations, thus minimizing deleterious consequences. The restorative capacity is centered on exogenous system reparative mechanisms, whereas the adaptive capacity pertains to intrinsic methodologies devised to respond to disturbances. De Giovanni et al. (2010) advance the notion of reactivity, characterizing it as the aptitude of an entity to function optimally—both operationally and financially—under unanticipated scenarios. It is imperative for contemporary firms and supply chains to cultivate a managerial paradigm that safeguards against operational underperformance during unforeseen events. Elevated levels of reactivity in firms are concomitant with an enhanced potential to restore financial trajectories post

unpredictable adversities. Golan et al. (2020) underscore the indispensability of a proactive systemic approach in navigating challenges, particularly pandemics akin to COVID-19. Conventional resilience methodologies, such as inventory buffers intended for disaster mitigation, may prove insufficient. Instead, a paradigm shift towards flexible redundancy is advocated, enhancing the resilience of systems and networks against unforeseen disruptions. Amidst the exigencies wrought by COVID-19, there's an intensified call for firms and supply chains to epitomize resilience by adeptly pivoting to emergent realities (Golan et al, 2020). Ivanov (2020) posits that the celerity and efficacy of resilience are contingent upon robust systems and stellar performance. Indeed, resilience is not a monolithic construct; it is predicated on a confluence of factors including conducive economic conditions, resource availability, strategic investments, organizational adaptability, and market opportunities. Consequently, firms with a sustainable business model are predisposed to heightened resilience, more so during tumultuous epochs such as the COVID-19 pandemic.

Figure 37 Distribution of resilience



Using the sample described in section 2, Figure 37 displays firms' resilience in percentages, which are distributed as follows: 260 firms can recover in less than 3 months (49.58%), 243 firms can recover in less than 6 months (46.22%), 18 firms can recover in less than 12 months (3.36%), and 4 firms can recover in more than 12 months (0.84%).

Accordingly, firms turned out to be most likely optimistic by the end of the first wave regarding the chance to recover quickly and restore their business affairs and volumes at the pre-COVID levels either in less than 3 months or in less than 6 months. Since most of the firms links to these two categories, we created a dummy variable capturing resilient firms with label "1", which will be able to recover in less than 3 months, representing 49.58% of the sample, and non-resilient firms with label "0", which will be able to recover in more than 3 months and representing 50.42% of the sample. This suggests that, by the end of the first wave, these firms believe they have the resources, strategies, or market conditions favorable enough to restore their business operations and volumes to levels seen before the pandemic in under 6 months. This can also be linked to the fact that most businesses have either adapted, have strong contingency plans, or operate in sectors less affected by the disruptions, thus expecting a faster recovery.

3.7.1 Correlation analysis of resilience and indicators of performance

In this section, we analyze the correlation existing between the resilience and the performance indicators. The results are displayed in Table 11.

Table 11 Correlation between resilience and performance indicators.

	Stock availability	Customer service	Sales	ROI	Product quality	Market share	On Time Delivery
Time to recovery	-0.147**	-0.221**	-0.329** *	-0.199**	-0.105*	-0.150**	-0.089*

***p-value<0.01; **p-value<0.05; *p-value<0.1.

According to our statistical analysis, it emerges that adequate stock ensures that there is no break in the supply-demand chain. In disruptive periods, consistent supply is paramount to maintaining customer trust. By ensuring a consistent stock flow, firms not only cater to ongoing demands but also gain an edge over competitors who might be facing stockouts. A diversified supplier strategy, for instance, reduces the risk of supply chain interruptions. Buffer stocks act as a safeguard against unexpected demand surges

or supply chain lags. Similarly, exceptional customer service can lead to increased brand loyalty and customer retention, especially during challenging times when consumers seek reliability. By investing in customer service, firms can build a loyal customer base that will stick with the brand even during disruptions. Similarly, training personnel to address customer concerns promptly and adopting technology to enhance service can lead to higher customer satisfaction, thus ensuring a stable customer base and potentially quicker recovery.

In a similar vein, sales are a direct indication of a firm's market presence and customer trust. Maintaining sales during disruptions means the firm has a strong and loyal customer base. Diversifying sales channels ensures a broader reach to potential customers. An enhanced online platform, given the increasing digital shift, ensures that the firm remains accessible to its customers. Consistent sales, even during disruptions, provide firms with a stable revenue stream, ensuring financial stability and resilience.

Furthermore, the correlation analysis reveals that a higher ROI indicates efficient use of resources and investments. By focusing on high-return projects and investments, firms ensure they get the most out of their limited resources and, especially during disruptions, financial efficiency becomes critical. Overall, strategies yielding a higher ROI will provide better financial cushioning against unforeseen challenges. Regarding other facets of operations management, product quality is directly related to brand image and trustworthiness. Maintaining consistent product quality, firms signal to their customers that even during challenges, the brand's standards remain unwavering. This fosters trust, ensuring that customers remain loyal, and aiding in quicker recovery post-disruption. Finally, market share is a reflection of a firm's competitive position. Firms with a larger market share have a wider customer base and greater influence. By focusing on strategies to retain or expand market share, firms not only maintain their dominance but also ensure that post-disruption recovery is expedited due to their expansive influence.

3.7.2 Regression analysis of resilience and indicators of performance

To test the relationship between the indicators of performance robustness and resilience, we ran a linear regression model characterized by the equation noted below. Since it is necessary to verify this relationship without the contributions of any performance indicator when analyzed jointly, this regression analysis represents the benchmark for our investigation and the related equation can be written as:

$$\text{Time to recovery} = \beta_1 + \beta_2 * \text{Sales} + \beta_3 * \text{ROI} + \beta_4 * \text{Product Quality} + \beta_5 * \text{Market Share} + \beta_6 * \text{Stock Availability} + \beta_7 * \text{Customer Service} + \beta_8 * \text{On-Time Delivery} + \varepsilon$$

where β_1 is the constant coefficient of the regression line, ε is the error term of the regression model, and the coefficients $\beta_2 \dots \beta_8$ indicate whether Sales, ROI, Product Quality, Market Share, Stock Availability, Customer Service, and On-Time Delivery predict the Restoration Time.

The results, which are displayed in Table 12, demonstrate the impact of each indicator on companies' resilience. Therefore, they inform on which indicator firms can rely on to survive disruptive events. In fact, the findings of the regression analysis indicate the value of each coefficient associated with the independent variables and the correlated p-values.

Table 12 Regression results and analysis

Hypothesis	Intercept	Stock Availability	Customer Service	Sales	ROI	Product Quality	Market Share	On-Time Delivery
Time to recovery	16.57***	0.005	-0.023	-0.093***	0.025	-0.011	-0.011	0.001

***p-value<0.01; **p-value<0.05; *p-value<0.1; italic values are not significant

According to our results, firms can perform an average Time to Recovery of 16.57 months for their businesses. This means that if the pandemic were to conclude immediately after the submission of the survey, it is projected that businesses would require approximately 16.57 months to revert to their standard performance trajectory. An intricate observation within the dataset reveals that the agility with which these firms bounce back to their pre-pandemic vitality is not necessarily anchored to the readiness or availability of their stock (Coefficient: 0.005 with p-value: >0.1). This somewhat counterintuitive discovery

emerges from a nuanced understanding of stock management dynamics. Typically, businesses are continually engaging in refining and streamlining inventory practices irrespective of external calamities like COVID-19 interruptions. This indicates that a singular focus on reinforcing inventory mechanisms cannot necessarily be the panacea for accelerated recovery periods.

A parallel strand of analysis concerning customer service gives equally insightful facets. The empirical evidence suggests that a firm's stability and recovery rate during the pandemic is not intrinsically bound to the robustness of its customer service strategies (Coefficient: -0.023 with p -value: > 0.1). A deeper dive into this phenomenon indicates a potential reason: the pandemic, despite its extensive disruption, did not unduly sway customer brand loyalties. Although enhancing customer service quality is undoubtedly commendable, these findings show that relying solely on such improvements does not substantially bolster a firm's resilience and performance, especially during widespread disruptions.

A particularly salient outcome pertains to the role of Sales in a firm's resilience architecture. The data underscores this with a significant coefficient (Coefficient: -0.093 with p -value: < 0.0001), positioning Sales as a paramount determinant in fostering resilience and facilitating the recuperation of performance benchmarks. The observed negative correlation between Sales and Restoration Time implies a direct and beneficial impact, signalling that bolstered Sales dynamics can notably decrease the time companies require for restoration. As reflected in various academic and industry literature, even amidst the tumult of the pandemic, businesses innovatively recalibrated their strategies to cater to evolving consumer demands, further corroborating the crucial role of Sales dynamics during such crises.

However, on the flip side, the resilience of a business during such unforeseen disruptions does not seem to be tied up to ROI metrics (Coefficient: 0.025 with p -value: > 0.1). This observed dissonance could be attributed to the prolonged negative aftermath of the pandemic on typical ROI trajectories. Furthermore, the firms' resilience is not significantly influenced by the robustness of Product Quality (Coefficient: -0.011 with p -value: > 0.1), hinting at its subsidiary role during systemic crises. Also, the relationship between Market Share and performance resilience becomes even more intricate during pandemics, which

is underscored by its lack of statistical significance in the model (Coefficient: -0.011 with p-value: >0.1). One of the more counter-intuitive findings is associated with On-Time Delivery dynamics. Despite its conventional importance, the study identifies it as an inadequate resilience vector during the COVID-19 era (Coefficient: 0.001 with p-value: >0.1). This can be contextualized with real-world scenarios, like Amazon's marked delivery delays during the pandemic's initial surge.

To conclude, the study meticulously unravels that, amidst the turbulence of the COVID-19 outbreak, companies could predominantly harness the power of robust Sales dynamics to carve a path of resilience, exemplified by a truncated Restoration Time. Conversely, bolstering traditionally significant facets like Inventory Management, Customer Service, ROI, Product Quality, Market Share, and On-Time Delivery doesn't manifestly expedite the resilience and recovery process.

3.7.3 The technologies moderation effect on resilience and indicators of performance

In this section, we look at the moderator effect of technologies on Time to Recovery and performance indicators to understand the impact of technologies on resilience and firm performance during the first wave of COVID-19. Table 13 displays the results.

Table 13 Technologies moderator effect

	Big Data and ML Moderator	Blockchain Moderator	AI Moderator	Drones Moderator	3D Printing Moderator	Mobile Apps Moderator	Social Networks Moderator
Time to recovery x moderator	-0.488	-0.056 **	-1.423 *	1.261 *	-2.583 *	0.374	0.254
Customer Service x moderator	0.004	0.178	-0.148	0.154 *	-0.470 *	0.638 **	0.387
Stock availability x moderator	0.2	0.266 **	0.314 **	0.636 *	1.684 **	-0.107	-0.277
Sales x moderator	-0.024	-0.437 *	-0.069	-1.038 *	-0.409 *	-0.396 ***	-0.016
ROI x moderator	0.015	0.136	0.129	0.821 *	-0.170	0.600 ***	0.187
Product Quality x moderator	0.002	0.727 *	0.841 **	-1.811 *	2.083 *	-0.432	-0.319
Market Share x moderator	-0.018	0.923	-0.164	0	-0.103	-0.935 **	0.411
On-Time Delivery x moderator	0.362	- 0.558	0.482 **	0	-0.076	0.383	- 0.187

* p-value < 0.1, ** p-value < 0.05, *** p-value < 0.01, • not significant.

According to the results, Big Data and Machine Learning are not effective in increasing firms' ability to restore their performance to pre-pandemic levels. Although the existing literature highlights the relevance of this technology, in the Italian sample we have analyzed, Big Data did not have a significant impact. This may be related to the unexpected challenges that emerge during a crisis and the companies need to collect new relevant data based on the ongoing situation to achieve efficient solutions. Similarly, the impact of the Mobile Apps on Time to Recovery is not significant. Indicating that Mobile App adoption is not a variable capable of moderating the relation between firms' resilience and performance indicators. Companies devise Mobile Apps based on the customers' current needs, which do not necessarily cover the new capabilities that customers require during the pandemic or other crises. Furthermore, Social Network does not have a significant impact on enhancing companies' ability to recover their business performance. Although firms can collect data and feedback from customers during the pandemic via Social Networks, it does not directly help to solve operational issues along the supply chain. For instance, the low quality may be related to losing some of the main suppliers during the disruption and the feedback from social networks cannot help find new suppliers for critical materials and it requires initiatives from the designers and managers to overcome the issues.

Blockchain technology has a significant impact on improving Time to Recovery through improving Sales and the restoration time is positively affected by the adoption of this technology. This result is based on the significant negative relationship between Sales and Time to Recovery. By using Blockchain technology, companies can unlock the full value of their datasets, activating a continuous flow of information that leads to better supply chain coordination. The benefits of exploiting the advantages of fostering more reliable data, and transforming these data into a sustainable competitive advantage, are reflected in final consumers and, consequently, in Market Share and Sales, which enable companies' resilience. However, blockchain has the opposite effect on Time to Recovery through Customer Service and Product Quality. These results are probably linked to the nature of Blockchain, which is not yet fully suitable for developing Customer Service as an

enabler of resilience. Additionally, Blockchain could not leverage the benefits of Product Quality robustness in the short run.

Moreover, the results show a positive impact of the adoption of 3D Printing on Time to Recovery through Stock Availability and Sales. Indeed, the implementation of 3D Printing technologies can support organizations in the areas of inventory and sales management, fostering the firms' capacity to manage Stock Availability and improve the Sales process. However, according to the results, this technology can hinder Time to Recovery if firms strive to cope with the disruption through Customer Service and Product Quality. In these cases, the adoption of 3D Printing technology has the potential to slow down the recovery process.

Furthermore, the analysis shows the overall positive impact of the adoption of AI in fostering a company's resilience. AI increases connectivity, transparency, and visibility enabling companies' flexibility. However, AI has a negative impact on Time to Recovery through focusing on variables such as Customer Service, Product Quality, and On-Time Delivery. This outcome is probably linked to consumers' expectations of quality, customization, and delivery efficiency, which have increased exponentially during the COVID-19 outbreak. Therefore, companies that decide to integrate AI into the production process to satisfy new customers' needs should consider the likely slowdown of their recovery time in case of disruptive events.

Finally, Table 4 shows that firms' resilience in terms of Time to recovery is negatively affected by the use of drones although this technology can have positive effects on the recovery time through Sales and Product Quality. This is related to its negative impact on the restoration time through Stock Availability, Customer Service, and ROI. Currently, organizations are not still exploiting the full potential of drones although they are effective in last-mile deliveries, warehouse management, and information collection. Therefore, companies should carefully assess this technology before adoption as it can worsen Time to Recovery if the company is targeting to enhance its resilience through improving its performance in indicators such as ROI.

3.7.4 A stochastic analysis of resilience and indicators of performance

In this section, we make use of Bayesian Networks (BNs) techniques to extract some additional information with respect to the traditional regression analysis, on how firms' resilience can be increased. Hereby, we also involve the digital technologies that firms adopt.

To run a BN, we define a procedure to identify the most important associations between performance risks, SC practices, and resilience. Besides establishing the links associated with the research questions, we also use ML techniques to detect some unknown relationships according to the following steps:

Step 1) Import the dataset in BayesiaLab 9.1 and discretize the continuous variables according to the OptRandom* algorithm, such that the constellation of nodes is composed of Y performance risks, and X SC practices, where:

Y{Quality, ROI, Delivery time, Customer Service, Efficiency, SC Visibility, Sales} and

X{All technologies and SC Practices}.

Afterwards, we only retain the technologies and the SC practices with a significant impact on the stochastic analysis.

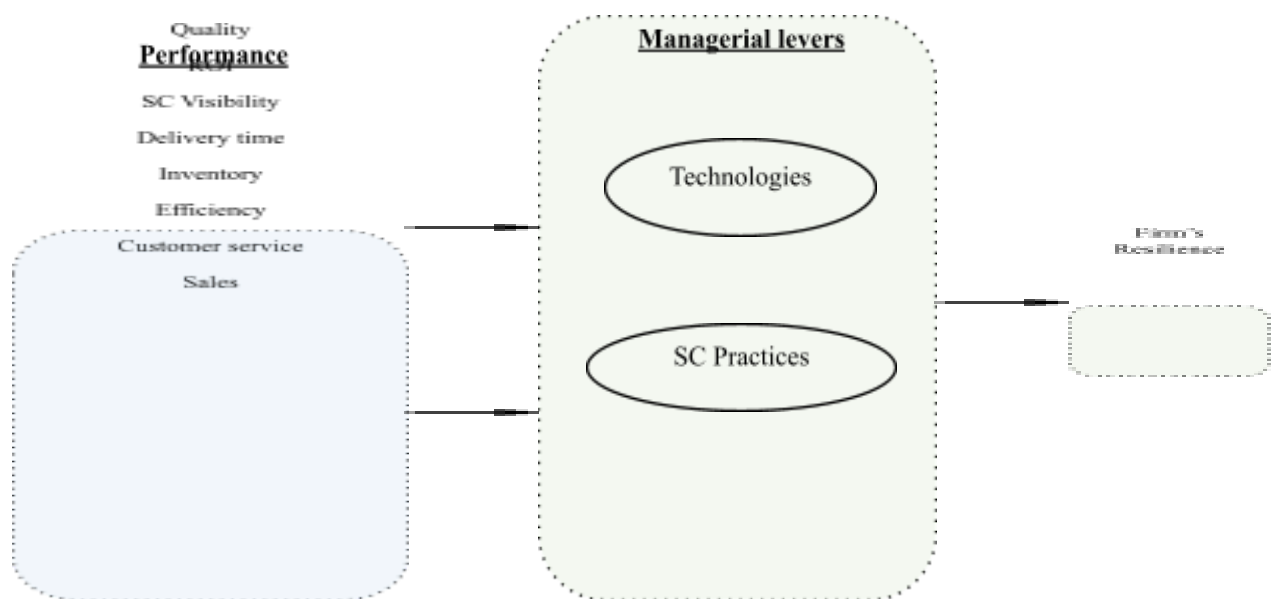
Step 2) Use the unsupervised ML algorithms available in BayesiaLab 9.1 to learn about the existence of other relationships. Select the best algorithm according to the Minimum Description Length (MDL), which evaluates all significant and unknown relationships and keeps the most relevant. Hence it is a measure of BN robustness.

Step 3) Run some perturbation tests to check BN robustness and identify the final BN version using the node force and the Kullback-Leibler index. These analyses and indices allow us to corroborate the output in Step 2, strengthening the evidence of the BN's robustness.

Step 4) Use hard evidence analyses to create two benchmark cases (very risky situation vs. no risky situation). This step allows us to create benchmarks composed of firms experiencing either high performance risks or no performance risks due to COVID-19.

Step 5) Use a marginal positive hard evidence analysis to learn from the BN and answer research questions 1- 4. We analyze changes in terms of mean and standard deviation, use the Wald test to check for significant variations, and report the log-loss function to show BN robustness.

Figure 36 Research design



3.7.5 Joint probability distributions and Bayesian networks

Starting from the whole research design as displayed in Figure 12, we retain only some of the SC practices and technologies that, from a stochastic point of view, showed significance. Therefore, we display the results of the joint probability distributions in Tables 13 and 14. The joint probability distribution for performance risks is displayed in Table 13, and the joint probability distribution for SC practices is presented in Table 14. Therefore, for example, $P(\text{Omnichannel}=1)=46.19\%$ signifies that the firms in our sample adopt Omnichannel with probability 46.19%, conditioned to the full network of relationships established in Figure 37, which is composed of performing quality with probability 52.94%,

the delivery time with probability 50.17%, supply chain visibility with probability 47.80%, etc. Instead, the joint probability for our sample firms to be resilient (e.g., recover within three months after the outbreak ends) corresponds to $P(\text{Resilient}=1)=43.45\%$. Therefore, while 49.58% is the prior probability that a firm is resilient, 43.45% is the probability that a firm is resilient conditioned to the network under investigation.

Table 13 Joint probability distribution for performance risks

	P(Y=1) (Non-risky performance)	P(Y=0) (Risky performance)
Quality (QL)	52.94%	47.06%
Delivery time (DT)	59.17%	40.83%
Supply Chain Visibility (SCV)	47.80%	52.20%
Sales (Sales)	53.78%	46.22%
Customer service (CS)	57.37%	42.63%
Inventory (Inv)	48.74%	51.26%
ROI (ROI)	65.55%	34.45%
Efficiency (Eff)	55%	45%

Table 14 Joint probability distribution for SC practices/strategies

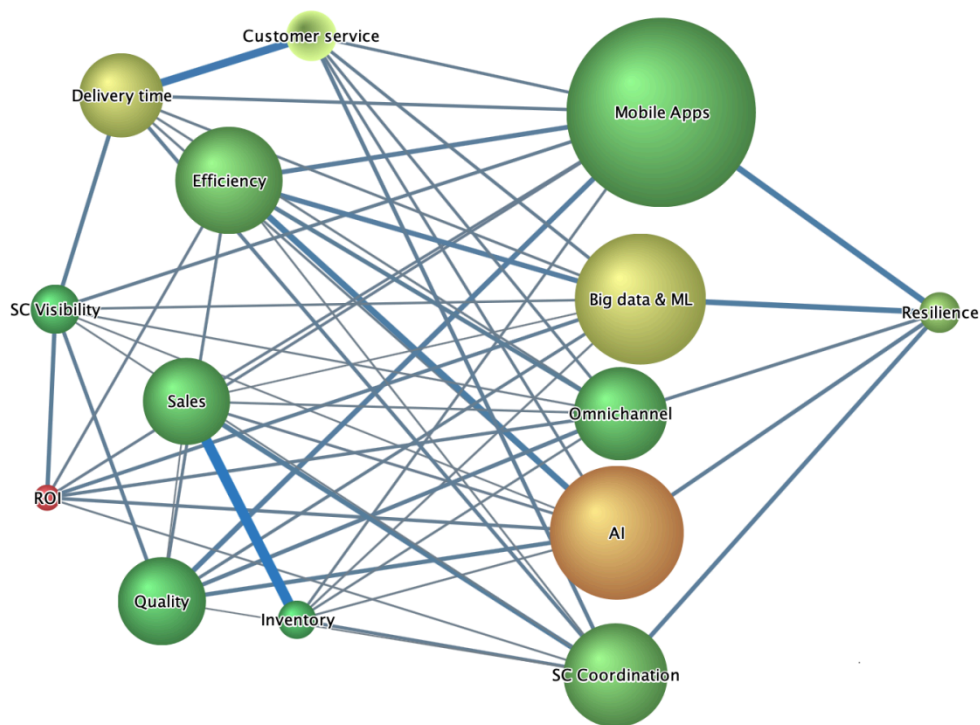
	P(X=1)	P(X=0)
Omnichannel (Omni)	46.19%	53.81%
Supply Chain Coordination (SCC)	55.09%	44.91%
Big Data & Machine Learning (BDML)	40.44%	59.56%
AI (AI)	55.09%	44.91%
Mobile Apps (Apps)	54.45%	45.55%

Running Steps 1-3 of the proposed procedure allows us to identify the final BN. Hereby, the BN displays the relationships linked to our research questions (dotted arcs), as well as new relationships discovered by the machine learning algorithm (continuous line arcs), exemplified by new links among performance risks. These arcs have been derived using the searching methods EQ (equivalent classes) and applying a post-processing taboo search algorithm. When using traditional, unsupervised techniques, the MDL is 5289.256 on average. Figure 38 reveals that the risks for delivery time and sales are the only two parent risk categories, for which a prior probability distribution exists. They generate a set of conditional probability distributions to the other performance risks, which become child risk categories.

Accordingly, we can observe that the probability of performing in inventory management is conditioned to the probability that firms can perform high sales even during the period of COVID-19. In fact, firms need to optimise their inventory when the sales are performed to a great extent. The high amount of inventory managed has an impact on the quality of goods, especially during COVID-19 when there is shortage of mobilized resources. Hereby, the firms are required to guarantee high levels of quality for the goods they have in stock independent of the pandemic. Furthermore, the probability that firms are able to perform the delivery lead time during the COVID-19 period ensures high consumer service, especially in a period during which people are in lockdown. Along with consumer service, the probability to perform the lead time impacts on the probability that the firms make goods at the original production cost, without being influenced by the consequences of the pandemic. This is most likely linked to the firms' ability not only to deliver to consumers without any delay but also to procure raw materials and goods following standard procedures even during the COVID-19 period. Moreover, the probability that firms perform both the delivery time and the quality is associated to a high probability of guarantee visibility over the supply chain, which reflects the firms' ability to make information on quality and delivery transparent and available over the supply chain, which translates into a high probability for firms to perform the ROI. The latter impacts efficiency, showing that the more firms are able to ensure financial and economic returns, the more they invest such returns to pursue efficiency through ad hoc actions (e.g., process innovation).

Finally, Figure 38 displays the statistical results associated with the BN. The force node represents the dimension of a node; therefore, the bigger a node, the higher its importance in the overall analysis. The thickness of an arc measures the Kullback-Leibler index; hence, the stronger the arc, the closer the difference between the original and the theoretical distributions. Finally, the color of each node corresponds to the entropy, which represents the expected amount of information conveyed by a node. The green color identifies high entropy, the yellow color corresponds to medium entropy, and the red color corresponds to low entropy.

Figure 38 Bayesian network on node force (size), Kullback-Leibler index (arcs), and Entropy (colors)



3.7.6 Performance and Omnichannel

Table 15 reports the analysis of the network of relationships linking performance risks with the adoption of omnichannel strategies. The findings that we obtain in this section are completely new with respect to the literature, which focused on how the adoption of omnichannel impacts business risks and performance (e.g., Grewal et al. (2017), Brynjolfsson et al. (2013), Hubner et al. (2016)). Instead, we perform a reverse analysis and seek to discover whether firms experiencing low-performance risks adopted omnichannel strategies during the first wave of the COVID-19 pandemic. Therefore, we can identify which performance risks drive firms toward the adoption of this SC practice. To achieve our research target, we use the positive hard evidence analysis on each performance risk, while keeping the distributions of the other risks at the benchmark level (the probability distributions displayed in Table 13).

Table 15 reports the Δ probability of adopting omnichannel, which corresponds to the increased probability of adopting omnichannel when firms enjoy low risks. For example, when the risk of inventory shortage is fully mitigated, e.g., $P(\text{Inv}=1)=1$, the probability that firms achieved this outcome by adopting omnichannel moved from 0.462 (see Table 15) to 0.484, with a variation of 0.022 (see Table 16), which is not statistically significant (low

t-value). Consequently, we can conclude that the goal of mitigating inventory shortage risks during the first wave of the COVID-19 pandemic did not push firms to a higher probability of adopting omnichannel strategies. Consequently, inventory shortage risks are not effective drivers to suggest that firms should adopt omnichannel strategies. In contrast, firms achieved that result by adopting other SC practices.

Interestingly, as displayed in Table 15, none of the probability of adopting omnichannel varied significantly according to the other performance risks. Therefore, we can conclude that when firms were able to mitigate the performance risks, the probability of adopting omnichannel strategies was not modified. Hence, firms enjoying a state of low-performance risks during COVID-19 have adopted other SC practices.

Finally, when checking the synergies among performance risks, we discover that the risks of decreasing sales, ROI, inventory, and quality, when occurring simultaneously, suggest the adoption of omnichannel strategies. When fixing $P(QL=1) = P(\text{Sales}=1) = P(\text{Inv}=1) = P(\text{ROI}=1) = 1$, we capture the synergistic effect among these performance risks and investigate whether firms' need to mitigate all of them simultaneously suggests the adoption of omnichannel. In fact, the probability of adopting omnichannel moved from 46.2% (see Table 14) with $P(QL=1) = 0.5294$, $P(\text{Sales}=1) = 0.5378$, $P(\text{Inv}=1) = 0.4874$, and $P(\text{ROI}=1) = 0.6555$ (see Table 15) to 63.1% when $P(QL=1) = P(\text{Sales}=1) = P(\text{Inv}=1) = P(\text{ROI}=1) = 1$, with a t-value=2.873 (p-value<0.05). Accordingly, firms should adopt omnichannel during events like the COVID-19 pandemic only when the risks of sales, ROI, inventory, and quality simultaneously impact the business model.

Table 15 Performance Risks and Omnichannel strategy

	Customer service	Delivery time	SC Visibility	Quality	Inventory	Sales	ROI	Efficiency
Δ	-0.017	-0.051	-0.047	0.056	0.022	0.034	0.04	-0.015
Probability of adopting Omnichannel								
t-value	0.373	1.165	1.04	-1.222	0.48	-0.6	-0.873	0.329
Result	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported
Log-loss function	0.8	0.76	0.76	0.92	1.04	0.89	0.62	0.86

*p-value<0.1, ** p-value<0.05, *** p-value<0.01, italic t-values are not statistically significant

Considering that the probability of adopting omnichannel is 46.2% with $P(QL=1)=0.5294$, $P(Sales=1)=0.5378$, $P(Inv=1)=0.4874$, and $P(ROI=1)=0.6555$, the improved probability 63.1% is obtained by adding all improvements linked to $P(QL=1)=P(Sales=1)=P(Inv=1)=P(ROI=1)=1$. These certain probabilities allow one to sum the probability 46.2% to all the Δ Probability resulting from Table 15 and linked to quality, sales, inventory, and ROI, which are given by 5.6%, 2.2%, 3.4% and 4%, respectively. The difference between 46.2% and 63.1% is significant only when these SC practices are considered all together. Note that computing the simple sum of probability can lead mislead the reader since $46.2\%+5.6\%+2.2\%+3.4\%+4\%=61.4\%$ is different from 63.1%. This difference depends on the joint probability distributions, which create synergies among the variables that have been considered and lead to an increased overall probability.

3.7.7 Performance Risks and Supply Chain Coordination

In this section, we analyze the impact that performance risks have on SC coordination. Our results are novel comparatively to the current literature since the major focus has been on how SC coordination influences SC risks and performance (e.g., Choi et al. (2020), Prekker and De Giovanni (2028), Qi et al. (2004)). In this research, we undertake a reverse approach by studying how the deterioration of performance has pushed firms to modify the supply chain contracts and agreements. Table 8 displays the chain of probabilities linking performance risks to SC coordination. The outcomes in Table 8 allow us to answer RQ2 and then identify the performance risks that drove the changes in the contractual agreements among SC members during the first wave of the COVID-19 pandemic. Hence, the Δ Probability of adopting SC Coordination links to the SC members' availability to consider the challenges induced by COVID-19 to adjust the contractual terms, clauses, and deadlines, when mitigating the performance risks.

Our results suggest that firms which mitigated the risks of low quality, inventory shortage, and sales reduction during the first wave of COVID-19 have most likely pursued SC coordination. The highest contribution to this result is given by the mitigation of inventory shortage risks, addressing the strong relationships that exist between an effective inventory management system and an effective SC. The COVID-19 pandemic brought many issues surrounding goods production and delivery due to lockdowns and restrictions to people's mobility, contributing to the risks of inventory shortages around the globe. Firms that realized the importance of this risk have adjusted and negotiated their contract agreements to manage the exceptions imposed by COVID-19. In fact, the probability of adopting SC coordination shows a significant increase of 32.2% with a $t\text{-value}=5.771$ ($p\text{-value}<0.01$).

Furthermore, firms that removed sales risks during the first wave of COVID-19 activated SC coordination mechanisms. The risk of low sales has been the most serious risk that firms faced during the pandemic since sales represent the financial inflow to guarantee the normal prosecution of business affairs. When firms changed their behavior and strategies to mitigate sales risks, SC coordination was most likely adopted. Therefore, the SC members' commitment to supporting sales development and bypassing the related risks led firms to adopt and conform to contract terms according to COVID-19's threats. This result is supported by an increase in the probability of embracing SC coordination of 31.6%, with a $t\text{-value}=5.722$ ($p\text{-value}<0.01$).

Our results show that the need to guarantee product quality and diminish the risks of non-conformance or defective goods pushed firms to adopt SC coordination. The probability of seeking out this SC practice increases by 13.1%, with a $t\text{-value}=2.31$ ($p\text{-value}<0.05$), demonstrating firms' efforts to ensure product quality, even during the COVID-19 pandemic, by following the idea that quality links to customer satisfaction and retention, even during outbreak periods. The occurrence of contractual changes can be linked to quality inspections and controls, contribution to quality management, incentives and certifications to perform high-quality standards during COVID-19, and the practice of carrying out operations in COVID-free circumstances and environments.

Finally, we observe that firms that wished to mitigate the risks of inventory shortage, loss of sales, and product quality have been driven by SC coordination. Our results suggest that,

on average, firms' probability of managing the disruptions due to COVID-19 through SC coordination was 55.09% (see Table 16). When firms enjoyed the mitigation of risks for inventory shortage, loss of sales, and product quality, the probability of employing SC coordination increased to 93.75% with a t -value=4.746 (p -value<0.001), by exploiting the synergistic effect of the conditional probability distributions. That is, the original joint probability that firms adopt SC Coordination was 55.09%, given that the probability of performing sales, quality, and inventory are 53.78%, 52.94%, and 48.74%, respectively. Through a what-if analysis we discover that when the joint probability distributions of performing sales, quality, and inventory become 100%, the probability of adopting SC coordination goes to 93.75%. In contrast, the other performance risks linked to delivery time, supply chain visibility, customer service, ROI, and efficiency do not have any impact on the probability of adopting SC coordination.

Accordingly, the firms' goal of softening this tripartite of risks pushes the SC to revise the contractual agreements and terms to accommodate the COVID-19 challenges. In contrast, removing the risks linked to customer service, delivery time, SC visibility, ROI, and efficiency requires firms to abandon the idea of pursuing SC coordination. At most, they can complement firms' wishes to undertake SC coordination.

Table 16 Performance Risks and Supply Chain Coordination

	Customer service	Delivery time	SC Visibility	Quality	Inventory	Sales	ROI	Efficiency
The probability of adopting SC coordination	0.030	0.018	0.039	0.131	0.322	0.316	0.0008	0.049
t-value	-1.549	-1.278	0.421	2.31**	-5.771***	-5.722***	-1.054	0.196
Result	Not supported	Not supported	Not supported	Supported	Supported	Supported	Not supported	Not supported
Log-loss function	0.8	0.76	1.07	0.92	1.04	0.89	0.61	0.86

p-value<0.1, ** p-value<0.05, *** p-value<0.01, italic t-values are not statistically significant

3.7.8 Performance and Technologies

In this section, we explain our results relative to the links between performance risks and digital technologies. Hence, the results are completely new with respect to the literature

that focuses on the impact of digital technologies on risks and performance (e.g., De Giovanni, 2022). Rather, our investigation seeks to discover which performance risks have pushed firms to adopt big data & ML, AI, and mobile apps during the first wave of the COVID-19 pandemic to recover the performance lost.

Table 17 Performance Risks and Big Data & Machine Learning

	Customer service	Delivery time	SC Visibility	Quality	Inventory	Sales	ROI	Efficiency
Δ								
Probability of adopting Bid data & ML	0.012	0.015	0.051	0.052	0.030	0.05	-0.098	0.051
t-value	-0.262	-0.305	1.178	-1.185	0.785	-1.172	2.319**	-1.175
Result	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Supported with opposite sign	Not supported
Log-loss function	0.8	0.76	1.07	0.92	1.04	0.91	0.61	0.86

*p-value<0.1, ** p-value<0.05, *** p-value<0.01, italic values are not statistically significant

Table 17 reports the first analysis of the performance risks and the adoption of big data and ML. Accordingly, most of the performance risks that we analyzed did not push firms to invest in big data and ML during the COVID-19 pandemic. While the adoption of big data & ML has been lauded by the literature during normal periods, the challenges imposed by COVID-19 push firms to look for alternative SC practices and options when they seek to mitigate performance risks. Within our analysis, the only significant Δ Probability of adopting big data and ML links to the risks of decreasing ROI. Interestingly, firms that got rid of the risks associated with ROI during the COVID-19 pandemic showed a lower interest in investing in big data and ML. The probability that firms adopted this digital technology moves from 0.4044 (see Table 15) with $P(ROI=1)=0.6555$ (see Table 15) to 0.306 when $P(ROI=1)=1$, with a significant negative difference (p -value<0.05). Accordingly, firms targeting the low risks of losing ROI abandoned the idea of investing in big data & ML during the first wave of COVID-19 and pursued other types of investments.

Finally, we analyze the synergistic effects among performance risks to verify the existence of some clusters of risk that suggest the adoption of big data & ML. The analysis of joint conditional probability distributions indicates that the simultaneous presence of risks linked to customer service, delivery time, SC visibility, and quality leads decision makers to adopt big data & ML. When fixing the positive hard evidence to $P(QL=1)= P(DT=1)=$

$P(SCV=1) = P(CS=1) = 1$, the adoption of big data & ML becomes highly probable. In fact, the probability of adopting this digital technology moves from 40.4% to 59.1% with a t -value=3.121 (p -value<0.01). Accordingly, the simultaneous presence of quality risk, delivery time risk, SC visibility risk, and customer service risk pushes firms to adopt big data & ML.

Table 18 Performance Risks and AI

	Customer service	Delivery time	SC Visibility	Quality	Inventory	Sales	ROI	Efficiency
Δ Probability of adopting AI	0.012	0.015	0.051	0.052	0.030	0.050	0.049	0.050
t-value	0.815	1.122	1.469	-1.182	0.699	-0.981	-1.011	1.391
Result	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported	Not supported
Log-loss function	0.8	0.76	0.76	0.92	1.04	0.89	0.62	0.86

* p -value<0.1, ** p -value<0.05, *** p -value<0.01, italic values are not statistically significant

We report the Δ Probability of adopting AI in Table 18, which links to the increased probability of adopting AI during the COVID-19 pandemic when firms enjoy low risks. Unfortunately, as for omnichannel, none of the firms adopting AI were motivated by the need to reduce some risks for the performance under investigation. Hence, we can summarize the findings by saying that when firms mitigated the performance risks, the probability of investing in AI remained unvaried. Therefore, firms reaching the state of low risks for the entire batch of performance under investigation during the first wave of COVID-19 adopted alternative SC practices to achieve that target.

However, the analysis of the joint probability distributions linked to the performance risks reveals that the joint effects of customer service, delivery time, ROI, quality, sales, and inventory can push firms to adopt AI systems. When fixing the positive hard evidence, such as $P(QL=1) = P(DT=1) = P(ROI=1) = P(CS=1) = P(Sales=1) = P(Inv=1) = 1$, the probability of adopting AI systems goes from 55.09% (see Table 19) with $P(QL=1) = 0.5294$, $P(Sales=1) = 0.5378$, $P(Inv=1) = 0.4874$, $P(CS=1) = 0.5737$, and $P(ROI=1) = 0.6555$ (see Table 19) to 57.3% when $P(QL=1) = P(DT=1) = P(ROI=1) = P(CS=1) = P(Sales=1) = P(Inv=1) = 1$, with a t -value=3.135 (p -value<0.01). Accordingly, firms are pushed to adopt AI systems when the

risks for customer service, delivery time, ROI, quality, sales, and inventory occur at the same time.

Table 19 displays firms' willingness to adopt mobile apps to reach a state of low performance risks. Hereby, we show whether firms mitigating performance risks during the COVID-19 pandemic have most commonly adopted mobile apps. In contrast to the other SC practices, the use of mobile apps has been demonstrated to be very effective, as it links to the wishes of avoiding several types of risk.

Table 19 Performance Risks and Mobile Apps

	Customer service	Delivery time	SC Visibility	Quality	Inventory	Sales	ROI	Efficiency
Δ								
Probability of adopting Mobile Apps	0.156	0.177	0.192	0.193	0.065	0.066	0.032	-0.107
t-value	-3.716***	-4.31***	-4.749***	-4.81***	-1.475	-1.498	-0.793	2.331**
Result	Supported	Supported	Supported	Supported	Not supported	Not supported	Not supported	Supported with an opposite sign
Log-loss function			1.07	0.707				

*p-value<0.1, ** p-value<0.05, *** p-value<0.01, italic t-values are not statistically significant

The Δ Probability of adopting mobile apps changes significantly when firms face the problem of customer service risks. In fact, the probability goes from 54.45% (see Table 14) to 70% when $P(CS=1)=1$ with a t-value=-3.716 (with p-value<0.01). Unlike other digital technologies, the use of mobile apps during the COVID-19 pandemic represented a true possibility for firms to directly link to consumers by offering promotions, showing availabilities, proposing services, granting a different consumer experience, and offering new ways to approach the finalization of purchasing. Indeed, the COVID-19 outbreak forced firms and consumers to adopt and use mobile apps daily, with the result of speeding up their adoption. However, mobile apps target a great and unique personal shopping experience and offer more value than a simple online shopping experience that guarantees social distancing.

The Δ Probability of adopting mobile apps also changes significantly when firms experience delivery time risks. Hereby, starting from a probability of adopting mobile apps of 54.45%, firms' wishes to mitigate the delivery time risk exemplified by $P(DT=1)=1$ brings

the probability of adopting mobile apps to 72.1%, with an increase of 17.7% and a $t\text{-value}=-4.31$, which is statistically significant ($p\text{-value}<0.01$). Both customers and employees can connect and have seamless experiences. Customers do not need to call the store and check whether the goods have arrived. Rather, they receive news and updates directly from the apps. The stores take advantage of the apps by knowing when consumers are on their way and estimating when they will arrive. The app alerts employees to bring the order for contactless delivery, which is very useful during COVID-19 to guarantee social distancing. Therefore, firms seeking to mitigate delivery time risks can easily achieve that target by integrating mobile apps with the business model.

This result links to firms' commitment toward SC visibility. In fact, our results demonstrate that the Δ Probability of adopting mobile apps increases when firms experience SC visibility risks. Hereby, starting from a probability of adopting mobile apps of 54.45% with $P(\text{SCV}=1)=0.4780$, the goal of removing the risks associated with SC visibility, given by $P(\text{SCV}=1)=1$, brings the probability of adopting mobile apps to 73.6%, which corresponds to a variation of 19.2% that is statistically significant, with a $t\text{-value}= 4.749$ ($p\text{-value}<0.001$). In fact, Starting from a joint probability of 54.45% when $P(\text{CS}=1)=0.5337$, the probability becomes 70% when firms surely perform consumer service, that is, $P(\text{CS}=1)=1$.

By using the mobile apps, the entire network of stores and suppliers undertook new tasks and responsibilities during the first wave of the COVID-19 pandemic, exemplified by controlling production and store capacity, including countless constraints in the optimization models to guarantee social distancing, tracking goods across countries and various distribution centers, track customers across multiple store entrances and exits, analyze queues of customers and deliveries to monitor the exact moment when actions and strategies could be initiated, and receive feedback and information from consumers and suppliers worldwide. All of these advantages contribute to creating full knowledge regarding what the eco-system experiences during outbreak periods, creating diffused information to be used for enhancing SC visibility and making sure to access and manage all information related to orders, physical and virtual goods, and shipments across the entire SC. Hence, firms seeking to mitigate any interruption of the knowledge creation and diffusion process concretized through SC visibility are inclined to adopt mobile apps.

As displayed in Table 11, firms seek to adopt mobile apps when the risk of non-conforming or defective items exists. Our results show that the Δ Probability of adopting mobile apps increases when firms seek to mitigate quality risks, with a positive variation of 19.3% with a t -value=-4.81 (p -value<0.001), which occurs when $P(QL=1)=1$. In other words, firms that got rid of quality risks during the first wave of the COVID-19 pandemic have most likely accomplished this through the adoption of mobile apps. The use of this digital technology allows each supplier along the SC to demonstrate how the business functions, the operational practices that have been adopted and implemented, and how the logistics activities have been carried out regarding the entire SC journey. By demonstrating all of these features, firms ensure their loyalty and trust and guarantee high product quality. Mobile apps can shed light in this direction and can be adopted by all firms dealing with quality issues and risks during the COVID-19 pandemic.

Note that the Δ Probability of adopting mobile apps decreases when firms remove the efficiency risks, with a negative variation of 10.7% with a t -value=2.331 (p -value<0.05), which occurs when $P(Eff=1)=1$. This result can be linked to the activation of atypical processes to guarantee the correct adoption and use of mobile apps, which require investments for both development and implementation, changes in consumers' habits and purchasing behavior, and maintenance and upgrade costs. Therefore, during the first wave of COVID-19, firms experiencing a high risk of increasing production costs were less prone to adopt mobile apps. Rather, they focused on other SC practices to achieve this target. Similarly, firms did not use mobile apps when seeking to mitigate the risks of high inventory, as well as sales and ROI reduction, since these are all consequences not fully manageable through mobile apps exclusively during a disruptive period like the COVID-19 outbreak.

Surely, firms that aimed at getting rid of customer service risks, delivery time risks, SC visibility risks, and product quality risks during the first wave of the COVID-19 pandemic have adopted mobile apps in 86% of the cases. Therefore, firms aiming at better simultaneously controlling these four risks are pushed to adopt mobile apps. All other risks are then secondary and contribute to creating more challenges for firms.

3.7.9 Managerial levers and resilience

This section seeks to discover how the adoption of managerial levers can guarantee resilience. In this research, resilience is measured as a firm's capacity to recover its business volume and affairs after the first wave of the COVID-19 pandemic. Our results, which are displayed in Table 20, demonstrate that firms can increase their probability of being highly resilient when adopting omnichannel, SC coordination, AI, and mobile apps. Each of these options offers a great contribution to the firm's resilience. Starting from the probability to be resilient of 43.45% when, according to Table 20, the joint probability distribution for the SC practices is $P(\text{Omni}=1)=0.4619$, $P(\text{SCC}=1)=0.5509$, $P(\text{BDML}=1)=0.4044$, $P(\text{AI}=1)=0.5509$, and $P(\text{Apps}=1)=0.4554$. As done before, we will investigate how the probability of being resilient changes when firms surely adopt the proposed SC practices.

The sure adoption of omnichannel implies a higher probability for firms to be resilient. The Δ Probability of being resilient has a positive variation of 13.9%, with a $t\text{-value}=-3.109$ ($p\text{-value}<0.001$). This is in line with previous research investigating the positive effect of omnichannel on the firms' resilience addressing the question through empirical approaches (e.g., Roggeveen and Sethuraman, 2021; Trabucco, 2022; Briedis et al., 2020). Differently from previous research, our stochastic approach shows the extent to which firms can improve their resilience when relying on omnichannel, that is: the certain use of omnichannel will allow firms to increase their resilience by 13.9%.

Similarly, as it emerges from Table 20, SC coordination helps firms to be more resilient, thanks to the positive commitments of suppliers in adjusting contract clauses, terms, and agreements to accommodate the challenges attributable to COVID-19. The Δ Probability of being resilient has a positive variation of 15%, with a $t\text{-value}=-3.341$ ($p\text{-value}<0.001$), when firms adopt ad-hoc coordination mechanisms to address COVID issues. This result is in line with the literature that sponsors SC coordination to increase the level of resilience (e.g., Lohmer et al., 2020). However, as explained by Lohmer et al. (2020), there is a need to quantify the resilience that firms and supply chains gain when undertaking specific actions, to better align the strategic objectives with the SC requirements. Our contribution moves in this direction. By adopting a what-if analysis we can demonstrate that firms surely adjusting the SC contractual terms and agreements to face the COVID-19 challenges can increase the resilience by 15%; therefore, by aligning the SC relationships

and commitments to the general pandemic situation, firms will be able to recover the performance lost during the COVID-19 in less than three months.

Table 20 Supply Chain Practices and Resilience

	Omnichannel	SC	Big Data & ML	AI	Mobile Apps
	I	Coordination			
Probability of being resilient	0.139	0.150	-0.057	0.103	0.153
t-value	-3.109***	-3.341***	-1.237	-2.252**	-3.392***
Result	Supported	Supported	Not supported	Supported	Supported
Log-loss function	1.1	0.86	1.31	1.45	0.88

*p-value<0.1, ** p-value<0.05, *** p-value<0.01, italic t-values are not statistically significant

In terms of digital technologies, the adoption of AI allows firms to increase their probability of being resilient by 10.3%, with a t-value=2.252 (p-value<0.05), by exploiting the predictive capacity of such systems. This result contrasts with the findings by De Giovanni (2021a), which show that the adoption of AI and related smart SC can have a negative effect on the firms' capacity to recover profits due to uncertain events when their amplitude is very high; in fact, AI needs to be supported by other technologies as it may be not sufficient. Differently, our results suggest to firms the implementation of AI to be more resilient after COVID-19. Then, we increase the body of knowledge in this domain by adopting a stochastic approach that allows us to estimate the amplitude of resilience improvements that firms may acquire by evaluating the probability that AI is in place. Specifically, the probability of implementing AI can lead to a resilience improvement of 10.3%.

Furthermore, mobile apps substantially contribute to firm resilience by increasing the probability of performing resilience by 15.3%, with a t-value=3.392 (p-value<0.001). The general positive link existing between the firms' resilience and the adoption of mobile apps during COVID-19 has been empirically demonstrated in several empirical research (e.g., Trabucco, 2022). Beyond confirming these results, our findings contribute to the body

of knowledge by showing that firms can be resilient even without adopting mobile apps. However, the sure adoption of mobile apps gives the opportunity to increase the resilience of 15.3%, by ensuring a direct connection with consumers and a continuous interface with them.

Overall, the sure adoption of omnichannel, SC coordination, AI, and mobile apps constitute a portfolio of SC practices designed to increase firms' probability of being resilient, which signifies recovering in less than three months after the first wave of coronavirus in this research. As displayed in Table 20, our results demonstrate that the probability of being resilient rises from 43.45% to 89.9% (with a p -value <0.001), which suggests that the synergies among omnichannel, SC coordination, AI, and mobile apps can provide a great opportunity for firms to quickly re-establish their business volumes and affairs after a disruption event like the COVID-19 pandemic.

Finally, the results displayed in Table 20 show that the use of big data and machine learning techniques is not suitable for improving the firms' resilience. In fact, the change in the probability of recovery within three months after the pandemic is not significant. These findings contrast with the literature (e.g., Papadopoulos et al., 2017) probably because the first wave of COVID-19 was too disruptive to make big data and machine learning beneficial.

4. Conclusions

This report provides a great overview of the sustainability practices undertaken by Italian companies, along with resiliency practices, performance, technologies, supply chain practices and relationships. The comprehensive analysis of the GRI standards adoption among Italian companies offers a multifaceted view of the current landscape of corporate sustainability reporting. Across the economic, environmental, and social dimensions, the variation in the implementation of these standards is notable, reflecting the complexities and challenges faced by businesses in integrating sustainability into their core operations.

Beginning with the economic indicators, it becomes apparent that Italian companies exhibit limited disclosure on several aspects including market presence, economic performance, and indirect economic impacts. This restrained approach to reporting can be attributed to various factors, such as constrained resources, the absence of a standardized framework for reporting, and a predominant focus on short-term profitability over long-term sustainability goals. Moreover, the intricacies of reporting on procurement practices, anti-corruption measures, anti-competitive behaviour, and tax practices add to the challenges faced by these companies. This lack of comprehensive disclosure signifies a need for a more robust commitment to transparency and the adoption of standardized reporting mechanisms.

In the environmental domain, there is a discernible effort by companies to adopt these practices, yet the complete integration of these standards remains elusive for a significant number. Challenges in this area stem from complexities in sourcing recycled materials, managing energy efficiently, and handling waste effectively. These challenges are not merely operational but also strategic, reflecting a need for a holistic approach to environmental stewardship that goes beyond mere compliance.

The social indicators present a mixed level of reporting, with some areas like occupational health and safety, and training and education witnessing higher disclosure rates. However, this is juxtaposed with lower levels of reporting in areas like the rights of indigenous people, child labor, and socio-economic compliance. This disparity suggests

that while some companies are making strides in certain areas of social responsibility, there is still significant room for improvement in others.

When comparing the adoption of GRI practices between SMEs and larger corporations, a disparity is evident. Larger corporations tend to have more advanced GRI reporting practices, attributed to their greater resources, higher public scrutiny, and complex regulatory requirements. SMEs, despite facing challenges like limited resources and lack of expertise, are progressively adopting GRI practices, driven by motivations to enhance market reputation and operational efficiency.

The analysis further reveals that Leaders generally have higher mean values and standard deviations in economic indicators, suggesting more mature but variable reporting practices in areas such as procurement, anti-corruption, and anti-competitive behavior. This variability indicates a robust commitment to these standards among Leaders but also points to significant differences in how these standards are applied across different organizations.

In the environmental standards domain, Leaders consistently demonstrate higher mean scores, underlining their strong commitment to environmental stewardship. This commitment is particularly evident in areas such as energy, water, effluents, biodiversity, emissions control, and waste management. The social standards also see Leaders scoring higher overall, with marked differences in areas like employment, labor relations, occupational health and safety, and diversity. These differences reflect a more pronounced focus on workforce welfare, training, and social responsibility among Leaders.

Statistical test, Pearson Chi-Square, underscores significant differences between SMEs and Leaders in multiple GRI standards. These differences highlight a higher level of commitment and consistency among Leaders in implementing and reporting sustainable practices, especially in areas like anti-corruption, emissions control, labor relations, and human rights assessment.

When examining the correlation between various GRI practices, a significant relationship is observed, suggesting that companies often integrate multiple aspects of sustainability into their operations. For instance, a strong correlation between Supplier Environmental

Assessment and Supplier Social Assessment indicates an integrated approach to evaluating suppliers. This correlation underscores the interconnected nature of different sustainability aspects and the need for a comprehensive approach to sustainability reporting.

The sector-specific analysis of GRI practices adoption in Italy further illuminates the landscape. In the Agri-food sector, the focus is notably on Occupational Health and Safety and Anti-corruption, yet less emphasis is placed on the Rights of Indigenous People and Sustainable Land Use. The Education sector shows a strong emphasis on Occupational Health & Safety and Diversity and Equal opportunities but pays minimal attention to Child Labor and Forced or Compulsory labor. The Engineering sector is characterized by a substantial emphasis on Occupational Health and Safety and Diversity and Equal Opportunities but shows a limited focus on Local communities. Similarly, in the Financial sector, there is a robust focus on Diversity and Equal opportunities and Human Rights assessment, but less attention is given to Marketing and labelling.

The Healthcare sector places significant importance on Customer Health and safety and Occupational Health and Safety, coupled with a high adoption rate for Anti-corruption, yet shows limited attention to the Rights of indigenous people. In the ICT sector, the emphasis is on Occupational Health and Safety, Anti-corruption, and Diversity and Equal opportunities, but less on Local communities and Biodiversity. The Manufacturing sector demonstrates significant emphasis on Occupational Health and Safety and Anti-corruption, with a notable focus on Diversity and Equal opportunities, but less on Biodiversity. Lastly, the Service sector shows strong emphasis on Occupational Health & Safety and Customer Health & Safety, but limited focus on Biodiversity and Forced or Compulsory labor.

The analysis highlights varying priorities and approaches across sectors, with each sector demonstrating unique strengths and areas for improvement in their sustainability practices. This sectoral variation underscores the need for tailored approaches to sustainability that address the specific challenges and opportunities present in each sector.

An additional analysis of this report focuses on the relationship between sustainability practices and the GRI Framework. We summarize and provide a comprehensive list of sustainability practices, as correlated with GRI standards. The analysis underscores the importance of sustainability practices across different business areas, from market diversification and renewable energy investment to environmental initiatives like biodegradable packaging. Each of these practices, when aligned with GRI standards, contributes to a holistic and comprehensive approach to sustainability. This approach is vital for businesses looking to enhance their sustainability performance and report their progress effectively.

Moreover, the case studies of companies like Intel, Google, IKEA, and Nestlé provide insights into the diverse ways sustainability can be integrated into business operations. These examples reflect how sustainability initiatives, ranging from water conservation and carbon footprint reduction to renewable energy and community engagement, can be effectively aligned with GRI standards. This alignment not only facilitates structured and effective reporting but also demonstrates a company's commitment to sustainability.

The relationship between supply chain sustainability and resilience, as analyzed through the application of GRI standards, offers critical insights into the current state of corporate sustainability in Italy. The study highlights a clear disparity in resilience between SMEs and larger corporations, with the latter typically exhibiting superior performance in various sustainability dimensions. This gap underscores the resource and capability differences between these entities, emphasizing the greater access to resources, advanced technologies, and strategic foresight that larger corporations possess. Leaders generally demonstrate a higher commitment to incorporating sustainability into their operations, as evidenced by their higher resilience scores across most sectors, notably in areas like anti-corruption measures and advanced technological integration.

However, the analysis also reveals that both SMEs and Leaders exhibit similar trends in their resilience strengths and weaknesses, suggesting that the fundamental challenges in sustainability and resilience are consistent across businesses of different sizes. This points to a universal need for more robust sustainability frameworks and practices that transcend the scale of operations. The use of Sankey diagrams further elucidates how

specific GRI standards impact overall resilience, offering valuable insights into the interconnected nature of sustainability practices.

Along with a comprehensive analysis of the environmental initiatives, a deeper investigation of the can be done by analyzing the indicators of performance and the resilience. Today, governments, societies, and companies are facing various types of disruptions as frontiers that can adversely affect people's daily lives and business performance. The recent disruptions like COVID-19, economic crises, and the emergence of new technologies intensified firms to invest more in improving their resilience performance compared to the past. The main reason is related to the changes that disruptions cause at an accelerated pace by affecting customer preferences, material and stock availability, distribution systems, and other operations along the whole value chain. This report studies the impact of COVID-19 as a recent disruptive event on different performance indicators to offer new insights related to the multifaceted challenges during unexpected events. The results of the report help policymakers, managers, and researchers to understand the adaption strategies to overcome the unprecedented challenges as well as the vulnerabilities of firms. So, the results of this report will be helpful in devising new strategies to reshape the supply chain and networks to reach a more resilient structure for confronting future unexpected disruptions.

To reach this goal, we use a sample consisting of 525 Italian companies collected through interviews after the first wave of COVID-19. We analyze this sample to find out more about the capacity of firms to overcome challenges and maintain their performance level during the disruption. Moreover, analyzing this sample provides insights into the main managerial practices adopted by firms to face disruptions besides clarifying their investments in sustainable practices and resilience in terms of time-to-recovery. Accordingly, we focus on five managerial practices including support from the supply chain partners through financial and commercial aids, adjustment of contractual terms, and support for consumers by reducing prices and offering more promotions and deals. Moreover, we discuss seven different performance indicators consisting of stock availability, customer service, sales, ROI, product quality, market share, and on-time delivery. Besides, we analyze the adoption of nine technologies by the firms that are big

data and machine learning, blockchain, artificial intelligence, drones, 3D printing, mobile apps, social networks, call centers, and Omni-channel. In addition, we provide further analysis regarding sustainable practices such as investment in green technologies, investment in green practices, and investment in green packaging. We summarize the main outputs of this report as follows:

- Among the managerial practices, Italian companies were not successful in being beneficiaries of support from their partners through commercial and financial aid. The analysis shows only 19.42% and 20.19% of the cases were able to ensure the proposed practices respectively. Moreover, the high standard deviations of using these practices indicate a meaningful variation among companies in accessing commercial and financial aid. This is related to various factors like the nature of business relationships, the capacity of partners, market dynamics, and specific strategies employed during the pandemic. Moreover, Italian companies had a low performance (28% of the cases) in implementing the practice of "supporting the consumers by reducing the prices over the supply chain" with a high standard deviation. Therefore, the major parts of the companies were not able to provide price relief to potentially impact maintaining demand and sustaining market activity.
- Italian companies had a better performance in practices "adjustments of contractual terms from the supply chain partners" and "supporting the consumers by offering more promotions and deals over the supply chain" compared to other managerial practices. However, they were not successful in achieving contractual adjustments with their partners and only 33% of the cases were able to ensure this practice. Besides, although they had a relatively moderate level of success (44.76% of the cases) in supporting the consumers through promotions and deals over the supply chain, the high standard deviation (49.78%) reveals the complex challenges and difficulties in adapting to disruptions in the supply chains and providing promotions aligned with the emerging needs and preferences of consumers.
- In terms of performance indicators, Italian companies were able to successfully maintain the quality level of the products and their market position (93.54% and 90.91% of the cases respectively) during the disruption period with a low standard

deviation in the sample. This indicates their strong commitment to ensuring customer satisfaction by delivering high-quality products and adapting themselves to the new market conditions using proper business strategies. Moreover, the sample analysis shows that Italian companies were successful in implementing approaches to ensure on-time delivery, customer service, stock availability, and ROI in 85.02%, 83.01%, 82.33%, and 79.49% of the cases respectively. However, the standard deviation of these indicators is higher compared to indexes like product quality and market share which indicates a variety of desperation among them regarding the proposed indicators. Furthermore, despite having a good performance in some of the indicators, only 66.42% of the cases could maintain their sales and the high standard deviation (30.21%) indicates a significant variation in their sales performance. This shows that disruption can adversely affect the demand rates and companies are not agile to provide new products and services based on the new conditions to compensate for the lost demand.

- There is a significant relationship between the indicator “sales” and the managerial practice “support partners through financial aids” emphasizing on this point that strong sales gains increased credibility and the company will have more chance to receive financial assistance from the stakeholders. However, reliance on the partners may cause some negative impacts on the decision-making autonomy of the firms and it is crucial to make a balance between leveraging support and maintaining financial autonomy. In addition, there is a significant relationship between supporting customers with reduced prices and sales. Reducing prices may lead to more demand but it also may cause shortages, decreasing customer service, and increasing on-time delivery. Moreover, appealing promotions and captivating deals drive sales. However, companies had difficulties in developing proper systems to manage the sudden demand fluctuations due to promotional offerings which negatively affected customer experience.
- Among the new technologies, social networks, mobile apps, and omni-channels have the highest rate of adoption (53%, 24%, and 23% of cases respectively). During the pandemic, the social network was a valuable contact point between

customers and companies to apply communication strategies but it is vital to take into account the possibility of receiving fake information. However, the analysis indicates that there is no significant relationship between social networks and recovery time. Mobile apps are more responsive compared to websites which makes it possible for the companies to manage the increment of online traffic during the crisis. They are also helpful for data collection and analysis to provide personalized and high-quality services to customers according to new conditions. Our data analysis indicates although mobile apps are useful for increasing customer services there is no significant relationship between this technology and resilience in terms of time to recovery. Omni-channel was a competitive advantage for the companies when the physical stores were forced to be closed. However, not all the companies were successful in managing the online channels as they became overwhelmed with the increment of the online users during the pandemic. Furthermore, despite that our data analysis reveals the positive impact of implementing technologies like blockchain, AI, and 3D printing on improving recovery time, the majority of the companies in our sample were not interested in using these technologies. The reason may be related to the type of their business, implementation cost, and lack of knowledge to adopt them along their supply chain.

- Our data analysis shows that investment in green technologies, green packaging, and green practices was not significant (43%, 7%, and 3% of the sample respectively). Companies need to invest more in these green projects as during the crises lack of these types of practices may adversely affect their sustainability performance. For instance, during the pandemic, people preferred to drive their personal cars instead of using public transportation. In that case, public electric sharing vehicles besides using drones and electric delivery cars for last-mile delivery services could mitigate CO2 emissions. In addition, the increment in online shopping increases the use of product packaging and green packaging strategies are vital to prevent harmful environmental impacts.
- Analyzing the firms' resilience in terms of time to recovery indicates that 49.58% of the cases can recover in less than 3 months, 46.22% of the cases can recover in

less than 6 months (46.22%), 3.36% of them can recover in less than 12 months, and the others (0.84%) can recover in more than 12 months. According to the correlation analysis, during the disruptive period, adequate stock ensures a consistent supply and is a safeguard against unexpected demand changes. So, it is a competence for companies to manage demand fluctuations compared to the rivals who may face stockouts. Additionally, maintaining customer service and product quality at a high level by adopting new technologies or other solutions to alleviate customer concerns during the disruption will increase customer loyalty, and lead to a quicker recovery. Similarly, consistent sales as an indicator to analyze the market presence of the company cause a stable revenue stream and consequently ensure financial resilience. Moreover, companies require implementing strategies to retain or expand their market share to maintain their dominance besides expediting their post-disruption recovery. Furthermore, the ROI indicator shows how well the companies are in efficient use of their limited resources against unforeseen challenges during the disruption.

- To discover that firms can rely on which indicators to survive disruptive events, we ran a regression analysis. The outputs show that during the COVID-19 outbreak, improving traditionally significant facets like customer service, ROI, product quality, market share, and on-time delivery doesn't manifestly expedite the resilience and recovery process. However, companies could harness the power of robust sales dynamics to carve a path of resilience and reduce recovery time.
- The Bayesian Network analysis reveals that the probability of performing significant actions to optimize inventory processes depends on the probability of having high sales even during COVID-19. Besides, the firms need to ensure a high product quality independent of the pandemic. Moreover, having an efficient delivery lead time during the lockdown guarantees a good performance in customer service. In addition, the lead time impacts firms' performance about being able to produce goods at the original production cost because the lead time is also related to raw material procurement during the pandemic. Furthermore, the probability that firms have a successful performance in delivery time and quality level is related to the probability of ensuring visibility along the supply chain and

improving ROI (tracking delivery and quality to improve financial returns) which consequently affects firms' efficiency.

- Further analysis using the Bayesian network indicates that companies were not interested in adopting omni-channel as a practice to mitigate any of their performance risks individually. However, they adopted omni-channel when they were focusing on mitigating the risks of sales, ROI, inventory, and quality simultaneously. Moreover, companies have most likely pursued SC coordination during the first wave of COVID-19 to alleviate the risks of low quality, inventory shortage, and sales reduction. Furthermore, the adoption of big data and machine learning occurs when the risks linked to customer service, delivery time, SC visibility, and quality are present simultaneously. Otherwise, the only risk that individually persuades the decision-makers to implement big data and ML is decreasing ROI. Finally, the results show that firms can increase the probability of being highly resilient by adopting omnichannel, SC coordination, AI, and mobile apps as a portfolio of SC practices. Interestingly mobile apps have a significant impact on resilience only when we estimate the stochastic effect while it shows no significant impact when deterministic approaches are used.

This report provides useful insights about the resilience of Italian companies during the pandemic focusing on the main managerial practices, performance indicators, and new technologies. Besides the managerial and practical analysis of this report that can be helpful for policymakers, companies, and researchers, it helps to devise a broader questionnaire related to the PNRR. However, as this report is based on analyzing secondary datasets, it includes some limitations. First, this report does not analyze different proactive and reactive dimensions of resilience like readiness, complexity, and flexibility separately. Second, our analysis does not include all types of sustainable practices and their impacts on resilience. Finally, we need to focus on different sectors and business models to find out more about their requirements for improving their resilience.

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Appendix

Appendix 1. GRI Standards and Disclosures

GRI Standards	Disclosures
GRI1: Market Presence	Ratios of standard entry level wage by gender compared to local minimum wage
	The proportion of senior management hired from the local community
GRI2: Economic performance	Metrics related to company economic performance
GRI3: Indirect economic impacts	Infrastructure investments and services supported
	Significant indirect economic impacts
GRI4: Procurement practices	Proportion of spending on local suppliers
GRI5: Anti-corruption	Operations assessed for risks related to corruption
	Communication and training about anti-corruption policies and procedures
	Confirmed incidents of corruption and actions taken
GRI6: Anti-competitive behaviour	Legal actions for anti-competitive behaviour, anti-trust, and monopoly practices
GRI7: Tax	Approach to tax
	Tax governance, control, and risk management
	Stakeholder engagement and management of concerns related to tax
	Country-by-country reporting
GRI8: Materials	Materials used by weight or volume
	Recycled input materials used
	Reclaimed products and their packaging materials
GRI9: Energy	Energy consumption within the organization
	Energy consumption outside of the organization
	Energy intensity
	Reduction of energy consumption
	Reductions in energy requirements of products and services
GRI10: Water & Effluents	Interactions with water as a shared resource
	Management of water discharge-related impacts

GRI Standards	Disclosures
	Water withdrawal
	Water discharge
	Water consumption
GRI11: Biodiversity	Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas
	Significant impacts of activities, products, and services on biodiversity
	Habitats protected or restored
	IUCN Red List species and National Conservation List species with habitats in areas affected by operations
GRI12: Emissions (pollutants)	Emissions of ozone-depleting substances (ODS)
	Nitrogen oxides (NOx), sulfuric oxides (SOx), and other significant air emissions
GRI13: Emissions (GHG)	Direct (Scope 1) GHG emissions
	Energy indirect (Scope 2) GHG emissions
	Other indirect (Scope 3) GHG emissions
	GHG emissions intensity
	Reduction of GHG emissions
GRI14: Waste	Waste generation and significant waste-related impacts
	Management of significant waste-related impacts
	Waste generated
	Waste diverted from disposal
	Waste directed to disposal
GRI15: Environmental compliance	Environmental Compliance metrics
GRI16: Supplier environmental assessment	New suppliers that were screened using environmental criteria
	Negative environmental impacts in the supply chain and actions taken
GRI17: Employment	New employee hires and employee turnover
	Benefits provided to full-time employees that are not provided to temporary or part-time employees
	Parental leave
GRI18: Labor/management relations	Minimum notice periods regarding operational changes
GRI19: Occupational Health and Safety	Occupational health and safety management system
	Hazard identification, risk assessment, and incident investigation

GRI Standards	Disclosures
	Occupational health services
	Worker participation, consultation, and communication on occupational health and safety
	Worker training on occupational health and safety
	Promotion of worker health
	Prevention and mitigation of occupational health and safety impacts linked by business relationships
	Workers covered by an occupational health and safety management system
	Work-related injuries
	Work-related ill health
GRI20: Training and Education	Average hours of training per year per employee
	Programs for upgrading employee skills and transition assistance programs
	Percentage of employees receiving regular performance and career development reviews
GRI21: Diversity and Equal Opportunities	Diversity of governance bodies and employees
	The ratio of basic salary and remuneration of women to men
GRI22: Non-discrimination	Incidents of discrimination and corrective actions taken
GRI23: Freedom of Association and Collective Bargaining	Operations and suppliers in which the right to freedom of association and collective bargaining may be at risk
GRI24: Child Labor	Operations and suppliers at significant risk for incidents of child labour
GRI25: Forced or Compulsory Labour	Operations and suppliers at significant risk for incidents of forced or compulsory labour
GRI26: Security practices	Security personnel trained in human rights policies or procedures
GRI27: Rights of Indigenous People	Incidents of violations involving the rights of indigenous peoples
GRI28: Human Rights assessment	
GRI29: Local communities	Operations with local community engagement, impact assessments, and development programs
	Operations with significant actual and potential negative impacts on local communities
GRI30: Supplier social assessment	New suppliers that were screened using social criteria
	Negative social impacts in the supply chain and actions taken
GRI31: Public Policy	Political contributions

GRI Standards	Disclosures
GRI32: Customer Health & Safety	Assessment of the health and safety impacts of product and service categories
	Incidents of non-compliance concerning the health and safety impacts of products and services
GRI33: Marketing and labelling	Requirements for product and service information and labelling
	Incidents of non-compliance concerning product and service information and labelling
	Incidents of non-compliance concerning marketing communications
GRI34: Customer privacy	Substantiated complaints concerning breaches of customer privacy and losses of customer data
GRI35: Socio-economic compliance	Metrics related to Socio-Economic compliance
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Source: Global Sustainability Standards Board (2022)

Appendix 2. GRI Standards (Leaders vs SMEs) – Pearson Chi-Square Analysis

GRI standards	Leaders		SMEs		Pearson Chi-Square
	%	m (□)	%	m (□)	
GRI4: Procurement practices	45%	0.45 (0.50)	35%	0.35 (0.48)	2.859*
GRI5: Anti-corruption	76%	0.76 (0.43)	48%	0.48 (0.50)	21.889***
GRI6: Anti-competitive behaviour	49%	0.49 (0.50)	29%	0.29 (0.46)	11.046***
GRI8: Materials	51%	0.51 (0.50)	37%	0.37 (0.49)	4.889**
GRI9: Energy	81%	0.81 (0.39)	22%	0.22 (0.41)	93.824***
GRI10: Water & Effluents	73%	0.73 (0.45)	26%	0.26 (0.44)	56.982***
GRI11: Biodiversity	49%	0.49 (0.50)	4%	0.04 (0.20)	78.920***
GRI12: Emissions (pollutant)	63%	0.63 (0.48)	19%	0.19 (0.39)	56.407***
GRI13: Emissions (GHG)	80%	0.80 (0.40)	19%	0.19 (0.39)	101.362***
GRI14: Waste	77%	0.77 (0.42)	26%	0.26 (0.44)	70.339***
GRI15: Environmental compliance	51%	0.51 (0.50)	17%	0.17 (0.38)	36.013***
GRI16: Supplier environmental assessment	55%	0.55 (0.50)	15%	0.15 (0.35)	50.133***
GRI17: Employment	75%	0.75 (0.44)	39%	0.39 (0.49)	33.869***
GRI18: Labor/management relations	48%	0.48 (0.50)	27%	0.27 (0.44)	12.940***
GRI19: Occupational Health & Safety	85%	0.85 (0.36)	73%	0.73 (0.44)	5.250**
GRI20: Training and Education	80%	0.80 (0.40)	24%	0.24 (0.43)	83.386***
GRI21: Diversity and Equal Opportunities	84%	0.84 (0.37)	33%	0.33 (0.47)	68.804***
GRI22: Non-discrimination	60%	0.60 (0.49)	16%	0.16 (0.37)	57.120***
GRI23: Freedom of Association and Collective Bargaining	42%	0.42 (0.50)	4%	0.04 (0.2)	63.145***
GRI24: Child Labor	42%	0.42	2%	0.02	75.659***

GRI standards	Leaders		SMEs		Pearson Chi-Square
	%	m (σ)	%	m (σ)	
		(0.50)		(0.13)	
GRI25: Forced or Compulsory Labour	42%	0.42 (0.50)	2%	0.02 (0.13)	73.408***
GRI26: Security practices	33%	0.33 (0.47)	30%	0.3 (0.46)	0.312
GRI27: Rights of Indigenous People	16%	0.16 (0.37)	2%	0.02 (0.13)	19.929***
GRI28: Human Rights Assessment	56%	0.56 (0.50)	11%	0.11 (0.32)	64.197***
GRI29: Local communities	56%	0.56 (0.50)	27%	0.27 (0.45)	21.989***
GRI30: Supplier social assessment	57%	0.57 (0.50)	12%	0.12 (0.33)	62.130***
GRI31: Public Policy	42%	0.42 (0.50)	0%	0.00 (0.00)	84.385***
GRI32: Customer Health & Safety	58%	0.58 (0.50)	17%	0.17 (0.38)	51.166***
GRI33: Marketing and labelling	42%	0.42 (0.50)	5%	0.05 (0.22)	55.563***
GRI34: Customer privacy	46%	0.46 (0.50)	32%	0.32 (0.47)	6.011**
GRI35: Socio-economic compliance	36%	0.36 (0.48)	8%	0.08 (0.27)	32.837***
GRI36: Sustainable land use	22%	0.22 (0.41)	9%	0.09 (0.28)	9.237***
GRI37: Responsible data management	18%	0.18 (0.39)	30%	0.30 (0.46)	4.907**

Note: N= 277 firms; *** p<0.01, **p<0.05, *p<0.10; m=mean, σ= standard deviation

Appendix 3. GRI Standards Correlation

	GRI4	GRI5	GRI6	GRI8	GRI9	GRI10	GRI11	GRI12	GRI13	GRI14	GRI15	GRI16	GRI17	GRI18	GRI19	GRI20	GRI21	GRI22	GRI23	GRI24	GRI25	GRI26	GRI27	GRI28	GRI29	GRI30	GRI31	GRI32	GRI33	GRI34	GRI35	GRI36	GRI37	
GRI4	1																																	
GRI5	.458**	1																																
GRI6	.387**	.547**	1																															
GRI8	.269**	.231**	.266**	1																														
GRI9	.209**	.364**	.237**	.185**	1																													
GRI10	.334**	.402**	.363**	.324**	.510**	1																												
GRI11	.253**	.274**	.296**	.301**	.458**	.444**	1																											
GRI12	0.099	.241**	.243**	0.028	.410**	.310**	.348**	1																										
GRI13	.141*	.329**	.256**	.135*	.545**	.419**	.483**	.857**	1																									
GRI14	.147*	.307**	.174**	.122*	.497**	.372**	.446**	.408**	.525**	1																								
GRI15	.204**	.211**	.220**	.217**	.304**	.229**	.372**	.203**	.334**	.273**	1																							
GRI16	.204**	.195**	0.105	0.106	.383**	.277**	.430**	.236**	.350**	.336**	.277**	1																						
GRI17	.288**	.348**	.384**	.325**	.460**	.439**	.390**	.214**	.333**	.305**	.214**	.261**	1																					
GRI18	.298**	.306**	.350**	.362**	.364**	.370**	.357**	0.116	.154*	.196**	.181**	.164**	.458**	1																				
GRI19	.323**	.413**	.212**	.200**	.393**	.354**	.174**	.220**	.284**	.317**	.257**	.257**	.285**	.303**	1																			
GRI20	.132*	.293**	.189**	0.063	.570**	.358**	.446**	.423**	.555**	.418**	.305**	.352**	.364**	.241**	.264**	1																		
GRI21	0.096	.260**	.189**	.150**	.416**	.264**	.390**	.470**	.582**	.436**	.372**	.356**	.276**	0.094	.303**	.465**	1																	
GRI22	0.112	.216**	.177**	.168**	.403**	.332**	.476**	.306**	.406**	.356**	.342**	.392**	.305**	.318**	.232**	.541**	.412**	1																
GRI23	.203**	.214**	.227**	.240**	.389**	.318**	.563**	.240**	.394**	.359**	.392**	.432**	.348**	.325**	.169**	.378**	.366**	.407**	1															
GRI24	.279**	.267**	.224**	.242**	.416**	.401**	.531**	.315**	.458**	.425**	.367**	.492**	.303**	.264**	.200**	.425**	.380**	.406**	.684**	1														
GRI25	.270**	.261**	.233**	.252**	.409**	.393**	.517**	.325**	.451**	.418**	.355**	.481**	.297**	.233**	.197**	.418**	.374**	.416**	.645**	.937**	1													
GRI26	0.087	.260**	.135*	0.085	0.060	0.002	.223**	0.021	0.058	0.061	.293**	.174**	-0.032	0.031	.136*	.123*	.156**	.156**	.177**	.167**	.154*	1												
GRI27	.177**	.120*	.163**	.155**	.228**	.202**	.366**	.229**	.270**	.249**	.305**	.335**	.182**	.175**	.150*	.193**	.182**	.248**	.330**	.425**	.394**	.265**	1											
GRI28	0.059	.312**	.154*	.207**	.394**	.301**	.400**	.304**	.488**	.363**	.432**	.432**	.308**	.180**	.240**	.347**	.421**	.428**	.460**	.498**	.487**	.222**	.353**	1										
GRI29	.163**	.236**	0.092	.148*	.283**	.244**	.352**	.281**	.394**	.325**	.280**	.312**	0.112	.123*	.262**	.265**	.305**	.218**	.306**	.346**	.337**	.274**	.326**	.349**	1									
GRI30	.186**	.263**	.217**	.201**	.400**	.325**	.441**	.299**	.430**	.433**	.273**	.654**	.296**	.177**	.269**	.385**	.407**	.372**	.463**	.461**	.471**	.169**	.281**	.480**	.294**	1								
GRI31	.220**	.283**	.283**	.285**	.466**	.370**	.498**	.335**	.468**	.396**	.449**	.492**	.395**	.385**	.233**	.476**	.415**	.448**	.525**	.532**	.514**	.199**	.451**	.475**	.308**	.481**	1							
GRI32	0.055	.226**	.215**	.221**	.427**	.293**	.462**	.216**	.351**	.364**	.365**	.432**	.360**	.292**	.154*	.442**	.329**	.388**	.471**	.472**	.441**	.179**	.191**	.382**	.319**	.446**	.516**	1						
GRI33	.138*	.164**	.219**	.249**	.360**	.308**	.375**	.173**	.327**	.367**	.343**	.363**	.299**	.201**	0.107	.385**	.299**	.320**	.424**	.432**	.416**	0.070	.183**	.369**	.240**	.353**	.467**	.539**	1					
GRI34	0.074	0.051	.125*	-0.013	.124*	-0.005	.165**	.174**	.204**	.167**	.247**	.182**	-0.044	-0.001	.198**	.227**	.285**	.203**	.204**	.181**	.130*	.162**	.218**	.232**	.147*	.162**	.238**	.162**	.214**	1				
GRI35	.146*	.233**	.189**	.203**	.333**	.207**	.337**	.240**	.263**	.229**	.452**	.311**	.255**	.287**	.192**	.285**	.237**	.407**	.266**	.366**	.374**	.277**	.330**	.439**	.287**	.280**	.423**	.372**	.330**	.147*	1			
GRI36	-0.039	-0.008	0.000	.145*	.172**	0.111	.254**	0.097	.190**	.141*	.197**	.129*	.149*	.125*	0.063	.141*	0.107	.254**	.185**	.206**	.155**	.118*	.254**	.264**	.161**	.136*	.257**	.235**	.126*	0.062	.185**	1		
GRI37	0.029	.216**	0.090	-0.014	-0.085	-.131*	-0.018	-0.052	-0.094	-0.064	.146*	0.000	-.127*	-0.061	0.053	-0.031	0.056	-0.004	-0.067	-0.069	-0.086	.741**	0.095	0.061	.157**	-0.009	0.020	0.000	-0.029	.171**	.167**	0.034	1	

Note: **. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed) (08)

Appendix 4. GRI Standards per sector

Sector	Agri-food		Education		Engineering		Financial		Healthcare		ICT		Manufacturing		Services	
	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)
GRI4: Procurement practices	50.00%	0.50	67.00%	0.67	43.00%	0.43	0.00%	0.00	26.00%	0.26	28.00%	0.28	41.00%	0.41	33.00%	0.33
GRI5: Anti-corruption	62.00%	0.62	67.00%	0.67	65.00%	0.65	25.00%	0.25	84.00%	0.84	47.00%	0.47	59.00%	0.59	47.00%	0.47
GRI6: Anti-competitive behaviour	38.00%	0.38	33.00%	0.33	43.00%	0.43	25.00%	0.25	26.00%	0.26	32.00%	0.32	41.00%	0.41	20.00%	0.20
GRI8: Materials	56.00%	0.56	67.00%	0.67	43.00%	0.43	0.00%	0.00	53.00%	0.53	19.00%	0.19	48.00%	0.48	27.00%	0.27
GRI9: Energy	40.00%	0.40	33.00%	0.33	59.00%	0.59	25.00%	0.25	58.00%	0.58	30.00%	0.30	48.00%	0.48	33.00%	0.33
GRI10: Water & Effluents	54.00%	0.54	33.00%	0.33	49.00%	0.49	0.00%	0.00	58.00%	0.58	19.00%	0.19	52.00%	0.52	20.00%	0.20
GRI11: Biodiversity	29.00%	0.29	0.00%	0.00	32.00%	0.32	0.00%	0.00	5.00%	0.05	9.00%	0.09	26.00%	0.26	7.00%	0.07
GRI12: Emissions (pollutant)	21.00%	0.21	33.00%	0.33	59.00%	0.59	0.00%	0.00	21.00%	0.21	21.00%	0.21	47.00%	0.47	27.00%	0.27
GRI13: Emissions (GHG)	40.00%	0.40	33.00%	0.33	62.00%	0.62	0.00%	0.00	32.00%	0.32	26.00%	0.26	50.00%	0.50	27.00%	0.27
GRI14: Waste	48.00%	0.48	0.00%	0.00	59.00%	0.59	0.00%	0.00	47.00%	0.47	26.00%	0.26	56.00%	0.56	13.00%	0.13
GRI15: Environmental compliance	44.00%	0.44	0.00%	0.00	41.00%	0.41	50.00%	0.50	37.00%	0.37	17.00%	0.17	27.00%	0.27	7.00%	0.07
GRI16: Supplier environmental assessment	27.00%	0.27	0.00%	0.00	38.00%	0.38	0.00%	0.00	21.00%	0.21	23.00%	0.23	36.00%	0.36	27.00%	0.27
GRI17: Employment	50.00%	0.50	33.00%	0.33	62.00%	0.62	50.00%	0.50	63.00%	0.63	38.00%	0.38	58.00%	0.58	33.00%	0.33
GRI18: Labour/management relations	33.00%	0.33	33.00%	0.33	43.00%	0.43	0.00%	0.00	53.00%	0.53	28.00%	0.28	32.00%	0.32	53.00%	0.53
GRI19: Occupational Health & Safety	77.00%	0.77	100.00%	1.00	89.00%	0.89	25.00%	0.25	95.00%	0.95	47.00%	0.47	86.00%	0.86	80.00%	0.80

Sector	Agri-food		Education		Engineering		Financial		Healthcare		ICT		Manufacturing		Services	
	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)
GRI20: Training and Education	37.00%	0.37 (0.49)	33.00%	0.33 (0.58)	59.00%	0.59 (0.50)	25.00%	0.25 (0.50)	53.00%	0.53 (0.51)	47.00%	0.47 (0.50)	49.00%	0.49 (0.50)	13.00%	0.13 (0.35)
GRI21: Diversity and Equal Opportunities	46.00%	0.46 (0.50)	67.00%	0.67 (0.58)	70.00%	0.70 (0.46)	25.00%	0.25 (0.50)	58.00%	0.58 (0.51)	36.00%	0.36 (0.49)	59.00%	0.59 (0.49)	33.00%	0.33 (0.49)
GRI22: Non-discrimination	25.00%	0.25 (0.44)	0.00%	0.00 (0.00)	51.00%	0.51 (0.51)	25.00%	0.25 (0.50)	32.00%	0.32 (0.48)	34.00%	0.34 (0.48)	36.00%	0.36 (0.48)	7.00%	0.07 (0.26)
GRI23: Freedom of Association and Collective Bargaining	23.00%	0.23 (0.43)	0.00%	0.00 (0.00)	32.00%	0.32 (0.47)	25.00%	0.25 (0.50)	16.00%	0.16 (0.37)	13.00%	0.13 (0.34)	17.00%	0.17 (0.38)	7.00%	0.07 (0.26)
GRI24: Child Labour	25.00%	0.25 (0.44)	0.00%	0.00 (0.00)	19.00%	0.19 (0.40)	0.00%	0.00 (0.00)	16.00%	0.16 (0.37)	9.00%	0.09 (0.28)	21.00%	0.21 (0.41)	0.00%	0.00 (0.00)
GRI25: Forced or Compulsory Labour	25.00%	0.25 (0.44)	0.00%	0.00 (0.00)	19.00%	0.19 (0.40)	0.00%	0.00 (0.00)	16.00%	0.16 (0.37)	9.00%	0.09 (0.28)	20.00%	0.20 (0.40)	0.00%	0.00 (0.00)
GRI26: Security practices	33.00%	0.33 (0.47)	33.00%	0.33 (0.58)	38.00%	0.38 (0.49)	25.00%	0.25 (0.50)	26.00%	0.26 (0.45)	34.00%	0.34 (0.48)	26.00%	0.26 (0.44)	40.00%	0.40 (0.51)
GRI27: Rights of Indigenous People	12.00%	0.12 (0.32)	0.00%	0.00 (0.00)	16.00%	0.16 (0.37)	0.00%	0.00 (0.00)	0.00%	0.00 (0.00)	6.00%	0.06 (0.25)	4.00%	0.04 (0.20)	7.00%	0.07 (0.26)
GRI28: Human Rights Assessment	31.00%	0.31 (0.47)	0.00%	0.00 (0.00)	30.00%	0.30 (0.46)	0.00%	0.00 (0.00)	47.00%	0.47 (0.51)	19.00%	0.19 (0.40)	31.00%	0.31 (0.46)	13.00%	0.13 (0.35)
GRI29: Local communities	40.00%	0.40 (0.50)	33.00%	0.33 (0.58)	49.00%	0.49 (0.51)	50.00%	0.50 (0.58)	47.00%	0.47 (0.51)	21.00%	0.21 (0.41)	38.00%	0.38 (0.49)	47.00%	0.47 (0.52)
GRI30: Supplier social assessment	31.00%	0.31 (0.47)	0.00%	0.00 (0.00)	43.00%	0.43 (0.50)	0.00%	0.00 (0.00)	26.00%	0.26 (0.45)	15.00%	0.15 (0.36)	36.00%	0.36 (0.48)	7.00%	0.07 (0.26)
GRI31: Public Policy	17.00%	0.17 (0.38)	0.00%	0.00 (0.00)	27.00%	0.27 (0.45)	0.00%	0.00 (0.00)	21.00%	0.21 (0.42)	9.00%	0.09 (0.28)	17.00%	0.17 (0.38)	0.00%	0.00 (0.00)
GRI32: Customer Health & Safety	48.00%	0.48 (0.50)	0.00%	0.00 (0.00)	38.00%	0.38 (0.49)	0.00%	0.00 (0.00)	53.00%	0.53 (0.51)	21.00%	0.21 (0.41)	30.00%	0.30 (0.46)	13.00%	0.13 (0.35)
GRI33: Marketing and labelling	31.00%	0.31 (0.47)	0.00%	0.00 (0.00)	14.00%	0.14 (0.35)	25.00%	0.25 (0.50)	32.00%	0.32 (0.48)	6.00%	0.06 (0.25)	21.00%	0.21 (0.41)	7.00%	0.07 (0.26)
GRI34: Customer privacy	29.00%	0.29 (0.46)	33.00%	0.33 (0.58)	51.00%	0.51 (0.51)	50.00%	0.50 (0.58)	37.00%	0.37 (0.50)	40.00%	0.40 (0.50)	34.00%	0.34 (0.48)	40.00%	0.40 (0.51)

Sector	Agri-food		Education		Engineering		Financial		Healthcare		ICT		Manufacturing		Services	
	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)	%	m (□)
GRI35: Socio-economic compliance	13.00%	0.13 (0.34)	0.00%	0.00 (0.00)	24.00%	0.24 (0.43)	25.00%	0.25 (0.50)	32.00%	0.32 (0.48)	17.00%	0.17 (0.38)	19.00%	0.19 (0.39)	13.00%	0.13 (0.35)
GRI36: Sustainable land use	23.00%	0.23 (0.43)	0.00%	0.00 (0.00)	22.00%	0.22 (0.42)	25.00%	0.25 (0.50)	5.00%	0.05 (0.23)	4.00%	0.04 (0.20)	14.00%	0.14 (0.35)	0.00%	0.00 (0.00)
GRI37: Responsible data management	21.00%	0.21 (0.41)	33.00%	0.33 (0.58)	27.00%	0.27 (0.45)	25.00%	0.25 (0.50)	32.00%	0.32 (0.48)	32.00%	0.32 (0.47)	20.00%	0.20 (0.40)	40.00%	0.40 (0.51)
N	52		3		37		4		19		47		100		15	

Note: N=277 firms