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Summary n. 1/2025

In Memory of Alfio

I dedicate this special issue of the journal I edit to Alfio, a lifelong friend and esteemed academic colleague. His memory will remain indelibly etched in my mind and, above all, in the innermost depths of my soul.

<div align="right">

Salvatore Esposito De Falco

</div>

Alfio Cariola has gone "somewhere else". He was a friend with whom I shared a long journey-first together in the distant lands of Calabria and then, unfortunately, apart, though always maintaining a continuous relationship through phone calls and letters.

Such is life; my professional ties with Calabria were gradually fading. Yet, a strong bond had formed between us.

He was always an active member of the scientific community close to the Consortium for Industrial and Managerial Economics (CUEIM), as evidenced by the numerous articles he published in Sinergie, a journal dedicated to studies and research. These works reflect a scholar deeply connected to the issues of his land, capable of rigorously addressing concrete theses related to its development and the effectiveness of development policies. On a human level, they highlight his remarkable ability to collaborate with fellow researchers and to support and enhance the work of his university colleagues and department members.

I wish to recall here his study, conducted in collaboration with Michele Costabile, "Conclusions: Resources, Values, Perspectives", published in Sinergie – Rapporto di ricerca n.16 (Enterprises and Territories. The Actions of Sviluppo Italia Calabria for the Genesis and Growth of Entrepreneurship). This work holds significant value, with a preface by the unforgettable Francesco Samengo, President of Sviluppo Italia Calabria.

Time passes. It has been a long time since I had the opportunity to closely follow his academic career; the first milestone was reached in 1992, with his doctoral examination at the University of Cassino.

Time passes. Yet, he was always in my thoughts, especially during my visits to the port of Vibo Valentia, where he would greet me with a crate of special tomatoes, grown in a small area near Paola.

This is the ever-present memory I hold of the man, the professor, the friend-woven into the fabric of a wonderful season of my life.

Gaetano Maria Golinelli

Alfio Cariola was a distinguished researcher who profoundly influenced countless individuals throughout his career. He possessed a remarkable ability to lead a group of brilliant and talented colleagues, elevating their unique skills and contributions in an extraordinary way. His scientific, teaching, and leadership capabilities as the coordinator of a research group are clearly reflected in the outcomes he achieved: successful recruitment of new talent, career advancements even during times of limited resources, achievements across all disciplines represented within the UNICAL group, and an exceptional ability to attract promising doctoral candidates. These accomplishments depict a colleague we all aspire to have in our departments-someone with unparalleled wisdom, vision, and balance. These qualities allowed him to consistently find the most effective solutions to the myriad challenges, both large and small, that academic life presents on a daily basis. Alfio Cariola's decisions and his life's work will remain a lasting source of inspiration for researchers and professors in the field of Management.

Francesco Ricotta

To professor Alfio Cariola, long term colleague and true friend. That there is a great example of curiosity for challenging research questions, design thinking and strong ("engineering") determination on methodological deployments, never forgetting the research relevance that always come with high quality scientific research. We will miss you as well as your generous organizational citizenship will be a long lasting benchmark. Thank you Alfio. You filled with real contents the meaning of the word friendship.

Michele Costabile

I remember Alfio as the guiding light that led me through my educational journey in the fields of logistics, operations, and supply chain management. His great sense of humor coupled with the academic brilliance infused my passion for these fields and still motivate me every day. Despite being out of Italy for years, every Calabrian trip was never complete without going to his

office, where we shared ideas, exchanged advices, and experienced real friendship. Alfio's infusion of kindness, strength, and intelligence enriched not just my life but also my career. Those who knew him will remember his lively spirit, his dedication to academia, and his ability to connect with people from all walks of life. Even though his physical presence is gone, his inspiration lives on in my heart and in the hearts of people he touched. Losing Alfio left an enormous gap in my life. I miss his contagious laughter, sharp mind, and the fact that he always made time to chat. He will be in my memories forever, reminding me of the great mentor and friend I was lucky to have.

Pietro De Giovanni

With deep affection, dear Alfio, we are carrying forward several research projects started together with you. We dedicate our research activities to you, Alfio, as a professor, mentor and friend. You have made your life a total dedication to your students and colleagues. You have shaped generations of young minds and supported university entrepreneurship by encouraging spin off and startup creation. You strongly contributed to the development of the University of Calabria with integrity and honesty, working hard, until the last minute of your life.

Through your research work, you have made a significant contribution to the national and international scientific community, encouraging your students to explore both mainstream topics and frontier research. You have always promoted third mission activities, fostering continuous collaboration between the research system, businesses, and institutions. As an active member of the Italian Society of Management, you never failed to provide your scientific contributions at annual conferences, instilling in your young colleagues the feel of belonging to the great national management research community.

We are all grateful for who you were and for what you have left in us and in so many generations of students, managers and entrepreneurs around the world. Thank you, Alfio, immortal in our hearts.

Mariacarmela Passarelli

To Alfio, dear mentor and friend. Through his example, expertise, and generosity, he has paved a path that has enriched my academic and personal journey. Thanks to his guidance, I have had the opportunity to grow as a researcher and professor, developing a perspective on the discipline that I will always carry with me. His contributions to corporate financial and management academy, as well as his tireless dedication to the University, will remain a benchmark for all of us. This paper, intitled "Adaptation or Persistence? Capital Structure Choices of Italian Firms Over Time", on a topic dear to him, is dedicated to his memory with deep gratitude and esteem, in

the certainty that his teachings will continue to live on through the work of those who had the privilege of knowing him.

<div align="right">Maurizio la Rocca</div>

I remember Alfio with profound friendship and esteem as a pivotal mentor in my career. His insightful teachings helped shape my academic and professional path, providing inspiration during my university years and my collaboration with Prisma Management Consulting. His remarkable ability to combine academic rigour, professional vision and a unique sense of humour made our discussions both constructive and enjoyable. His memory will always be with us.

<div align="right">Elvira Tiziana la Rocca</div>

Remembering Alfio Cariola on this special occasion is an honor and a deeply emotional moment for me. His unfortunate passing left an enormous void in our academic community. Alfio was a brilliant scholar, constant guide, mentor, and source of support. He never had any reservations about offering advice, sharing his expertise, and dedicating himself sincerely to those around him. His honesty, good heart, and sincerity made an indelible mark on any person who had the privilege of collaborating with him. His mentorship will continue to guide us not only in the professional world but also in how we approach challenges and embrace opportunities. So, I feel more than grateful to contribute to this special issue in his memory.

<div align="right">Giuseppina Simone</div>

Alfio Cariola is more than just a friend or a colleague to me. I intend to use the present tense because his enduring commitment to the overwhelming number of duties he has taken on his shoulders in the last twenty years will not fade away because of his momentary transfer to a better place. Therefore, my memory of Alfio is not oriented to the past, to recall his manifold contributions to our beloved University of Calabria, but to the present and the future, as a promise to bring forward all the projects we were carrying out together. Paraphrasing S. Augustine of Hyppo, we sorely suffer his momentary absence, but we are grateful for having shared an important part of our lives with him.

<div align="right">Andrea Lanza</div>

Professor Alfio Cariola had a special relationship with everyone working in the Department of Business Administration and Law at the University of Calabria and, more broadly, across the entire University. The uniqueness of each relationship he built was primarily the result of his constant physical

presence in the University environment, from morning to night and often be-yond. Those rooms and hallways still feel his presence and will continue to do so for years. I consider myself very fortunate to have had Professor Al-fio Cariola as a guide of wisdom. The understanding we shared, often dis-cussing corporate finance late into the evening, is something I will always carry with me. Sharing a passion for finance, preparing exams, and grading together created a connection that will guide me throughout my academic career. He will always be by my side on this journey, with the hope that the projects we envisioned will come to fruition, with the commitment to work with passion inspired by his guidance.

Francesco Fasano

With infinite esteem, I would like to thank Alfio. I am deeply grateful to him for his constant encouragement and invaluable guidance throughout my academic journey, which has also led to numerous research collaborations. I had the privilege of having him as my Corporate Finance professor at the University of Calabria. His lectures have been a great source of inspiration for me.

Raffaele Staglianò

Entrepreneurship between Innovation and Sustainability

Salvatore Esposito De Falco[*]

1. In Memory of Alfio

This volume of the journal is dedicated to the memory of my friend and colleague Alfio Cariola, to whom I am deeply bound by a long-standing and deep friendship that arose during our PhD studies.

A full professor at the University of Calabria, dear Alfio developed, over the course of his long and brilliant career, an articulate academic and scientific path, characterised by a remarkable thematic breadth and a strong institutional commitment.

His passion for teaching was often reflected into the ability to involve colleagues, students, and friends in his ideas and his educational and scientific activities. One cannot fail to mention the role he played fostering not only cultural, but also human growth, authentically embodying the role of an academic, seeking not only to transmit knowledge, but also to guide and inspire his students.

He poured the same passion into research and scientific progress, combining his engineering knowledge with management and organizational expertise. In doing so, he developed new multidisciplinary methodological approaches through which to study topics of interest to our field.

His research items are collected in over 70 scientific publications, many

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of which have been featured in international journals, significantly contributing to the development of managerial literature and policies for innovation and territorial growth.

2. Entrepreneurship between Innovation and Sustainability

In line with Alfio Cariola's work, the papers published in this Special Issue are dedicated to the main topics he dealt with, which we have gathered around three main research trajectories:
- entrepreneurship and business growth;
- business models innovation;
- sustainability.

From these themes, important considerations emerge regarding their relevance and the perspectives that take shape in this new path, where, in the current capitalist scenario, entrepreneurship appears to be characterized by the simultaneous presence of two fundamental drivers: innovation and sustainability. We cannot forget that the theme of entrepreneurship has been examined in the literature through different angles, each of which is fundamental for the economic and social growth of the enterprise, but above all for the connotation linked to the propensity to risk and the ability to generate new economic and market value through innovation. Risk, value, innovation and sustainability are, in fact, all concepts referred to in the international literature on entrepreneurship.

According to Schumpeter (1934), the entrepreneur is indeed the innovator, the one who must introduce new productive combinations, break with the past and create economic discontinuity through the creation of the new. Knight (1921), in turn, emphasised the role of uncertainty and risk, interpreting the entrepreneur as one who, in making decisions under conditions of uncertainty, must necessarily assume the business risk. In the sociological perspective, Max Weber (1904) explored entrepreneurship as a social and cultural behaviour, emphasising the capitalist spirit as the result of specific norms and ethical values. For Weber, entrepreneurship has always been intrinsically linked to Protestantism, with the idea that economic success should reflect a divine blessing. Finally, from a managerial perspective, an interesting approach is provided by Drucker (1985), who sees the entrepreneur as a resource manager and value creator. According to the author, entrepreneurship is seen as the ability to exploit opportunities in the environment to generate innovation and growth, focusing on efficiency and effectiveness in management.

All the perspectives outlined so far have gradually blurred over time,

sometimes integrating as the concept of entrepreneurship shifted towards a more holistic view that considered not only technological innovation, but also social and environmental innovation. Today, the emerging idea of entrepreneurship is one that can no longer ignore the integration of innovation and sustainability. The resulting sustainable innovation is characterised by the ability to generate solutions that reduce environmental impact, improve social welfare and, at the same time, ensure economic sustainability.

All this points to a new entrepreneurial orientation, which is developing through changing social expectations and increasing regulatory pressure, pushing companies towards sustainability, no longer seen as an optional strategic choice, but as a competitive necessity.

The shift from a traditional view of entrepreneurship to a sustainability-oriented perspective is therefore not only an opportunity, but an imperative for modern businesses, which must rethink their role as agents of positive change.

Ultimately, entrepreneurship cannot avoid the need to engage with innovation and economic sustainability. The key innovation that modern businesses must embrace is sustainability itself, driving the transformation of business models toward more sustainable practices. This has led to the emergence of new business models capable of integrating into their strategies activities that are more sensitive to the circular economy, to enhancing the efficient use of resources, and to ensuring transparency and corporate social responsibility.

In other words, the new perspective that emerges can no longer be read from a reductionist perspective by separating one concept from the other, but imposes a holistic and systemic vision in which the driver of entrepreneurship becomes precisely that of sustainable innovation.

This is what emerges from reading the contributions in this volume, which we have chosen to aggregate according to the three main areas of Alfio's thinking: entrepreneurship, innovation and sustainability

3. Special Issue Contributions

The first topic – *Entrepreneurship and Enterprise Growth* – was addressed through four papers.

The first contribution, by Mattia Fasano, Elvira Tiziana La Rocca and Raffaele Staglianò, titled "Crowdfunding's impact on SMEs' growth. A case study approach", analysed the effect of equity crowdfunding (ECF) on the growth of two Italian SMEs operating in the agri-food and cleantech sectors; the two case studies were compared with similar enterprises not financed

through ECF. The research showed a significant improvement in performance, in terms of sales, EBITDA and ROA, following the application of such a financial strategy.

More generally, the paper contributes to the literature on entrepreneurship and alternative finance, highlighting the usefulness of ECF in overcoming financial constraints and fostering sustainable development paths. Furthermore, the paper reflects on the role of corporate governance in maximising the benefits of ECF, offering relevant insights for entrepreneurs and policy makers interested in promoting SME growth.

In this perspective, the paper by Maurizio La Rocca, Francesco Fasano, Daniele Monteforte, entitled "Adaptation or Persistence? Capital Structure Choices of Italian Firms Over Time", analysed the capital structure choices of over 500,000 Italian SMEs over the period 2012-2023, in light of the firm's financial life cycle theory. The results confirm a non-linear pattern in which firm age influences leverage choices: young firms make extensive use of debt, while mature firms favour self-financing. The study highlighted the persistence, over time, of the dynamics already identified by La Rocca *et al.* (2011), despite economic crises and structural transitions. The scientific interest lies in the empirical update of a classical model, with important implications for the definition of customised financing strategies along the different stages of the corporate life cycle.

The contribution by Mariacarmela Passarelli and Giuseppe Bongiorno, entitled "Digital Technologies and Student Entrepreneurship: a focus on University of Calabria", investigates the determinants that drive young entrepreneurs to found ITC firms through an empirical analysis conducted by interviewing a sample of students at the University of Calabria. The aim was to ascertain the micro (autonomy, self-efficacy, pro-sociality) and meso (family context, education) factors that influenced the propensity to set up digital enterprises. The results show that autonomy, self-efficacy and innovative teaching play a key role in stimulating entrepreneurship, while age and gender are less significant.

The last paper concerning this first research topic is the one by Francesco Ricotta, Mariacarmela Passarelli, Angelo Baccelloni "Empowering entrepreneurship through high-growth firms: insights from a decade-long bibliometric analysis", in which the strategic role of High-Growth Firms (HGFs) in the Italian economy is explored through a bibliometric analysis of the scientific literature from 2012 to 2021.

The purpose was to identify the main competitiveness drivers of HGFs and to understand how Industry 4.0 has redefined the theoretical and operational models associated with their growth. Three key drivers emerged from the analysis: technological investments, knowledge networks based on open

innovation and human capital development. The paper provides an evolutionary map of pre- and post-Industry 4.0 research strands, emphasising the strategic role of entrepreneurial ecosystems.

Ultimately, the four papers described have addressed the topic of entrepreneurship and business growth with a series of studies analysing growth dynamics and entrepreneurial innovation, considering alternative financial instruments such as crowdfunding, capital structure choices, new forms of student entrepreneurship and the role of high-growth enterprises.

The second topic – *Business Models Innovation* – includes two papers.

Pietro De Giovanni's paper, "Reflective vs. Formative Measurement Models in Operations and Supply Chain Research", addressed a node in Operations and Supply Chain Management (O&SCM) through Structural Equation Modeling (SEM).

The author highlights the frequent inappropriateness of traditional analysis models, which can undermine the empirical validity of analyses. Offering practical criteria and an application example, the Author proposes a critical methodological approach based on the construction of innovative conceptual models in O&SCM research. Ultimately, the contribution highlights a widespread limitation in the literature and proposes useful tools for more rigorous and innovative business model research.

The other work is by Andrea Lanza and Giuseppina Simone, titled "Value Creation in Tradition-led Industries: The Role of Innovative Practices. The Empirical Evidence from the Italian Wine Industry". The paper explores the adoption of innovative entrepreneurial strategies and their ability to generate value in tradition-dominated production contexts, as in the case of the Italian wine industry between 1999 and 2009. Through a quantitative analysis on panel data, the authors show that innovation (e.g. wine ageing in barrels) can produce a positive effect on the company's entire product portfolio. However, the size of the portfolio itself negatively moderates this relationship, highlighting tensions between innovative identity and traditional expectations.

The two papers described are ultimately dedicated to the topic of innovation in business models, with two research papers exploring measurement models in the supply chain and value creation in traditional industries, with a focus on the adoption of innovative strategies.

The third topic – *Sustainability* – also includes two papers. The first paper, by Mauro Sciarelli, Giovanni Landi, and Anna Prisco, titled: "Financial Performance and the Circular Economy: The Moderating Role of the CSR Committee", examines the relationship between financial performance and

the circular economy (EC) in European listed companies, analysing the moderating role of the CSR committee. Through an analysis of 567 companies over the period 2019-2023, the study shows that companies with better financial performance adopt EC practices more intensively. Moreover, the presence of a CSR committee within the Board of Directors positively reinforces this relationship, fostering the integration of sustainability within governance mechanisms. The contribution has a relevant scientific interest, as it fills a gap in the literature with respect to organisational factors that facilitate the transition towards circular models.

The latest work, by Michele Costabile and Pietro De Giovanni, titled: "Quantifying Social and Environmental Impacts through the Life Cycle Assessment", proposed an integrated approach to measuring social and environmental sustainability through the Life Cycle Assessment (LCA) methodology, applied to the case of cotton production in India. Using the ISO 14040 and 26000 standards, the authors quantify the impact of key inputs (electricity, fertilisers, pesticides, machinery) on the environment and social conditions, highlighting how targeted strategies can mitigate their negative effects. The scientific interest lies in the combination of LCA and S-LCA to develop credible and sustainable decarbonisation plans, providing decision-making tools for companies and policy makers. Implications include the adoption of safer and more efficient agricultural practices, with positive impacts on ecosystems, health and workers' rights.

The last two papers, therefore, focused on the topic of sustainability, helped to investigate the link between corporate performance, circular economy, sustainable governance and the assessment of social and environmental impacts.

In conclusion, all the papers illustrated offered a broad and in-depth analysis of the main research directions covered by Alfio Cariola: from the evolutionary trajectories characterising the contemporary entrepreneurial landscape, to the spread of crowdfunding as a development lever for SMEs, up to the dynamics of high-growth firms, from which a lively and changing picture emerges. At the same time, the papers highlight the role of innovation in traditional contexts and the need to adopt updated analytical tools to understand complex processes (e.g. supply chain and CSR). Finally, they have explored the growing commitment of businesses to environmental and social sustainability, emphasizing the measurement of impacts and the effectiveness of governance.

Crowdfunding's Impact on SMEs' Growth.
A Case Study Approach

Mattia Fasano*, Elvira Tiziana La Rocca**, Raffaele Staglianò***

Abstract

This paper explores the relationship between equity crowdfunding (ECF) and the growth of Italian SMEs. Using two case studies, one in the agri-food sector and the other in cleantech, and comparing them with non-crowdfunded equivalents, we find that ECF significantly enhanced the post-campaign growth of the two firms, which outperformed their counterparts. This highlights ECF as an effective solution for SMEs to overcome financial constraints problems and achieve growth. Some managerial implications emerge. While ECF poses specific key challenges, the study underlines the importance to take into account corporate governance concerns in maximizing the benefits of this funding opportunity. Our research underscores ECF's potential in entrepreneurial finance and offers insights into its long-term impact.

Keywords: equity crowdfunding, financial constraints, case studies, SMEs, firm growth, corporate governance.

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Equity crowdfunding e crescita delle PMI: analisi di alcuni casi studio

Sommario

Questo studio esplora la relazione tra equity crowdfunding (ECF) e la crescita delle PMI italiane. Attraverso l'analisi di due casi studio, uno nel settore agroalimentare e l'altro nel settore cleantech, e il loro confronto con un campione di imprese di controllo non finanziate tramite crowdfunding, emerge come l'ECF abbia significativamente migliorato la crescita post-campagna delle due imprese, anche con riferimento al campione di controllo. Questo evidenzia come l'ECF sia una soluzione efficace per superare i problemi di costrizione finanziaria per le PMI. Emergono alcune implicazioni manageriali. Pur presentando diverse sfide chiave, lo studio sottolinea la rilevanza di tener conto delle implicazioni di governance aziendale per massimizzare i benefici di questa opportunità di finanziamento. La presente ricerca mette in luce il potenziale dell'ECF nella finanza imprenditoriale e offre spunti sul suo impatto a lungo termine.

Parole chiave: equity crowdfunding, costrizione finanziaria, casi studio, PMI, Crescita d'impresa, corporate governance.

1. Introduction and Background

Previous research highlights that small and newly established firms often experience significant information asymmetries due to their limited credit history, lack of a proven track record, and reduced capacity to offer collateral, which negatively impact on their ability to finance new project (La Rocca *et al.*, 2011; La Rocca *et al.*, 2019). Considering that small-and medium-sized enterprises (SMEs) generally constitute a crucial driver of economic growth (Stel *et al.*, 2005), it has become relevant to develop alternative financing mechanisms for these firms. In recent years, we have observed a growing popularity of equity crowdfunding (ECF) as an alternative to traditional financing strategies, particularly for SMEs and startups (Belleflamme *et al.*, 2014; Cumming and Vismara, 2017). As a result, there has been a growing interest from the academic world in attempting to identify the causes of the crowdfunding campaigns success (Alhers *et al.*, 2015; Vismara, 2016; Walthoff-Borm *et al.*, 2018a). The growth of this financing mechanism has gained global importance (Butticè and Vismara, 2022), also focusing on critical issues such as climate change, highlighting that crowdfunding campaigns can support climate-related events even when they are of a rather local nature (Billio *et al.*, 2025). Interestingly, recent studies put in evidence the relevance role of local preferences of investors (Bade and Walther, 2021) and of local economic conditions (Lazos, 2024) for campaign success.

Despite the interest in ECF, studies that focus on firm growth after the conclusion of a campaign are still limited and they have only recently gained interest. Crowdfunding has the potential to democratize entrepreneurial finance by reducing barriers for both entrepreneurs and small investors with a consequent positive impact on campaign success (Cumming *et al*., 2021) and on ex-post campaign growth through the mechanisms of the wisdom of crowd; a principle whereby a crowd can outperform an individual in problem solving through averaging over large numbers (Surowiecki, 2005; Mollick and Nanda, 2016; Iyer *et al*., 2016; Schwienbacher and Larralde, 2012).

Given the potential usefulness of this mechanism, Eldridge *et al*. (2021) empirically, focusing on ECF platform in UK, find that firms using ECF financing obtain higher growth opportunities and higher operating performance ex-post an ECF campaign. Interesting, Troise *et al*. (2021) highlight the importance of ECF as an open innovation tool to address sustainability challenges in the agri-food sector, emphasizing how crowd investors can influence the innovation and growth trajectories of the firms they invest in. These findings confirm that ECF is a valuable means to support sustainable innovation efforts even in the post-campaign phase. Vismara and Wirtz (2025) examines the impact of environmental orientation on long-term financial performance of firms raising funds through ECF. The results indicate that in the long term, environmental orientation has a weaker positive impact when considered alone but becomes significant when combined with a successful ECF campaign. More generally, as suggested by Rossi *et al*. (2023), entrepreneurs learn from their crowdfunding experiences, and this learning influences their subsequent interactions with external investors, consequently shaping the firm's growth path. In addition to this background, previous corporate finance studies underline that it is crucial to focus on the governance characteristics of firms to understand what drives future growth and performance (Shleifer and Vishny, 1997; Cariola, 2006; Laeven and Levine, 2008).

The corporate governance in the domain of ECF, is an area of research that has only recently attracted researchers' attention. ECF financing creates corporate governance concerns that may become relevant (Cumming *et al*., 2021) also considering the nature of the project. Recent findings by Vismara and Wirtz (2025) show that corporate governance plays a crucial role as a moderator in ensuring the economic sustainability of environmentally oriented firms. Specifically, the authors find that environmental orientation has a stronger positive correlation with long-term firm performance when the offerings are structured under a nominee ownership model.

In fact, SMEs that launch an ECF campaign broaden the base of owner-

ship to small shareholders, raising corporate governance concerns due to the separation between ownership and control. Signori and Vismara (2018), in a seminar study, focusing on different possible ex-post outcomes of a UK-based crowdfunding campaign, find that firms with a higher number of investors during the initial campaign have less probability to be involved in a positive event such as SEO or M&A. Walthoff-Borm *et al.* (2018b), observing differences in terms of governance structure in two UK-based platforms, don't find difference in post-campaign profitability between ECF and non-ECF firms. Cumming *et al.* (2019), extending previous studies, examine how dual-class shares (A-shares, carrying voting right; B-shares, no carrying voting right) leading to a relinquish control to other shareholders rising a problem of separation between ownership and control, affect negatively campaign success. However, setting investment thresholds granting voting rights (A-shares threshold) positively influences outcomes, attracting professional investors and enhancing offering success. The presence of professional investors could play a significant role in the dynamics of the campaign. Some scholars suggest that small investors can benefit from the involvement of large institutional investors, who play a key role in identifying, overseeing, and supporting investment opportunities (Hornuf and Schwienbacher, 2016). It is important to acknowledge, though, that the impact of these contributions can differ among start-ups, depending on factors such as the specific characteristics of the company and the background of its founders.

The goal of our article is to help better understand the impact of ECF financing on ex-post firm growth of two Italian crowdfunders operating in two different sectors, comparing their ex-post growth paths with those of a sample of non-crowdfunders at national and regional level.

The paper is organized as follows. Section 2 describes the context of the analysis. In Section 3, the methodology and case studies are presented. The main results on firm growth are discussed in Section 4. Concluding remarks are provided in Section 5.

2. Equity Crowdfunding in Italy

In 2012 Italy adopted a specific law about ECF. To be more specific Italy issued the decree n. 179/2012, converted in law 17 December 2012, n. 221, named "Decreto crescita bis", in which the focus was on innovative start-ups. The reason why it was important to rule this specific type of firms is because the Italian network is mainly composed of small firms, which are the ones who encounter the most difficulties to obtain funding from banks, even more if we consider the new ones. In fact, the ECF is seen as a useful

tool to help the Italian small firms to grow, exploiting the potential of the web. The cited law has conferred on Consob the task of regulating the specific feature of this phenomenon to create trust among investors. To do so, from 26th June 2013, Consob settle the new regulation n. 18592/2013, to establish some rules for crowdfunding platforms. The key points are the special register in which the qualified entities have to be enrolled and the protection of the investors, thanks to transparent information and limits on the capital invested. After the regulation of the ECF the next step is to share this possibility even with firms that are not "innovative start-ups". For this reason, first the decree n. 3/2015, named "Legge di Stabilità 2015", involved the innovative SMEs, then the law n. 232/2016, named "Legge di Bilancio 2017", engaged all the SMEs as well.

The Politecnico di Milano (2024) released the 9th Italian report on crowdfunding, that collects various information on the crowdfunding market highlighting a positive trend for the Italian crowdfunding. Considering all the 1427 Italian campaigns carried out from 2014 to 2024, the success tax rate of the campaigns is 81% with an average of 95,8 new shareholders. Since 2014 the amount collected is 678,09 million euro. Interesting, in the last 12 months the shares without vote-rights is increased (17% to 31%).

3. Methodology and Case Studies

3.1 Research Method

We selected the multiple case studies methodology (Stewart, 2012) to understand the impact of ECF financing on firm growth path in gaining an understanding of complex processes over the time. A description of our two cases is summarized in Table 1. We selected firms that started their campaign on *crowdfundme*[1], one of the most used Italian platforms for ECF. In order to explore how different sectors, respond to the campaign, we chose one firm from each of the two sectors with traditionally different characteristics: agri-food and cleantech. The former represents a milestone in Italy and that has a very strong trend, meanwhile the latter is a sector in development and presents a higher risk level. For what concern the selection among all the firm in the chosen sectors, we select firms that had a successful campaign. Moreover, we chose two firms, constituted in 2013 and 2017, who started their campaign in the same year (2019) to have a long-term vision of the role of the ECF. We investigate the firm's growth paths by ob-

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[1] https://www.crowdfundme.it/

serving the dynamics of two accounting variables, namely Sales and EBITDA. Following La Rocca *et al.* (2019), we use ROA as a measure of operating performance, calculated as EBIT over Total Assets. We obtained accounting data from AIDA BvD database. To verify the impact that crowd-funding has on the growth of these variables, the level of these proxy is compared with matched firms that did not start an ECF campaign. The size of these firms is the same of the company of interest and they belong to the same sector, identified through the same 4-digits ATECO code, at national and regional level.

Table 1 – Sample description

Com-pany Name	Costitu-tion Year	Sector	Cam-paign Year	Amount Funded	% Of Sche-duled Goal	Share Quotes Type (A-Shares/B-Share	Crowdfun der Inve-stors	Crowd-funder Investors with Vot-ing Rights	Crowdfun der Pro-fessional Investors
Me-Mento S.r.l.	2017	Agri-food	2019	143.900,00€	144%	A-shares: 14% (thresh-old: 15.000€), B-shares: 86%	119	1	4
Tree Solu-tions S.r.l.	2013	Clean-tech	2019	178.500,00€	179%	A-shares: 48% (thresh-old: 10.000€), B-shares: 52%	149	3	3

Source: our elaboration on data from https://www.crowdfundme.it

Table 1 illustrates the main characteristics and facts regarding our sample, such as the percentage of scheduled goal, that can be used as a measure of the success. In fact, both cases collect more than the scheduled amount, thus emerge as successful campaigns. Other information reported in the Table 1, refers to the governance characteristics that highlight a diversification in the shareholder structure.

3.2 Memento S.r.l.

MeMento S.r.l. produces a non-alcoholic distilled drink with a flavour inspired by Mediterranean botanicals. The firm was founded by Eugenio Muraro in 2017, who took inspiration by the "*Ricettario Fiorentino*" of

1948 in order to creates his own drink. Using the combination of historical knowledge and modern innovation, the founder idea was to produce a new drink without alcohol and sugar.

The Italian Trade & Investment Agency identifies the agri-food sector as a very important one for Italy. In fact, it is the fourth most important manufacturing sector, representing the 12% of Italian exportation[2]. To be more specific, in the beve7rage sector, the difference between exportation and importation in Italy has increased every year since 2015[3].

In a very competitive sector like this, the main goal for *MeMento* is to obtain a significative growth selling only healthy drink and become a reference point as a premium non-alcoholic beverage. To do so, its expansion strategy is focused on entering international markets and positioning itself as a premium product, in order to reach their buyer target, that are people willing to pay more for a sophisticated and innovative drink. The goal is also to reach consumers who prefer to avoid alcoholic drinks. In this way, the company can increase the number of customers and the sales.

One of the main challenges is the entry in an already developed sector, such the agri-food one, the overcome of financing problems and the maintenance of a distinctive positioning.

MeMento presented a strategy to face this challenge through an expansion of production capacity and continue investing in international marketing, such as North America. Furthermore, others key points of the strategy are the brand line extension and the strengthening of the presence in Europe. To implement this idea the corporate governance had to take an important decision: how to fund these strategies. In 2019 the company decided to start a crowdfunding campaign, in order to increase the effectiveness of coverage and distribution. At the end of the campaign the amount collected was €143.900, 144% of the scheduled goal (€100.000).

Concerning governance aspects, Memento gains 119 equity crowdfunders, versus an average of 86 obtained by same sector's campaign in the same platform. Four of them are professional investors, and out of 90 of whom we could collect information about their investing habits, 57 of them already invested in other ECF campaigns[4]. For their campaign *MeMento* set a threshold of 15.000€ to issue Class A that is lower than the average threshold of the sector (22.733€). Only one investor decided to collect the former obtaining 13% of total quotes, in contrast with the average of six investors for campaigns with equal threshold.

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[2] https://www.ice.it/it/settori/vini-e-bevande-alcoliche
[3] Source: ISTAT data elaborated by ICE
[4] Source: AIDA BvD database

3.3 Tree Solutions S.r.l.

Tree Solutions is an innovative SME, founded in 2013, that developed a new system named "BRAIN". This tool collects a great amount of data from existing heating and cooling system and, using machine learning algorithm, it learns the usage of the specific scheme in order to obtain a better management of energy and avoid wasting it. In July 2013 Gunther Breda and Amerigo Restucci founded the company, which since 2015 established its operational headquarters in *Polihub*, the technological district of the Polytechnic of Milan. In 2018 *Tree Solutions* has 11 B2B customers, among these there are very big companies like *Eni Gas e Luce* and *Sorgenia*, who bought the BRAIN system for their customers. Moreover, is being defined a furniture to *BNL GRUPPO BNP Paribas* for its buildings. In 2018 alone, the 34 BRAINs installed have already reduced gas, diesel and LPG consumption by a total of 270 tons of oil equivalent and avoided the emission into the atmosphere of 648 thousand kg of carbon dioxide (CO_2) and 1337 kg of nitrogen oxides (NOX).

For what concern the energy sector, nowadays the main focus is on finding a way to cut energy consumption and to reduce air emissions. In fact, the investments in energy efficiency have a positive trend and reached 6,7 billion of € in 2017[5].

Is it possible to split the investments in Home&Building, Industrial and Public Administration sectors. Among these sectors, the first one has the more expenditure (65% of the total), and 80% of these investments are on pre-existing structure. This is why the company decided to produce a system that can be a useful for the already existing buildings.

The main difficulty for this firm is the competitive environment, because since the energy efficiency market is a new sector and is getting more important day by day, there are a lot of companies that are trying to get their spot. Moreover, another challenge is represented by the indirect competitors. In fact, instead of using a new system, some people could prefer to just replace the heating system with a new one to obtain the same results, without using something that they can find complex.

The strategy to overcome what pointed out before is to accelerate the commercial activities. For this reason, the company will use the capital to hiring new employees like project manager, IT specialists and sales agents. The first two roles are important to withstand the impact of an increasing distribution of the system. On the other hand, the sales agents are very important to improve the direct contact with B2C customers and also to bring

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[5] MIP, Energy&Strategy Group, Energy Efficiency Report 2018.

the *BRAIN system* to the main actors of the B2B market, such as firms that install and maintain the heating system. Moreover, the marketing department need a huge development as well. To reach all these goals it is necessary to deal with a huge expenditure and for this reason the corporate governance decided to start a crowdfunding campaign. The campaign reached €178.500, 179% of the scheduled objective (€100.000).

The campaign gains 146 equity crowdfunders, against the average of 102 obtained by same sector's campaigns in the same platform. Three are professional investors and out of 113 of whom we have information on investing habits, 70 of them already invested in other ECF campaigns[6]. For their campaign *Tree Solutions* choose a threshold of 10.000€ for the Class A quotes, lower than the average threshold (23.151€). One professional investor and two crowdfunders choose Class A shares, for a total of three investors who collected 48% of the total shares' quotes. For campaigns with a similar threshold, we can observe the average of six investors with 43% of the total shares' quotes.

4. Findings

For what concern the case of *Memento S.r.l*, there are 167 firms on national level and 30 firms on regional. Given the availability of data on the Aida database, we take into account two years before the campaign and two years after, Figure 1.a highlights how *MeMento* has a lower level with respect of the other matched samples, in both national and regional mean, until 2019. Notably, we can observe that in the post-campaign period, its level of sales started to rise, reaching the other firms' level, despite having significantly low values before the campaign. Figure 1.b highlights the EBITDA of MeMento. In this case as well, the value is lower than that of its counterparts before the campaign; however, in the post-campaign period, its level rises, surpassing the other firms. Finally, we observe similar results for ROA. Figure 1.c shows that after the crowdfunding campaign, the value of operating performance is higher than that of the counterparts, whereas it was lower before.

Considering the case of *Tree Solution* S.r.l, there are 233 firms on national level and 62 firms on regional level. Taking in account four years before the campaign and four years after, Figure 2.a highlights how *Tree Solutions* has a lower level of sales with respect of the other firms, in both national and regional mean, until 2019. In the post-campaign period, its sales began to rise, approaching the levels of other firms in 2021 and surpassing them the following year.

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[6] Source: AIDA BvD database.

Figure 1 – Sales a), EBITDA b) and ROA c) MeMento's per year with matched regional and national sample
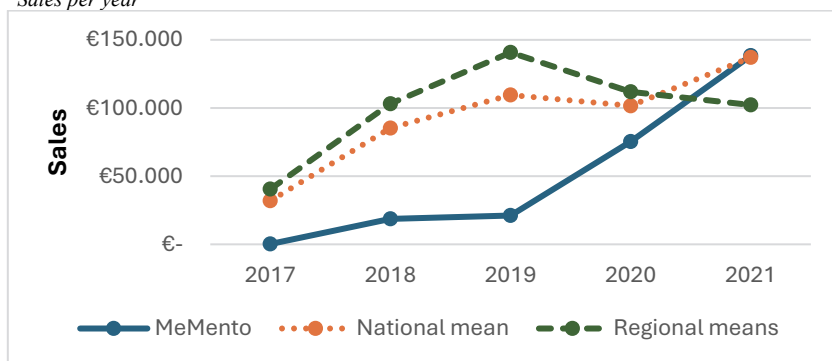
a) *Sales per year*
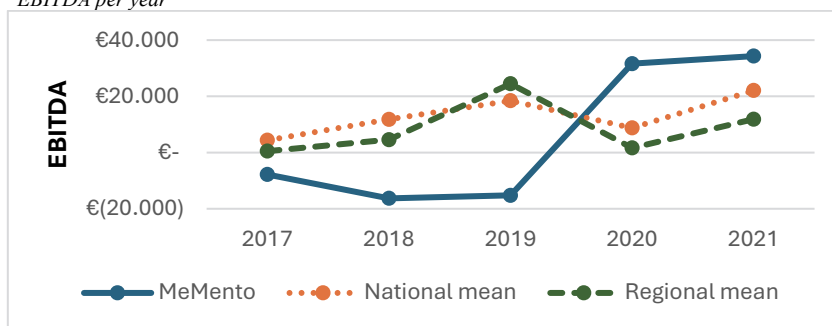
b) *EBITDA per year*

c) *ROA per year*
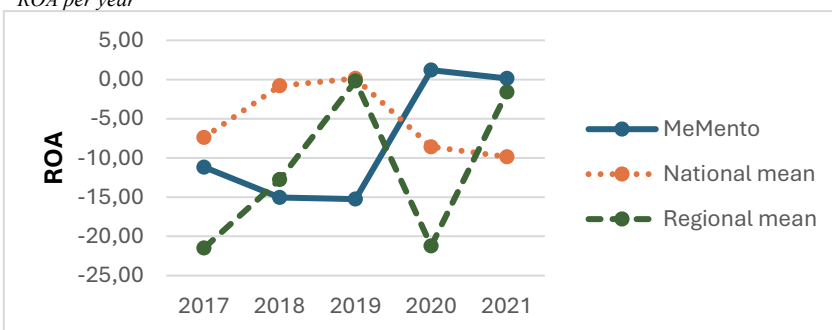
Source: our elaboration on AIDA dataset

Finally, Figure 2 illustrates the EBITDA of *Tree Solutions*, showing results similar to the previous figure.

Figure 2 – Sales a), EBITDA b) and ROA c) Tree Solutions' per year with matched regional and national sample

a) *Sales per year*
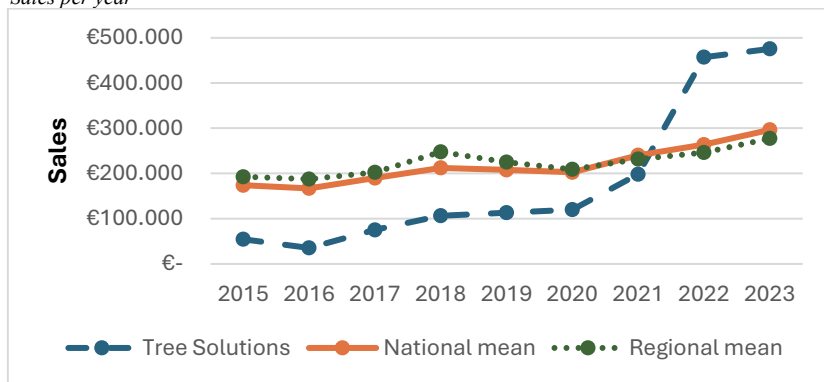
b) *EBITDA per year*
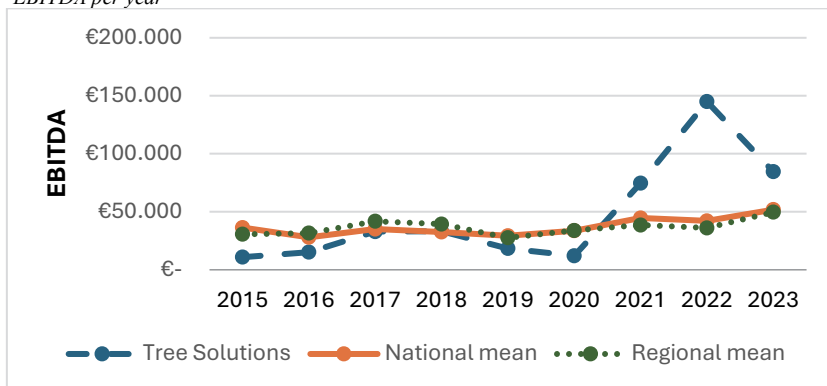
c) *ROA per year*
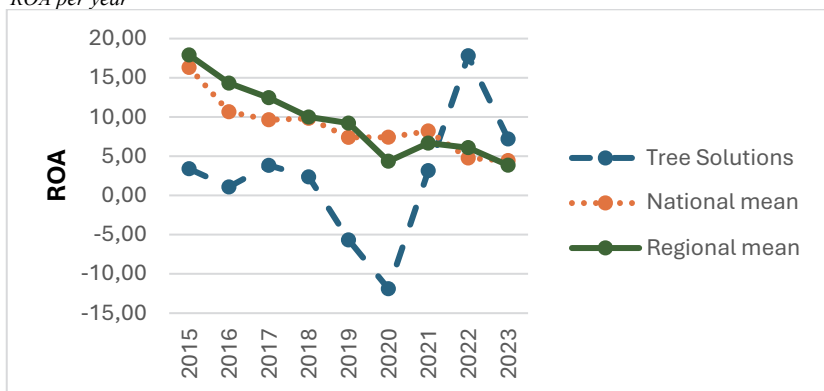
Source: our elaboration on AIDA dataset

Before the campaign, our selected firm was closer to the national and regional averages; however, in the post-campaign period, the index increased, surpassing the values of its counterparts. Regarding operating performance, Figure 2c reveals a pattern very similar to what we observed in Figure 2b. Before the year of the campaign, *Tree Solutions*' ROA was significantly lower than that of its counterparts; however, after the campaign, it increased, surpassing the national and regional averages.

5. Discussion and Conclusion

To explore firm growth in the context of ECF, we employed the multiple case study method. Specifically, we analyzed the growth dynamics of two Italian crowdfunded firms operating in different sectors. Our findings suggest that a successful ECF campaign can help SMEs achieve better performance.

We observed trends in MeMento's financial metrics compared to a matched regional and national sample. Before the crowdfunding campaign, MeMento's performance across all three metrics was consistently lower than the regional and national averages. However, following the campaign, a significant upward trend was observed across all indicators. Regarding *Tree Solutions*, our analysis reveals that prior to the crowdfunding campaign, the firm's financial indicators were generally aligned with or slightly below benchmark levels. However, in the post-campaign period, a marked improvement is evident across all three metrics.

These results underscore the positive influence of crowdfunding on the financial trajectories of both firms, suggesting that external financing through ECF can play a pivotal role in scaling operations and enhancing firm growth and operating performance (e.g., Surowiecki, 2005; Eldridge *et al*., 2021).

This work contributes to the literature by highlighting the importance of equity crowdfunding and of corporate governance system in explaining firm performances (e.g. Eldridge *et al*., 2021; Cariola, 2006). In terms of practical implications, this paper, in line with previous studies (Belleflamme *et al*., 2014; Cumming and Vismara, 2017), highlights that running an equity crowdfunding campaign is a valuable strategy adopted by SMEs for growing motive. In addition, according to Cumming *et al*. (2019), managers attempting to start a crowdfunding campaign, should try to take into account governance implications in order to maximize the performance.

For entrepreneurs, these findings highlight the critical importance of careful planning when launching an Equity Crowdfunding (ECF) campaign (Ahlers *et al.*, 2015; Vismara, 2018). By implementing effective strategies,

entrepreneurs can significantly increase their chances of running a successful ECF campaign and achieving long-term growth. Entrepreneurs should clearly communicate their business model, value proposition, and financial projections to potential investors. It is essential to establish realistic funding targets that accurately reflect the venture's capital needs, as setting overly ambitious goals may discourage investors. Additionally, entrepreneurs must be prepared to meet ongoing reporting and communication obligations, ensuring transparency and accountability after the campaign concludes.

The study has some limitations, mainly referring to the sample size. The limited sample size in this case study-based research restricts the applicability of findings to broader contexts. Selection bias is another concern, as the chosen firms may introduce unintended distortions that affect the validity of the study's conclusions. Addressing these limitations in future research by including a more diverse and representative sample, would enhance methodological rigor and better capture the complexities of real-world business dynamics.

While our findings suggest a compelling link between the success of the two firms and their equity crowdfunding (ECF) campaigns, we recognize that other factors may have contributed to their growth trajectories. Future studies should develop a more nuanced analysis of alternative explanations to provide a broader and more balanced understanding of the firms' performance post-ECF. For example, trends such as the rising demand for sustainable products and digital transformation initiatives could have created favorable market conditions, thereby amplifying growth independent of the ECF campaign (e.g., Crupi *et al.*, 2020; Scuotto *et al.*, 2021). In addition, it is important to note that access to funding through ECF might have facilitated the innovation process, suggesting a potential interplay between financing and innovation-driven growth (Chaudhary *et al.*, 2024).

Finally, comparing the firms under consideration with those that have not engaged in crowdfunding at the national and regional levels highlights the need to further explore the geographical aspect related to ECF dynamics. We hope that this study will encourage future research exploring the relationship between geographical economic conditions (Lazos, 2024), resource acquisition, and growth.

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Adaptation or Persistence?
Capital Structure Choices of Italian Firms Over Time

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Abstract

Understanding how firms finance their activities is crucial for fostering economic growth. The financial life cycle is a critical framework for understanding how firms' financing needs and strategies evolve over time. This paper examines the capital structure choices of Italian SMEs focusing on the role of firm life cycle. Using financial data from 512,027 firms companies over 2012-2023, we observe a nonlinear relationship between age and leverage. Results confirm a lifecycle pattern where younger firms rely more on debt, while mature firms shift towards internal funding. Our evidence supports the persistence of La Rocca *et al.* (2011)'s findings despite significant economic changes, including the global financial crisis, the coronavirus downturn and recent sustainability challenges. Our findings highlight the importance of tailored financing strategies for SMEs based on their life cycle stage.

Keywords: Capital Structure, Debt, Financial Life Cycle, Firm Value.

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Adattamento o persistenza? Le scelte di struttura del capitale delle imprese italiane nel tempo

Sommario

Comprendere come le imprese finanziano le proprie attività è fondamentale per promuovere la crescita economica. Il ciclo di vita finanziario è un quadro cruciale per analizzare come le strategie di finanziamento delle imprese evolvono nel tempo. Questo studio esamina le scelte di struttura del capitale delle PMI italiane, concentrandosi sul ruolo del ciclo di vita aziendale. Utilizzando dati finanziari di 512.027 imprese dal 2012 al 2023, si rileva una relazione non lineare tra età e debito finanziario. I risultati confermano un modello legato al ciclo di vita, secondo cui le imprese più giovani si affidano maggiormente al debito, mentre quelle mature si orientano verso il finanziamento interno. Le nostre evidenze supportano la persistenza delle conclusioni di La Rocca *et al.* (2011), nonostante significativi cambiamenti economici, tra cui la crisi finanziaria globale, la recessione causata dal coronavirus e le recenti sfide legate alla sostenibilità. I risultati sottolineano l'importanza di strategie di finanziamento su misura per le PMI in base alla fase del loro ciclo di vita.

Parole chiave: Struttura Finanziaria, Debito, Ciclo di Vita Finanziaria, valore d'impresa.

1. Introduction

Despite the increasing trend of business expansion driven by the disruptive force of competition processes arising from global challenges, the role of SMEs (SMEs) in the social and economic context of Italy and Europe remains crucial. This appears even more significant considering that small and medium-sized enterprises (SMEs) make up over 99% of EU companies (European Commission, 2023). It is therefore not surprising that over the years, the attention paid by the entire scientific community to this highly significant reality has grown enormously. The defining characteristic of SMEs is undoubtedly the figure of the entrepreneur and her/his ability to create opportunities for survival and value generation through continuous innovation efforts and a distinctive governance model.

In this context, one of the key aspects for the growth of such enterprises lies in the capital structure choices. The financial function, when formally established, is often the one that faces the greatest constraints for SMEs. These companies frequently encounter difficulties in accessing resources from credit and capital markets (Beck *et al.*, 2006). Such difficulties are often linked to various factors, such as: a) the limited availability of asset-based collateral (Beck *et al.*, 2008; Jaffee and Russell, 1976; Menkhoff *et al.*, 2012); b) the challenges entrepreneurs face in rationalizing and

demonstrating to external financiers the feasibility and profitability of their plans (Berger and Udell, 2006; Cowling, 2010); c) the entrepreneur's fear of losing control over their business (Hutchinson, 1995; Cressy and Olofsson, 1997).

The inevitable consequences of these organizational traits include a high cost of capital, a limited range of financial instruments utilized, and a capital structure composed particularly short-term debt (Comana, 2001), as short-term debts are less risky and financial intermediaries are more likely to finance firms with financial difficulties using this form of debt.

All these aspects have led to various attempts to address the controversial and sometimes conflicting theoretical positions regarding the role of capital structure in relation to business performance and the determinants of such financial decisions. This has spurred numerous analyses worldwide, even many years after the contribution of Modigliani and Miller (1963). Indeed, while the literature has traditionally focused on studying large corporations, significant effort has been required in recent years to assess the applicability and relevance of these theories to SMEs. The interest in capital structure decisions – specifically, the selection of the appropriate mix between debt and equity – is important considering the number of SMEs in Europe, as above mentioned. This also applies to Italy, as according to the latest ISTAT data, micro, small, and medium-sized enterprises represent 99% of all active businesses and employ about 76.5% of the total workforce. For many years now, scholars have become increasingly aware of the financial peculiarities of SMEs and the need to redefine financial management models with respect to company size. Various studies have been conducted on the subject, among which the work of La Rocca M., La Rocca T., and Cariola A., titled *Capital Structure Decisions During a Firm's Life Cycle* (La Rocca *et al.*, 2011), stands out. In this article, the authors analyzed a sample of Italian SMEs over the period from 1996 to 2005, and the financing decisions of such SMEs have been examined through the perspective of the business life cycle. Since the existing literature prior to this 2011 article had yielded rather diverse results regarding the determinants of firms' capital structure, the authors hypothesized that this could be due to a lack of consideration for certain important aspects of the firm that might influence financing decisions. Specifically, one particularly significant aspect concerns the firm's age and, more precisely, the stage of the business life cycle it is in. The researchers have shown that companies typically implement particular funding approaches and establish a unique order of financial choices as they progress through various phases of their business life cycle.

This research aims to study whether, many years later, the findings of La Rocca *et al.* (2011) still persist today. Since the publication of La Rocca *et*

al. (2011), the Italian economic context, and particularly the financial sector, has undergone profound changes, influenced by the sovereign debt crisis, European policies, and global events. After the 2008-2011 crisis, Italian banks faced pressure to strengthen their balance sheets, and European supervision and structural reforms led to greater banking concentration as well as the digitalization of services. Since credit constraints is more pronounced during times of crisis (Albareto and Finaldi Russo, 2012; Casey and O'Toole, 2014), during the pandemic and the recent energy crisis the Italian government introduced public guarantees on loans (e.g., the Guarantee Fund for SMEs), but the increase in ECB interest rates since 2022 has made credit more expensive again, negatively impacting businesses with high debt exposure. Today, the ecological and digital transition represents both a challenge and an opportunity, and banks are increasingly moving in this direction (Fasano and Cappa, 2022). Changes in the Italian economic context have had a direct impact on access to credit for businesses (Basile *et al*., 2024). Today, access to credit is strongly influenced by a company's ability to adapt to the challenges of digitalization and sustainability, often required as prerequisites for obtaining new financing. Recent studies show that SMEs with more sustainable orientation have greater access to bank credit and better ability to pay the cost of bank debt (D'Apolito *et al.*, 2024). In light of all these changes, it is particularly interesting to understand whether the capital structure choices of Italian businesses throughout their life cycle have changed compared to many years ago, or if they remain the same. This, of course, has important implications for both businesses and banks. Banks, by understanding the capital structure of businesses at various stages of their life cycle, could apply targeted financing policies based on the businesses' evolving needs, which change throughout the life cycle. While previous studies, such as La Rocca *et al*. (2011), have examined the capital structure decisions of Italian SMEs and their reliance on debt during different stages of their business life cycle, there has been limited research on whether these findings still hold true in the current economic context. This study aims to fill this gap by analyzing whether the capital structure choices of Italian firms have evolved over time or if they remain consistent with past findings, considering the recent economic and financial developments. Thus, the research gap that this article aims to address is to study whether, as highlighted by La Rocca *et al*. (2011), In the start-up and growth stages, firms continue to rely on debt as a crucial financial resource to sustain their business. In contrast, during the consolidation and maturity stages, debt still plays a central role, though to a slightly lesser extent.

The paper is structured as follows. Paragraph 2 presents the main theories on the topic, a brief literature review, and highlights the research gap.

Paragraph 3 outlines the methodology and variables. Paragraph 4 provides the empirical results, while Paragraph 5 offers conclusions and implications.

2. Literature Review and Research Gap

In this paragraph we report the main capital structure theories to assess the extent to which they can explain the financing models of SMEs.

First, the "corrected" Modigliani and Miller theory (1963), which accounts for the tax benefits of debt. It has been widely demonstrated that the M&M theory fails to capture the "real" behavior of firms in the presence of market imperfections. The same applies to SMEs, whose capital structure choices seem to align more closely with alternative models to those proposed by M&M. One theory that appears more applicable in practice is the trade-off theory. The trade-off theory posits that firms aim to achieve an optimal balance between debt and equity (e.g., Kraus and Litzenberger, 1973). According to this approach, established firms are more likely to rely on debt financing. These businesses typically enjoy stable profits, sufficient working capital, and steady cash flows, making financial flexibility less critical for them. Additionally, they face lower distress costs and reduced informational asymmetry (Berger and Udell, 1998; Fasano and Deloof, 2021; Fasano *et al.*, 2023).

Other important arguments are the Pecking Order Theory and the Signaling Theory. The Signaling Theory (Ross, 1977) does not align with the characteristics of SMEs, which are typically not publicly traded on financial markets and are tightly controlled by a few individuals. A different argument applies, however, to the Pecking Order Theory, which seems particularly well-suited to explaining the capital structure behaviors of SMEs. The Pecking Order Theory (e.g., Myers and Majluf, 1984) suggests that firms prioritize their financing choices based on the degree of information asymmetry. According to this hierarchy, they prefer to utilize internally generated funds first, followed by debt, and resort to equity as a last option. The logic of the "closed garden", characterized by aversion to expanding the shareholder base to outside entities, leads to a preference for internally generated funds, which do not incur transaction and agency costs. In summary, small enterprises prefer to finance themselves through self-financing, primarily due to management's fear of losing control of the company (Donaldson, 1961). However, this approach also conflicts with the limited size and high variability of self-generated cash flows, which are typical characteristics of smaller businesses (Carpenter and Petersen, 2002; La Rocca *et al.*, 2015).

Robb and Robinson (2014) note that start-ups are heavily reliant on

external debt, frequently sourced from banks, with many entrepreneurs securing loans using their personal assets. Similarly, Deloof and Vanacker (2018) emphasize that internal funding alone is often insufficient for a new company's growth, making external debt a critical resource for start-ups.

Klein *et al*. (2019) also underscore the significance of debt for young companies, observing that start-ups have increasingly turned to external debt through digital financing platforms.

Deloof *et al*. (2019) highlight that financial markets help mitigate the funding constraints faced by start-ups, encouraging them to utilize debt. Over time, as businesses mature, they tend to generate internal financial resources, which owners are more likely to reinvest into the firm. Furthermore, firms that take on debt in their early stages are more likely to survive and achieve higher revenues (Cole and Sokolyk, 2018).

Given this brief overview of the main capital structure theories, it is important to clarify that the choice of the right debt-equity mix also depends on a number of so-called firm-specific factors that need to be considered. A key factor is the age of the firm, which helps to understand some of the mechanisms behind the capital structure decisions of SMEs (Sánchez-Vidal and Martín-Ugedo, 2012). This refers to the «life cycle theory of financing» (Berger and Udell, 1998; Fluck, 2000). According to this approach, firms choose their capital structure based on the stages of the business life cycle they are in. In the early stage, characterized by high growth and limited existing operations, and contrary to what is assumed by the Pecking Order Theory, firms prefer to finance themselves through the issuance of new equity or, at most, convertible debt (Helwege and Liang, 1996). Only after this initial startup phase firms will begin to rely on self-financing (if available), debt issuance, and, as a last resort, the issuance of new equity. The use of equity (private equity or venture capital) during the early growth phase is driven by the need to grant maximum control to the promoters of the entrepreneurial initiative, who can move to external financiers only if the company produces positive results, in line with the literature on venture capital (Kaplan and Strömberg, 1999).

A vast body of literature emphasizes that the firm's life cycle is a key driver of SMEs' financing policies, which evolve over time as the firm changes its characteristics. Among these studies, the one by La Rocca *et al*. (2011) is particularly relevant. The authors have, in fact, demonstrated that firms tend to adopt specific financing strategies and a distinct hierarchy of financial decision-making as they move through the stages of their business life cycle. Their results showed that contrary to conventional wisdom, debt is found to be crucial for business activities in the early stages, serving as the first choice for financing. In contrast, during the maturity stage, firms adjust

their capital structure by gradually replacing debt with internal capital. For firms that have established their business, the pecking-order theory shows a high degree of applicability.

3. Data, Methodology and Variables

In answering the research question, in line with meny previous empirical studies we extracted the financial statements of Italian limited liability companies from the Orbis database (e.g. Fasano and La Rocca, 2024). Orbis is a dataset developed by Bureau Van Dijk, a company part of the Moody's group, specializing in data collection, processing, and distribution. Orbis is a global database providing detailed information on millions of companies, including Italian ones, covering financial, demographic, and corporate structure data. For Italian firms, Orbis obtains financial statement data from official sources, namely the Chamber of Commerce, ensuring updated and reliable information. Specifically, financial data were extracted for 512,027 Italian limited liability companies classified as SMEs based on the European Union definition over a 12-year period from 2012 to 2023. Subsequently, a statistical analysis was conducted, followed by an econometric analysis to address the research gap.

The variables considered are commonly used in studies in this field. Specifically, we used the same variables as La Rocca *et al*. (2011), additionally including a variable that measures a firm's liquidity level, which is important for private firms (Bigelli and Sánchez-Vidal, 2012). Leverage, which measures the overall financial debt level, calculated as the ratio of financial debt (both short- and long-term) to total assets, a commonly used measure to assess a firm's indebtedness. Cash, which represents the cash and cash equivalents available to firms, also expressed as a ratio to total assets. Size is the natural logarithm of total assets. ROA, calculated as the ratio of net income to total assets, which measures a firm's profitability level. Sales growth, which measures revenue growth year-over-year and serves as a proxy for the firm's ability to seize growth opportunities. Tangibility measures the proportion of tangible assets a firm holds relative to total assets, a critical variable as firms with more fixed assets can provide greater guarantees to banks. Lastly, the Age variable was calculated, representing the firm's age as the difference between the current year and the year of the firm's founding.

The Table 1 provides a description of the variables.

The methodology used follows that of La Rocca *et al.* (2011), which involves estimating the following model.

$$Leverage = Age + Age^2 + control\ variables$$

We used the OLS model with heteroskedasticity-robust standard errors. The dependent variable is Leverage. The capital structure choices during a firm's life are studied using a quadratic model, including both the variable Age, measuring the firm's age, and the variable Age², necessary to test for a potential nonlinear relationship. For better interpretability, the logarithm of the Age variable was used. Age is a crucial factor in financing decisions, as it often reflects the firm's ability to secure funding due to its reputation and higher likelihood of providing guarantees to banks.

Table 1 – Descriptions of variables

Dependent variable	Calculation
Leverage	(Long-Term Bank Debt + Short-Term Bank Debt) / Total Assets
Explanatory variables	
Age	Natural logarithm of a firm's Age
Cash	Cash & cash equivalents / Total Assets
Size	Natural logarithm of Total Assets
ROA	Net Income / Total Assets
Sales Growth	(Sales t – Sales t -1) / Sales t -1
Tangibility	Tangible Assets / Total Assets

4. Results

4.1 Descriptive Statistics and Correlation Matrix

Below are the descriptive statistics of the variables, including the mean, standard deviation, 23rd, 50th (median), and 75th percentiles, as well as the minimum and maximum values.

Table 2 – Descriptive statistics

	mean	sd	min	p25	p50	p75	max
Leverage	0.090	0.155	0.000	0.000	0.000	0.134	1.000
Age	15.222	13.404	0.000	5.000	11.000	22.000	143.000
Cash	0.172	0.192	0.000	0.026	0.101	0.256	3.201
Size	6.503	1.550	0.001	5.397	6.437	7.555	13.138
ROA	0.058	0.159	-0.777	0.014	0.046	0.109	0.591
Sales Growth	0.144	0.328	-0.269	-0.078	0.060	0.285	0.845
Tangibility	0.172	0.179	0.003	0.025	0.096	0.280	0.538

The Table 2 shows that the variable values align with the existing literature. The Table 3 presents the correlations between the variables of interest.

Table 3 – Correlation matrix

	1	2	3	4	5	6	7
Leverage	1.00						
Age	0.12***	1.00					
Cash	-0.23***	-0.11***	1.00				
Size	0.27***	0.48***	-0.25***	1.00			
ROA	-0.09***	-0.04***	0.23***	0.02***	1.00		
Sales Growth	-0.06***	-0.20***	0.06***	-0.10***	0.19***	1.00	
Tangibility	0.18***	0.19***	-0.25***	0.18***	-0.10***	-0.04***	1.00

$^+ p < 0.10, ^* p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$

We also calculated the VIF for each variable, finding a maximum value of 1.12 and an average of 1.10. This indicates no significant multicollinearity issues among our variables.

4.2 Main Model Results

Table 4 shows the results of our main model.

Table 4 – Main model results

	Leverage
Age	0.019***
	(63.92)
Age^2	-0.005***
	(-65.81)
Cash	-0.112***
	(-239.36)
Size	0.023***
	(-339.22)
ROA	-0.044***
	(-82.12)
Sales Growth	-0.004***
	(-15.36)
Tangibility	0.098***
	(186.78)
Number of observations	3.285.512
Adj R-squared	0.136

Industry and year fixed effects are included in the model. t statistics in parentheses
$^* p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$

The model results show that the Age variable is positive and statistically significant, while its quadratic term is negative and statistically significant, confirming the existence of a nonlinear relationship. This approach captures more complex dynamics than traditional linear models, such as the possibility of the relationship diminishing, intensifying, or changing direction. The figure below graphically illustrates the results.

Figure 1 – The leverage-age relationship
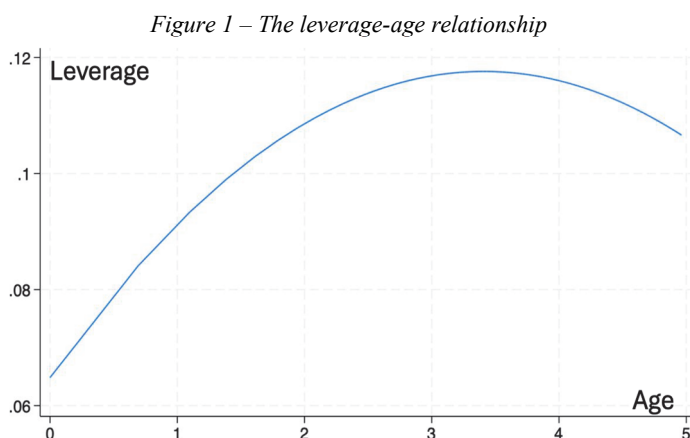
In this case, there is a maximum point where the debt-age relationship shifts from positive to negative. This occurs during the maturity phase of the firm, as also shown by La Rocca *et al.* (2011). Italian firms exhibit a similar pattern, with an initial upward trend indicating that young firms increasingly rely on debt to finance their investments. Moreover, in the maturity phase, firms seek to rebalance debt to stabilize their capital structure. As firms grow, internally generated financial resources, along with alternative funding sources, replace debt, reducing the proportion of financing through loans. Results thus show that the conclusions reached by La Rocca *et al.* (2011) remain valid after many years.

4.3 Further test

The Table 5 shows the results distinguishing between long and short-term financial debt. The results of this further test show that the U-shaped age-debt relationship exists both at the presence of long and short-term financial debt.

We also distinguished between northern and southern Region to test whether there could be a different financial behaviour of SMEs operating in

geographical contexts with many economic and social differences. Results are reported in Table 6.

The results show that despite the many north-south differences the financial behaviour of northern and southern firms is the same and in line with our main model findings.

Table 5 – Further test debt maturity

	Long-term debt	Short-term debt
Age	0.084***	0.005***
	(61.08)	(25.33)
Age²	-0.022***	-0.004***
	(-75.79)	(-9.41)
Cash	-0.186***	-0.080***
	(87.00)	(-284.44)
Size	0.015***	-0.009***
	(57.85)	(214.02)
ROA	-0.013***	-0.022***
	(-5.00)	(-67.56)
Sales Growth	0.024***	-0.004***
	(22.11)	(-21.78)
Tangibility	0.514***	-0.019***
	(268.79)	(-61.53)
Number of observations	3.285.512	3.285.512
Adj R-squared	0.104	0.111

Industry and year fixed effects are included in the model. *t* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6 – Results for northern and southern Regions

	Leverage (subsample of southern firms)	Leverage (subsample of northern firms)
Age	0.011***	0.028***
	(18.78)	(58.96)
Age²	-0.003***	-0.007***
	(-17.59)	(-66.72)
Cash	-0.049***	-0.156***
	(-57.54)	(-230.64)
Size	0.024***	0.021***
	(190.96)	(236.13)
ROA	-0.043***	-0.059***
	(-43.40)	(-73.84)
Sales Growth	-0.008***	-0.004***
	(-16.71)	(-9.21)
Tangibility	0.090***	0.089***
	(105.15)	(-129.93)
Number of observations	779.373	1.683.485
Adj R-squared	0.135	0.121

Industry and year fixed effects are included in the model. *t* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.4 Robustness test

As a robustness test we ran our main model using a different econometric technique, i.e. panel fixed effect. This model helps control for unobserved heterogeneity and provides more reliable estimates given the extensive longitudinal data. Results, which are reported in Table 7, support our main model findings.

Table 7 – Robustness test

	Leverage
Age	0.022***
	(62.81)
Age^2	-0.013***
	(-107.05)
Cash	-0.005***
	(-9.63)
Size	0.028***
	(176.97)
ROA	-0.065***
	(-133.48)
Sales Growth	-0.005***
	(-27.91)
Tangibility	0.102***
	(126.43)
Number of observations	3.285.512
Adj R-squared	0.067

Industry fixed effects are included in the model. *t* statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5. Implications and conclusions

This study analyzed the capital structure choices of Italian firms, focusing on the impact of their life cycle on these decisions. This is a hot topic in managerial finance literature, and we specifically aimed to examine whether the findings of La Rocca *et al.* (2011) remain many years after the authors' contribution. La Rocca *et al.* (2011), using a dataset from 1996-2005, found—contrary to expectations at the time—that young firms heavily rely on debt. Despite their more challenging and costly access to debt, external resources from banks were crucial in the early stages. The lack of internally generated resources and a robust equity market supporting nascent firms led Italian SMEs to rely on debt during their early years, reducing its use over time.

Years later, our analysis confirms these findings, demonstrating that despite crises, wars, and economic changes over the years, the financing preferences of Italian firms remain unchanged. Our results highlight varying debt levels throughout the firm life cycle, with optimal debt levels depending on

firm age. Choosing between debt and alternative financing sources involves benefits and costs whose relevance changes over time. This trade-off evolves, driving firms to make different financial decisions at various stages. We thus observe that despite the financial difficulties faced by young firms, such companies tend to rely heavily on the use of debt, which seems to be the primary financing choice for these firms.

This study confirms that the capital structure decisions of Italian SMEs are strongly influenced by the stage of the business life cycle. The implications of our work suggest that companies, particularly SMEs, must carefully consider their life cycle stage and adapt their financial strategies accordingly. During the initial stages, it is crucial to develop a proactive approach to attract capital, leveraging available opportunities. Banks play a crucial role in supporting SMEs through targeted financing policies. Understanding the dynamics of the business life cycle allows financial institutions to develop specific financial products tailored to the needs of firms at different stages of development. For example, in the start-up phase, banks can offer loans guaranteed by public funds or collaborate with private investors. In later stages, they could focus on refinancing tools to support expansion or debt restructuring.

One limitation of this study is its reliance on historical data, which may not fully capture the most recent economic changes of the last year. Additionally, the analysis is limited to Italian SMEs, which may restrict the generalizability of the findings to other countries with different economic contexts. For future research, it would be beneficial to conduct similar studies in other Italian regions (see for example Butzbach and Sarno, 2019) or European countries (see for example Michaelas *et al.*, 1999) to compare the capital structure decisions of SMEs across different economic contexts. Investigating the capital structure choices of SMEs within specific sectors could also provide valuable insights into sectoral variations. Finally, exploring how the digital (Fasano and La Rocca, 2024b) and ecological (Cariola *et al.*, 2020) transitions influence the financing strategies of SMEs could provide important insights for both businesses and policymakers.

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Digital Technologies and Student Entrepreneurship: Insights from the University of Calabria

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Abstract

The rapid advancement of digital technologies has elevated the importance of innovation, paving the way for digital entrepreneurship. This study contributes to the analysis of digital entrepreneurial intentions among university students by examining micro-level factors (autonomy, self-efficacy, pro-sociality) and meso-level factors (family context, education) using a sample of students from the University of Calabria. The findings indicate that autonomy, self-efficacy, and innovative education significantly enhance the intention to launch digital businesses. While gender and age do not appear to be significant factors, positive family perceptions play a supportive role in fostering digital entrepreneurship. This paper highlights the value of innovative teaching methods and pro-social values, offering valuable insights for future research and practical guidance for universities and policymakers seeking to build robust digital entrepreneurial ecosystems.

Keywords: Digital Entrepreneurship, Entrepreneurial Intention, University Students, Self-Efficacy, Pro-sociality, Digital Entrepreneurial Intention.

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Tecnologie digitali e imprenditorialità degli studenti: l'esperienza dell'Università della Calabria

Sommario

La rapida diffusione delle tecnologie digitali ha incrementato l'importanza dell'innovazione che ha aperto la strada all'imprenditorialità digitale. In questo contesto, si vuole contribuire all'analisi delle intenzioni imprenditoriali digitali fra studenti universitari, individuando fattori micro (autonomia, autoefficacia, pro-socialità) e meso (contesto familiare, formazione) su un campione di studenti dell'Università della Calabria. I risultati evidenziano come autonomia, autoefficacia e formazione innovativa favoriscano l'intenzione di avviare imprese digitali. Genere ed età non risultano significativi, ma percezioni familiari positive supportano l'imprenditorialità digitale. Il contributo sottolinea l'importanza di metodi didattici innovativi e dei valori prosociali, offrendo spunti per ricerche future e suggerendo come università e decisori politici possano sviluppare ecosistemi imprenditoriali digitali.

Parole chiave: Imprenditorialità Digitale, Intenzione Imprenditoriale, Studenti Universitari, Autoefficacia, Pro-sociale, Intenzione Imprenditoriale Digitale.

1. Introduction

In recent years, rapid developments in digital technologies have created new challenges and underscored the importance of innovation for start-ups[1]. Digitalization is considered «the single most important force in entrepreneurship and innovation» (Berger *et al.*, 2021, p. 436). Digital Entrepreneurship (DE) enables the discovery, evaluation and exploitation of novel opportunities to launch innovative goods and services, develop new business models, and create organizational systems by leveraging digital resources as enablers, context, or outcomes (Nambisan, 2017; Bachmann *et al.*, 2024). DE has gained growing attention in both academia and practice, referring to enterprises built on IT-based ideas in the digital economy (Hull *et al.*, 2007; Kollmann, 2008; Nambisan, 2017). It involves starting businesses online, conducting transactions and exchanging data via IT platforms (Tajvidi and Tajvidi, 2020).

Compared with traditional entrepreneurship, DE is typically cheaper, less limited by geography, easier to enter and exit, and more IT-intensive (Nambisan *et al.*, 2019; Wang *et al.*, 2019). Although DE research is still emerging

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[1] According to research conducted by the MIT Center for Digital Business, companies that apply digital transformation are 26% stronger than their competitors and have a 12% higher growth factor.

(Wang *et al.*, 2016), the concept of digital entrepreneurial intention (DEI) is increasingly relevant (Zaheer *et al.*, 2019). DEI describes the intention to create entrepreneurial activities involving digital goods, services, or other forms of digital work (Younis *et al.*, 2020). Student entrepreneurs are individuals who develop a business plan for a new or existing growth-oriented venture (Nabi *et al.*, 2018; Ferrante *et al.*, 2019). In Italy, university-based start-ups have gained scholarly and policymaking interest because they can drive knowledge transfer and regional growth. Programs like Enactus, Start Cup, and Contamination Labs have emerged to support these goals[2].

The World Economic Forum[3] argues that school systems should prepare students to work in dynamic, rapidly changing entrepreneurial and global environments. This vision requires a complete paradigm shift for academia, including changes in both the fundamentals of how schools operate and their role in society. Equipping students across all faculties with entrepreneurial skills can help them create value where uncertainty and resource limitations prevail (Fini *et al.*, 2009). Recent transformations in society and institutions are influencing students' lifestyles and career plans, asking for changing teaching methods and tools along with academic performance. The literature is rich of theoretical reviews (Sitaridis and Kitsios, 2024; Passarelli and Bongiorno, 2025), while empirical articles using data from students were limited (Secundo *et al.*, 2020; Rêgo *et al.*, 2024). Accordingly, this paper proposes an empirical investigation on the main factors influencing DEI among students. Specifically, the case of the University of Calabria is proposed.

This article is structured as follows: Section 2 outlines the theoretical framework for digital entrepreneurial intention among students (DEIS) and the factors that influence it. Section 3 presents the research design, while Section 4 explains the empirical analysis and results. The final section discusses conclusions, implications, and limitations.

2. Theoretical Framework

The growing adoption of digital technologies has heightened the appeal of entrepreneurship as a career (Youssef *et al.*, 2021). Over the past decade, disruptive advances have allowed entrepreneurs worldwide to adopt novel digital solutions (Bachmann *et al.*, 2024; Lungu *et al.*, 2024). Hull et al. (2007) describe DE as "a subcategory of entrepreneurship in which some or

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[2] https://www.enactusitaly.org/; https://www.pnicube.it/startcup; https://clab.cineca.it/;
[3] https://www.weforum.org/stories/2015/08/how-digital-technology-is-transforming-global-education/https://www.weforum.org/stories/2023/07/why-quality-education-is-the-foundation-of-entrepreneurship-and-economic-growth/

all of what would be physical in a traditional organization has been digitized". Meanwhile, Zhao and Collier (2016) define it as "creating new ventures and transforming existing businesses by developing novel digital technologies and/or novel usage of such technologies".

The role of digital media and ICTs in enabling entrepreneurial opportunities is particularly significant, as is the importance of digital infrastructure and entrepreneurial agents within ecosystems (Sussan and Acs, 2017). Platforms and infrastructures that utilize global computing power further underscore the potential of DE (Nambisan, 2017). Moreover, new technologies such as the Internet and ICTs enhance digital capabilities and entrepreneurial performance at every stage of a venture's life cycle (Paul *et al.*, 2023). Although digital platforms and environments offer new perspectives, they also disrupt traditional business operations (Sitaridis and Kitsios, 2024; Lungu *et al.*, 2024). These changes underscore the need to understand how digital tools are reshaping innovation and entrepreneurship. This starts with the entrepreneurial intention (EI) that represents «the conscious mental state before an action that directs attention toward starting a new business and becoming an entrepreneur» (Esfandiar *et al.*, 2019). In this study, we focus on digital entrepreneurial intention (DEI) represents individuals' plans to start new ventures using digital platforms and technologies (Garcez *et al.*, 2023). DEI and EI share many characteristics; however, DEI focuses more strongly on digital tools and can boost EI (Younis *et al.*, 2020). Various theories, including career anchor, career psychology, personality trait, social cognitive career, entrepreneurial attitude orientation, personality-motivation, planned behavior, goal-setting, and positive psychology, help explain technology-driven entrepreneurial intentions (Yeh *et al.*, 2020).

Li *et al.* (2024) show that continuous learning and entrepreneurship education can transform DEI into actual entrepreneurial behavior. Although the general research on entrepreneurial intentions is broad, studies dedicated to DEI among students remain relatively scarce (Secundo *et al.*, 2020). Digitalization allows students to launch ventures even while still studying. Consequently, universities, infrastructure, resources, and digital ecosystems support students' willingness to establish businesses (Garcez *et al.*, 2023). Thus, digital entrepreneurial intention among students (DEIS) involves aspiring to use digital tools and ICT to create new ventures, potentially based on digital goods, services, or activities (Younis *et al.*, 2020).

Based on this body of work, this study identifies the factors influencing the DEIS and explores their relationships and effects. These factors include micro aspects such as personality traits (e.g., neuroticism, agreeableness, extroversion, responsibility, self-efficacy, locus of control, need for achievement, openness to new experiences) (Costa and McCrae, 1992; McGee *et al.*,

2009; Singh Mehdi, 2022; Neneh, 2022), as well as pro-social behaviors directed toward individuals or society (Tiwari *et al.*, 2022). Meso aspects encompass family background and education (Criaco *et al.*, 2017; Badri and Hachicha, 2019; Do Nguyen and Nguyen, 2023). Some researchers argue entrepreneurship is innate (Silva, 2017), while others contend it can be nurtured through education, soft-skill acquisition (Arranz *et al.*, 2017), or a focus on sustainability-driven entrepreneurship (Liang *et al.*, 2019). Table A1 in the Appendix A summarizes these factors.

3. Research Design and Empirical Analysis

3.1 The Case of the University of Calabria

The sample for this study consisted of students from the University of Calabria (UniCal), a medium-sized public university in southern Italy founded in 1972 to promote regional development. UniCal remains dedicated to this mission by facilitating debate and creating an academic community focused on knowledge, cultural education, civic progress, and local economic growth. In terms of technology transfer, UniCal leverages its research output through patents, academic spin-offs, and innovative start-ups. Historically, the university relied on traditional teaching methods with limited online components. Over time, adopting digital resources has significantly influenced students' learning processes, creativity, idea generation, and career aspirations.

3.2 Research Design and Variables

We disseminated a questionnaire to the entire student body at the University of Calabria in the 2023/24 academic year. Appendix A (Table B1) details the three main sections of the questionnaire: (1) socio-demographic information, (2) digital entrepreneurial intention, and (3) micro- and meso-level factors. We received 162 valid responses from undergraduate, master's, and doctoral students. Guided by the factors in Table A1 (Appendix A), we applied an exploratory quantitative approach to investigate DEIS during a period of heightened digital adoption (Vodă and Florea, 2019).

We conducted factor analysis on items measured with 7-point Likert scales. The Kaiser-Meyer-Olkin (KMO) index was 0.7, indicating an adequate sample size. The Bartlett Sphericity Test was significant (p = 0.00), confirming the data were suitable for factor analysis. We retained factors with eigenvalues greater than 1 and used Varimax rotation.

Twelve factors emerged and are presented in Table A2 (Appendix A). The dependent variable (DEIS) measures a student's likelihood of launching a digital business. Building on Valliere (2015) and Rueda *et al.* (2015), it was operationalized as a dichotomous variable (0/1) indicating intent to pursue a digital-based business (Al-Mamary and Alraja, 2022; Krueger and Carsrud, 1993). The independent variables include the factor-analysis scores and control variables.

3.3 Method and Technical Check

We employed a logistic regression model to estimate each student's probability of aiming to start a digital venture (DEIS = 1) or not (DEIS = 0). Before running the regression, we assessed multicollinearity among continuous and categorical variables. Tolerance and Variance Inflation Factor (VIF) values were within acceptable limits (Tolerance > 0.826; VIF < 1.21). For categorical variables, a Spearman correlation analysis removed items with correlations above 0.5. We excluded provinces of residence due to significant correlations ($p < 0.05$). For further details, refer to the "Data Collection and Statistical Validation Procedures section" of Appendix A (Tables A2, A3), which includes methods and tables with references to the tests and variables used.

Figure 1 – Conceptual model
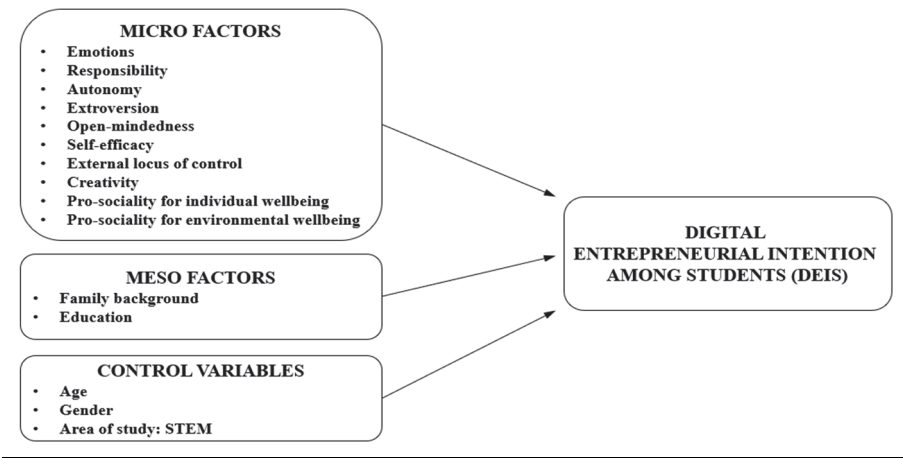
After these checks, 15 variables remained out of the original 20: 2 categorical (gender, area of study: STEM) and 13 continuous (age, educational background, pro-sociality for individual wellbeing, family background, emo-

tions, responsibility, autonomy, extroversion, open-mindedness, self-efficacy, external locus of control, creativity, pro-sociality for environmental wellbeing). The following figure shows the conceptual model.

4. Results

4.1 Descriptive Statistics

Of the respondents, 50% were female, and the average age was 26. Roughly 15.4% had only a high school diploma, 44% held a bachelor's degree, 32% had a master's, 1.2% had a specialization, and 7.4% were doctoral students. About 35% studied business administration, 15.4% economics, 50% STEM disciplines. Approximately 19% reported having a self-employed father, and 15.4% said their father was an entrepreneur. Among mothers, 32% were unemployed, 29.6% employed, and 7% had started a business. Most students were from and resided in the province of Cosenza (50.6%), followed by Catanzaro (19.1%).

4.2 Binary logistic regression

Table 1 shows the logistic regression results. The omnibus test for the model with predictors was statistically significant ($p < 0.05$), indicating satisfactory explanatory power. The model correctly classified about 78.4% of cases. Cox-Snell and Nagelkerke pseudo-R-square measures were 0.436 and 0.582, respectively both above 0.3, suggesting solid predictive ability. According to the Wald test, all included variables were significant (Table 1).

Personal factors, such as autonomy (odds ratio = 4.025), boosted the likelihood of launching a digital business. Self-efficacy (odds ratio = 1.577) also had a positive relationship with DEIS. Pro-sociality for individual wellbeing showed a positive impact on DEIS, indicating that a motivation to use digital technologies for societal benefit can encourage digital entrepreneurship. Education and family background were also significant. Students who took courses featuring innovative teaching methods were more likely (odds ratio = 6.452) to pursue digital entrepreneurship than those in traditional courses. The "area of study: STEM" variable had a strong negative effect on DEIS, possibly because of differences in curriculum design, probably due to lack of cross-disciplinary courses on entrepreneurship. Having parents with business experience also positively influenced students' intent to start digital ventures (odds ratio = 1.507). Neither gender nor age had a significant impact on DEIS.

	Variables	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I. for EXP(B)		
								Lower	Upper	
	Constant	3.111	1.753	3.15	1	0.076	22.438			*
	Emotions	0.234	0.248	0.889	1	0.346	1.263	0.777	2.053	
	Responsibility	0.125	.232	0.289	1	0.591	1.133	0.719	1.784	
	Autonomy	1.392	0.286	23.763	1	0	4.025	2.299	7.045	***
	Extroversion	0.055	0.235	0.054	1	0.816	1.056	0.666	1.674	
	Open-minded-ness	0.359	0.225	2.547	1	0.111	1.432	0.921	2.225	
	Self-efficacy	0.455	0.226	4.062	1	0.044	1.577	1.013	2.455	**
Micro factors	External locus of control	0.246	0.229	1.157	1	0.282	1.279	0.817	2.003	
	Creativity	0.194	0.236	0.674	1	0.412	1.214	0.764	1.927	
	Pro-sociality for individual wellbeing	0.45	0.24	3.526	1	0.06	1.569	0.981	2.511	*
	Pro-sociality for environmental wellbeing	0.157	0.228	0.476	1	0.49	1.171	0.748	1.831	
Meso factors	Family back-ground	0.41	0.223	3.398	1	0.065	1.507	0.974	2.332	*
	Education	1.864	0.331	31.659	1	0	6.452	3.37	12.351	***
	Age	-0.08	0.06	2.143	1	0.143	0.916	0.814	1.03	
Control variables	Gender	0.342	0.521	0.43	1	0.512	1.407	0.507	3.906	
	Area of study: STEM	-1.63	0.604	7.341	1	0.007	0.195	0.06	0.636	***

*Sign. p < 0.001 '***'; 0.05 '**'; 0.1 '*';*

Omnibus Tests Chi-square = 92.844; Sig = 0.000
-2 Log likelihood = 131.118
Cox and Snell Pseudo R Square = 0.436
Nagelkerke Pseudo R Square = 0.582
Percentage Correct (Classification) = 78.4

5. Discussion, Conclusion and Implications

This study investigated the main factors shaping DEIS at an Italian public university. Autonomy and self-efficacy stood out as key individual-level (micro) factors. Educational elements also played a substantial role: innovative teaching methods motivated students to create digital-based businesses (Martínez-Gregorio *et al.*, 2021). This aligns with previous research showing that entrepreneurship education fosters entrepreneurial mindsets (Badri and Hachicha, 2019; Cucino *et al.*, 2022; Passarelli and Bongiorno, 2025) and supports entrepreneurship as a viable career path (Do Nguyen and Nguyen, 2023). Pro-sociality for individual wellbeing also proved influential, suggesting that "positive" digital technology usage can lead to socially beneficial digital ventures (Ghatak *et al.*, 2020). The University of Calabria's longstanding "pro-social mission" may thus reinforce its students' interest in digital entrepreneurship. Digital media and ICT have a measurable effect on students' intentions to pursue digital-based start-ups.

From a pedagogical standpoint, innovative teaching approaches that integrate new technologies can simulate real-world entrepreneurial experiences and foster both hard and soft skills (Tiberius *et al.*, 2023). Universities might introduce standalone courses on soft-skill development or embed these competencies across existing programs (Succi and Canovi, 2020). Methods such as training, case studies, behavioral modeling, metaphor games, storytelling, action learning, design thinking, and role-playing could be effective (Arranz *et al.*, 2017; Passarelli and Bongirono, 2025).

Future academic offerings could emphasize more human-centered and ethically driven practices, promoting socially oriented entrepreneurship through digital tools (Singh and Mehdi, 2022). By integrating these values into both teaching and individual attitudes, universities can expand digital entrepreneurship. Adjusting teaching and outreach activities (the "third mission") can help create ecosystems that yield broader societal value (Amaral *et al.*, 2020).

Moreover, several practical implications can be identified. Universities should foster independent decision-making and problem-solving by incorporating hands-on experiences, start-up simulations, and real-world challenges into their programs. They should also encourage socially responsible digital ventures by supporting hackathons, accelerators, and funding opportunities for impact-driven innovations. To boost entrepreneurial intentions, it is essential to move beyond traditional lectures and integrate experiential learning, case studies, and digital entrepreneurship training into the curriculum. Additionally, Policymakers should ensure that entrepreneurial education is embedded in all university programs, particularly in STEM fields, to foster

innovation and business creation. Policies should also encourage cross-disciplinary courses that integrate business, technology, and digital skills, preparing students for digital entrepreneurship. Facilitating partnerships between universities, tech hubs, and industry leaders, to provide students with real-world entrepreneurial exposure, could be a winning strategy. Moreover, create a supportive ecosystem for digital entrepreneurship, can ensure that students receive the education, resources, and opportunities needed to launch and sustain successful ventures.

5.1 Limitations and Future Research Directions

This paper contributes to the literature on student digital entrepreneurship by highlighting the chief factors driving digital entrepreneurial intention. However, several limitations must be noted. First, because we used a single-university sample, the findings may not be fully generalizable. Future studies that include multiple universities or regions, even internationally, would provide richer comparative insights. Further research focusing specifically on STEM students could provide valuable insights and enhance the existing literature. Pushing the boundaries further, future research could explore factors such as stress, health, biological influences, and neuroscience perspectives (Nicolaou and Shane, 2014; Cucino *et al*., 2021) to better understand how students develop digital entrepreneurial intentions.

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Empowering Entrepreneurship through High-growth Firms: Insights from a Decade-long Bibliometric Analysis

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Abstract

In Italy, the debate on industrial development and economic growth incentives highlights several key themes. Family capitalism celebrated for its resilience, is simultaneously critiqued for curbing innovation and growth potential (Colli *et al.*, 2003; González *et al.*, 2012; Yanagisako, 2020); Medium-Sized Enterprises stand out for their competitiveness, yet their representation – only 0.5% of firms – limits their macroeconomic impact (OECD, 2012). Mean-while, innovation, a cornerstone of sustainable growth, remains stifled by insufficient entrepreneurial support and inadequate public incentives. Finally, capital shortages perpetuate a systemic barrier to industrial expansion, further constraining the nation's economic trajectory. Within this environment, High-Growth Firms (HGFs), or "Gazelles," exhibit exceptional competitiveness despite comprising just 0.2% of manufacturing and 0.4% of service firms in Italy. Defined as firms with over 10 employees and annual employment growth exceeding 20% for three consecutive years, HGFs have been extensively studied (Birch, 1981; Henrekson and Johansson, 2010) yet key growth drivers and the role of innovation ecosystems remain underexplored. To address this, a

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bibliometric analysis of 2012-2021 publications identified 283 highly cited articles, segmented into pre- and post-Industry 4.0/Horizon 2020 periods. Findings highlight three drivers of HGF competitiveness: technology investment for productivity, knowledge networks via open innovation, reskilling initiatives for human capital. Industry 4.0 technologies have expanded expertise access, reduced market entry barriers, and emphasized circular economy practices, fostering ambidextrous growth. To sustain HGFs, industrial policies must adapt and expand to meet innovation demands, leveraging these insights to replicate success across evolving economic landscapes.

High Growth Firm e sviluppo imprenditoriale: temi emergenti

Sommario

In Italia, il dibattito sullo sviluppo industriale e sullo sviluppo degli incentivi alla crescita economica ha nel tempo messo in luce diversi temi chiave. Il capi-talismo familiare, celebrato per la sua resilienza, è al contempo criticato per il suo effetto limitante sull'innovazione e sul potenziale di crescita (Colli *et al.*, 2003; González *et al.*, 2012; Yanagisako, 2020). Le medie imprese, pur distinguendosi per la loro competitività, rappresentano solo lo 0,5% delle aziende, riducendo così il loro impatto macroeconomico (OECD, 2012). Nel frattempo, l'innovazione, una pietra angolare della crescita sostenibile, continua a essere ostacolata da un insufficiente supporto allo sviluppo di iniziative imprenditoriali e da incentivi pubblici inadeguati. Da ultimo, le carenze di capitale rappresentano una barriera sistemica all'espansione industriale, limitando ulteriormente la traiettoria economica del Paese. In questo contesto, le High-Growth Firms (HGF), o "Gazelle", mostrano un'eccezionale competitività nonostante costituiscano appena lo 0,2% delle imprese manifatturiere e lo 0,4% di quelle nei servizi in Italia. Definite come imprese con oltre 10 dipendenti e una crescita annua dell'occupazione superiore al 20% per tre anni consecutivi, le HGFs sono state ampia-mente studiate (Birch, 1981; Henrekson e Johansson, 2010); tuttavia, i principali fattori di crescita e il ruolo degli ecosistemi dell'innovazione nel sostenerne sviluppo e crescita rimangono poco esplorati. Per affrontare questa lacuna, un'analisi bibliometrica sulla principale letteratura scientifica del periodo 2012–2021 ha identificato 283 articoli altamente citati, suddivisi tra i periodi pre- e post-Industria 4.0/Horizon 2020. I risultati evidenziano tre fattori trainanti della competitività delle HGF: investimenti tecnologici per la produttività, reti di cono-scenza sostenute dalla diffusione dell'open innovation, iniziative di riqualificazione del capitale umano. Le tecnologie dell'Industria 4.0 hanno ampliato l'accesso all'expertise, ridotto le barriere all'ingresso nei mercati e dato enfasi alle pratiche di economia circolare, promuovendo una crescita ambidestra. Per sostenere le HGFs, le politiche industriali devono adattarsi ed espandersi per rispondere alle esigenze

dell'innovazione, sfruttando questi approfondimenti per replicare il successo in contesti economici in evoluzione.

Parole chiave: High-Growth Firms (HGFs), Industry 4.0, Knowledge networks, Open innovation, Human capital.

1. Introduction and Background

The rise of Industry 4.0 – characterized by technologies like Internet of Thing (IoT), Artificial Intelligence (AI), and big data – has raised the interest of researchers on business and innovation models and also on firm performance (Passarelli *et al.,* 2019; Cariola and Passarelli 2020; De Giovanni and Cariola 2021). In this context, High Growth Firms (HGFs) or "Gazelles" started to play a pivotal role in job creation, innovation, and economic dynamism, despite being relatively rare. HGFs are a small but significant group of businesses with annual growth rates of 20% or more in employment or revenue over three consecutive years (Birch 1981).

In the last years, several researchers, have proposed literature as well as empirical studies, to explore the characteristics of HGFs (Martínez-Fierro *et al.,* 2019; Rocha and Ferreira 2021). However, several gaps remain in understanding the determinants of growth in the context of Industry 4.0. While previous studies have explored the role of innovation ecosystems (Martínez-Fierro *et al.,* 2019), firm capabilities (Rocha and Ferreira 2021), and policy frameworks (Horbach, 2008), a comprehensive assessment of how Industry 4.0 technologies influence the scalability and strategic positioning of HGFs is still missing. Additionally, the interplay between digital transformation and firm-level absorptive capacity remains underexplored, requiring further empirical validation. Thus, the present study proposes a bibliometric analysis to map the evolution of HGF research, particularly before and after the widespread adoption of Industry 4.0 (2016). This analysis helps identify the dominant themes, the main changes before and after the introduction of industry 4.0, offering new insights and future perspectives.

The paper is structured as follows: the first section provides an introduction to the research topic, outlining its relevance and objectives. The second section presents a comprehensive review of the literature, establishing the theoretical framework and key concepts. The third section details the research methodology, including data collection and analysis techniques. The fourth section discusses the results, highlighting key findings and their implications. Finally, the paper concludes with a summary of insights, contributions to the field, and potential directions for future research.

2. HGF and Industry 4.0: Background

One interesting view over HGF derive from the diffusion of the concept of industry 4.0. Introduced for the first time in 2011 during the Hannover Fair in Germany, this concept represents a transformative phase in industrial and manufacturing systems, characterized by the integration of digital and cyber-physical technologies within production processes and supply chains (Meindl *et al.,* 2021). At its core, Industry 4.0 relies on foundational technologies such as the Internet of Things (IoT), cloud computing, big data, and artificial intelligence to create intelligent production systems. The evolution of Industry 4.0 has been closely linked to the rise of four key dimensions: smart manufacturing, smart supply chain, smart products and services, and smart working, which reflect the increasing interconnectedness of various industrial functions and the shift toward fully integrated and adaptable manufacturing systems. Over the past decade, research in this field has significantly contributed to increase the degree of efficiency and effectiveness of the frame. One of our hypotheses is that the spread of Industry 4.0-related literature has significantly reshaped the concept of HGF, deeply influencing its defining dimensions. We specifically anticipate that the networks influencing and defining the concept of High-Growth Firms (HGF) have undergone significant transformations in the periods before and after the widespread adoption of Industry 4.0. These changes likely reflect shifts in technological paradigms, business models, and innovation ecosystems, which have restructured the way firms scale, collaborate, and compete in an increasingly digital and automated industrial landscape. For this reason, considering that the first government incentives related to industry 4.0 were formally introduced starting in 2011 – with a concrete launch marked by the Advanced Manufacturing Partnership in the USA – we have chosen 2016 as the cut off year for the pre-Industry 4.0 phase. The selection of 2016 as the cut off year for distinguishing pre- and post-Industry 4.0 is pivotal yet requires explicit justification. The year 2016 marked a critical turning point in global industrial dynamics, coinciding with the Fourth Industrial Revolution gaining widespread recognition. The World Economic Forum's annual meeting in Davos in 2016 cantered on Industry 4.0 technologies such as artificial intelligence, robotics, and the Internet of Things (IoT), emphasizing their transformative potential across sectors (Schwab 2016). Furthermore, several nations, including Germany, the United States, and China, launched strategic initiatives to integrate these technologies into their manufacturing sectors, symbolizing a global commitment to this industrial paradigm. By aligning the analysis to this milestone, the study ensures temporal relevance and contextual accuracy in understanding the evolving role of High-Growth Firms (HGFs).

3. Methodology

We adopted recent methodologies in bibliometric research (Ferreira and Serpa 2018; Caputo *et al.,* 2021) using a systematic review protocol for data collection (Wright *et al.,* 2007). The search, selection, and analysis of articles followed a structured procedure designed to identify the most relevant studies (Tranfield *et al.,* 2003; Denyer and Tranfield 2009). Throughout the process, we adhered to principles of equality, focus, accessibility, and transparency in handling the identified items (Thorpe *et al.,* 2005). Bibliometric-based citation analysis provides a powerful framework for mapping the intellectual structure and thematic progression of high-growth firm (HGF) research. This approach uses bibliometric data to visualize the state of art of the field and possible future researchers. Specifically, we retrieved bibliographic data from the Web of Science database using an extensive Boolean search including terms related to HGF, such as "Firm growth determinants", "Firm growth antecedents", "High-growth firms", "Innovation ecosystem", "Driver of innov*", "Driver of dynamic sectors", "Innovative firms" and "Gazelles firms". We included 283 articles from 2012 to 2021. We used R Bibliometrix syntax for the bibliometrix analysis.

Grounding on Aria and Cuccurullo (2017) definition of co-citation, we have investigated the intellectual framework in order understand how an author's work influences the scientific community using co-citation analysis (Kessler 1963), which examines whether two works are jointly cited by a third work. Over time, co-citation analysis can help identify changes in paradigms and schools of thought.

4. Main Findings

The analysis has been carried out across two distinct research trajectories in High-Growth Firms (HGF) studies, delineating the pre-Industry 4.0 period (before 2016) and the post-Industry 4.0 period (from 2016 onward). This segmentation allows for a comparative examination of how Industry 4.0 has influenced the evolution, dynamics, and strategic behavior of HGFs, highlighting key shifts in innovation, technology adoption, and market positioning between the two phases (Liao *et al.,* 2017; Dalenogare *et al.,* 2018).

4.1 The phase Pre industry 4.0

We performed a co-citation analysis on the most highly cited articles to identify the most influential authors and the trajectories of research within the field. This analysis uncovered a complex intellectual structure, delineating five distinct clusters that form the foundation of the field's theoretical and empirical framework. Table 2 provides a detailed breakdown of the articles categorized by cluster, while Figure 1 offers a graphical representation of the clusters, illustrating their interconnections and thematic focus.

Table 1 – Clusters detail of co-citation for pre industry 4.0

Cluster	Reference
1	Schumpeter J.A. 1934, Acs Z.J. 1990, Griliches Z 1990, Pavitt K 1984, Schumpeter J.A. 2003, Acs Zj 2008, Audretsch Db 1996, Audretsch Db 2005, Griliches Z 1979, Storey Davidj. 1994, Aghion P 1992, Coad A 2008, Heckman Jj 1979, Lucas Re 1988, Acs Zj 1988, Crepon B. 1998, Dosi G 1988, Fazzari Sm 1988, Hall B. 8498, Hall Bh 2002, Holzl W 2009, Jaffe Ab 1986, Jaffe Ab 1989, Jensen Mc 1976, La Porta 1999, Shane S 2009, Acharya Vv 2009, Acs Zj 2002, Acs Zj 2009, Akerlof Ga 1970, Arrow K. 1962, Audretsch D. 2006, Bushee Bj 1998, Chandler A.D. 1990, Colombo Mg 2005, Delmar F 2003, Geroski Pa 1995, Greene W.H. 2003, Hall Bh 2005, Henrekson M 2010, Himmelberg Cp 1994, Kirzner Im 1997, Klapper L 2006, La Porta 1998, Laporta R 1997, Malerba F 1995, Miller D. 2005, Nelson Rr 1959, Rajan Rg 1998, Romer Pm 1986, Romer Pm 1990, Santarelli E 2007, Saxenian A. 1994, Schneider C 2010, Shane S 2000
2	Horbach J 2008, Porter Me 1995, Rennings K 2000, Brunnermeier Sb 2003, Hart Sl 1995, Schmookler J. 1966, Jaffe Ab 1997, Suchman Mc 1995, Cleff T. 1999, Jaffe Ab 2002, Popp D 2006, Gonzalez Pd 2009, Horbach J 2012, Jaffe Ab 1995, Lanjouw Jo 1996, Lanoie P 2011, Peters M 2012, Rehfeld Km 2007
3	Cohen Wm 1990, Barney J 1991, March Jg 1991, Henderson Rm 1990, Nelson R.R. 1982, Dosi G 1982, Katila R 2002, Laursen K 2006, Chesbrough H.W. 2003, Teece Dj 1986, Powell Ww 1996, Eisenhardt Km 1989, Kogut B 1992, Podsakoff Pm 2003, Tushman Ml 1986, Cassiman B 2006, Eisenhardt Km 2000, Jaffe Ab 1993, Leonardbarton D 1992, Levinthal Da 1993, Teece Dj 1997, Wooldridge J.M. 2002, Chesbrough H. 2006, Cyert R.M. 1963, Dahlander L 2010, Eisenhardt Km 2007, Hargadon A 1997, Rosenkopf L 2001, Von Hippel 1988, Von Hippel 2005, Wernerfelt B 1984, Ahuja G 2000, Bathelt H 2004, Boschma Ra 2005, Chesbrough H.W. 2006, Dierickx I 1989, Fleming L 2001, Garud R 2003, Granovetter Ms 1973, He Zl 2004, Leiponen A 2010, Lundvall B.A. 1992, Nelson R.R. 1993, Ocasio W 1997, Ocasio W 2011, Schumpeter Joseph 1934, Shan Wj 1994
4	Vargo Sl 2004, Dimaggio Pj 1983, Payne Af 2008, Vargo Sl 2008, Vargo Sl 2011, Vargo Stephen 2008, Bourdieu P. 1977, Chandler Jd 2011, Edvardsson B 2011, Giddens A. 1986, Mccoll-Kennedy Jr 2012, Meyer Jw 1977, Prahalad Ck 2000, Simon H. 1996
5	Iansiti M. 2004, Boudreau Kj 2012, Rochet Jc 2003, Adner R 2010, Caillaud B 2003, Christensen Cm 1995, Eisenmann T 2006, Gawer A. 2002, Smith Wk 2011, Tiwana A 2010, Armstrong M 2006, Baldwin C.Y. 2000, Boudreau K 2010, Boudreau Kj. 2009, Ceccagnoli M 2012, Christensen Clayton 1997, Dhanaraj C 2006, Eisenmann T 2011, Evans D. 2006, Gawer A 2007, Gawer A 2008, Glaser B.G. 1967, Jacobides Mg 2006, Moore Jf 1993, Parker Gg 2005, Stinchcombe A.L. 1965

Figure 1 – Large component of the citation network in the pre industry 4.0 phase
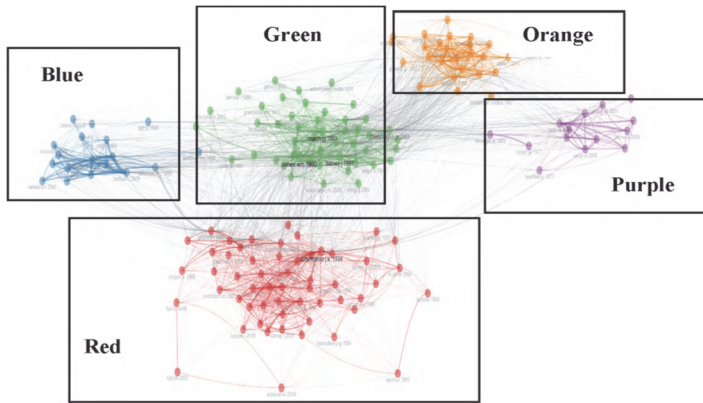
- *The first cluster (Red)* focuses on the economic foundations of innovation, anchored by Schumpeter's (1934) theory of creative destruction; it reminds also Griliches' (1979) insights on R&D spillovers, highlighting the pivotal role of innovation in driving economic growth. These perceptions are particularly relevant to explore the dynamic evolution of High-Growth Firms (HGFs), as the disruptive power of innovation is often the engine behind their rapid scaling and economic impact. HGFs leverage R&D spillovers and capitalize on innovation-driven opportunities to establish competitive dominance in their industries.
- *The second cluster (Green)* delves into organizational and strategic dimensions, emphasizing absorptive capacity (Cohen and Levinthal 1990), resource-based views (Barney 1991) and the balance between exploration and exploitation (March 1991) as critical enablers of competitive advantage. For HGFs, these theories are essential: absorptive capacity enables these firms to rapidly assimilate and apply external knowledge, while the resource-based view underscores the importance of leveraging unique internal assets to sustain growth. Furthermore, their ability to balance exploration (innovation) and exploitation (efficiency) is a hallmark of their adaptability and success in volatile markets.
- *The blue cluster* delves into the role of institutional and policy frameworks, with key contributions such as DiMaggio and Powell's (1983) institutional isomorphism and Porter's (1995) hypothesis linking regulation to competitive advantage. HGFs, operating in dynamic and often regulated environments, exemplify how firms can use institutional and regulatory pressures as drivers for innovation. For example, the Porter hypothesis suggests that well-designed environmental regulations can spur

innovation, a strategy often observed in HGFs that lead in green technologies or eco-innovation.

- *The orange cluster* centres on the dynamics of networks and ecosystems, featuring Chesbrough's (2003) open innovation and Powell's (1996) insights into inter-organizational collaborations. HGFs thrive in networked ecosystems, using partnerships, alliances, and collaborations to access resources, expand their market reach, and accelerate innovation. Open innovation practices allow these firms to integrate external ideas and technologies, creating a virtuous cycle of growth and innovation.
- *Finally, the purple cluster* highlights the intersection of environmental sustainability and technological change, drawing on works like Horbach's (2008) analysis of environmental innovation and Schmookler's (1966) demand-pull theory. These insights align with the strategies of HGFs in industries where environmental concerns and technological advancements converge. Such firms often lead in developing environmentally sustainable innovations that address market demands while also driving competitive advantage and long-term growth.

4.2 Findings: Post-Industry 4.0 (2016-2021)

As for the pre-Industry 4.0 period, from the co-citation analysis, we immediately observed a notable shift toward a reduced number of clusters, reflecting an evolution characterized by increased specificity and a more focused exploration of key themes. This narrowing of thematic scope is accompanied by a parallel refinement of the theoretical paradigms that underpin these works, signing a trend toward greater conceptual clarity and practical application in the theories developed during this period.

Table 2 – Clusters detail of co-citation for post industry 4.0

Cluster	Reference
1	Barney J 1991, Teece Dj 1997, Cohen Wm 1990, Laursen K 2006, Chesbrough H.W. 2003, Fornell C 1981, Podsakoff Pm 2003, Dahlander L 2010, Nelson R.R. 1982, Eisenhardt Km 1989, Eisenhardt Km 2000, Vargo Sl 2004, March Jg 1991, Werner-felt B 1984, Chesbrough H.W. 2006-1, Grant Rm 1996, Hart Sl 1995, Katila R 2002, Dyer Jh 1998, Penrose E.T. 1959, Teece Dj 2010, Boons F 2013, Chesbrough H. 2006, Dosi G 1982, Eisenhardt Km 2007, Gioia Da 2013, Osterwalder A. 2010, Strauss A. 1998, Tranfield D 2003, West J 2014-1, Anderson Jc 1988, Chen Ys 2006, Crossan Mm 2010, Del Giudice 2014, Granovetter Ms 1973, Huizingh Ekre 2011, Nonaka I 1994, Nonaka I. 1995, Ocasio W 1997, Tushman Ml 1996, Van De 2009, West J 2014-2, Alavi M 2001, Armstrong Js 1977, Bansal P 2000, Carrillo-Hermosilla J 2010, Cyert R.M. 1963, Dimaggio Pj 1983, Hair J.F. 2009, Horbach J 2008, Kammerer D 2009, Nahapiet J 1998, Payne Af 2008, Pfeffer J. 1978, Porter M. 1985, Porter Me 2014, Powell Ww 1996, Russo Mv 1997, Spender Jc 1996, Uzzi B 1997, Von Hippel 2005, Vrontis D 2017, Zahra Sa 2002, Angelidou M 2014,

	Bocken Nmp 2014, Cavusgil St 2003, Chang Ch 2011, Chesbrough H. 2014, Chesbrough H.W. 2006-2
2	Acs Zj 2014, Autio E 2014, Isenberg Dj 2010, Feld B. 2012, North Dc 1990, Schumpeter J.A. 1934, Spigel B 2017, Bathelt H 2004, Cooke P 1997, Lumpkin Gt 1996, Shane S 2000, Stam E 2015, Acs Zj 2009, Acs Zj 2017, Audretsch Db 2016, Autio E 2018, Bahrami H 1995, Delgado M 2010, Mack E 2016, Marshall A. 1920, Nambisan S 2017, Porter Me 1998, Aghion P 1992, Asheim Bt 2011, Audretsch Db 1996, Brown R 2017
3	Adner R 2010, Teece Dj 2007, Moore Jf 1993, Gawer A 2014-1, Adner R 2017, Gawer A 2014-2, Gawer A. 2002, Teece Dj 1986, Adner R 2006, Zott C 2011, Henderson Rm 1990, Yoo Yj 2010, Kapoor R 2013, Gawer A 2007, Iansiti M 2004, Jacobides Mg 2018, Lusch Rf 2015, Nambisan S 2013, Parker G.G. 2016, Rochet Jc 2003, Wareham J 2014, Cennamo C 2013, Eisenmann T 2006, Iansiti M. 2004, Autio E. 2014, Boudreau K 2010, Ceccagnoli M 2012, Clarysse B 2014, Gulati R 2012, Parker Gg 2005, Ritala P 2013, Sarasvathy Sd 2001, Tilson D 2010, Adner R 2016, Christensen Clayton 1997, Coase Rh 1937, Dhanaraj C 2006, Evans Ds. 2016, Gawer A 2008, Jacobides Mg 2006, Moore J.F. 1996, Rohrbeck R 2009, Thomas Ldw 2014, Tiwana A 2010, Van Der 2012, West J 2003, Williamson Pj 2012, Yoo Y 2012, Adner Ron. 2012, Ansari S 2016, Baldwin C.Y. 2000, Chesbrough H 2014, Hagiu A 2015, Kapoor R 2015, Katz Ml 1985, Nelson R.R. 1993, Santos Fm 2009, Vargo Sl 2015, Alexy O 2013, Amit R 2001, Anderson P 1990, Armstrong M 2006, Boudreau Kj 2012, Caillaud B 2003, Casadesus-Masanell R 2007

Figure 2 – Large component of the citation network in the post industry 4.0 phase
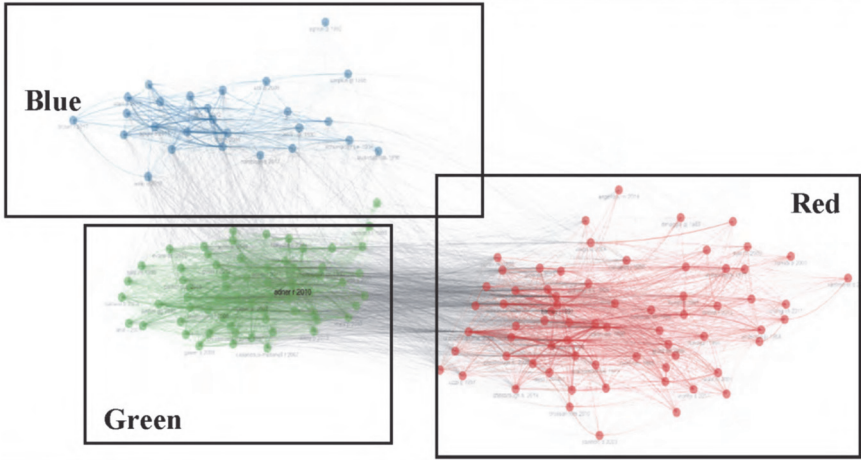
Under this perspective the co-citation analysis highlights thematic clusters that provide a nuanced perspective on the dynamic drivers of high-growth firms (HGFs) in a post-Industry 4.0 context, emphasizing innovation ecosystems, entrepreneurial frameworks, and strategic adaptability. This structure can be contrasted with the pre-Industry 4.0 framework, which emphasized foundational theories and the interplay between economic, organizational, institutional, and ecological dimensions. We found three different cluster.

- *Cluster 1 (Red): resource-based view and dynamic capabilities*: this cluster highlights the importance of internal firm competencies, particularly the resource-based view (Barney 1991) and dynamic capabilities (Teece *et al.,* 1997), as critical drivers for high-growth firms (HGFs). These firms achieve rapid scaling by leveraging unique, inimitable resources and adapting to environmental changes through dynamic capabilities. The concept of absorptive capacity (Cohen and Levinthal, 1990) further enriches this cluster by emphasizing HGFs' ability to assimilate and apply external knowledge to drive innovation. In comparison to the pre-Industry 4.0 analysis, this cluster closely aligns with the green cluster, which also focuses on absorptive capacity and resource-based views. However, the post-Industry 4.0 perspective builds on these ideas by emphasizing the role of dynamic capabilities as essential for navigating rapid technological advancements and digital transformation in this era.
- *Cluster 2 (Blue): entrepreneurial ecosystems and national systems of entrepreneurship*. This cluster examines systemic factors that shape entrepreneurial success, with a focus on the role of institutional contexts and ecosystems. Foundational works like Acs *et al.,* (2014) on national systems of entrepreneurship and Isenberg's (2010) framework for entrepreneurial ecosystems highlight the importance of supportive policies, cultural norms, and robust networks in fostering the success of high-growth firms (HGFs). The pre-Industry 4.0 blue cluster emphasized institutional and policy frameworks, drawing on concepts such as DiMaggio and Powell's (1983) institutional isomorphism and Porter's (1995) hypothesis. While both analyses acknowledge the importance of institutions, the post-Industry 4.0 framework shifts its focus to the dynamic interactions within entrepreneurial ecosystems, reflecting the growing complexity and interconnectedness of contemporary markets.
- *Cluster 3 (Green): Co-development and technological change*. This cluster examines the interdependencies and co-evolution within innovation ecosystems, with seminal contributions such as Adner and Kapoor's (2010) work on value creation in innovation ecosystems and Moore's (1993) analogy of business ecosystems. HGFs thrive in these ecosystems by leveraging technological interdependence and engaging in strategic collaborations that drive innovation. The orange cluster from the pre-industry 4.0 framework focused on networks and inter-organizational collaborations (Chesbrough, 2003).

5. Conclusion and Contribution

The evolving conceptual structure reflects the heightened complexity and interconnectedness of HGF dynamics in the Industry 4.0 era. While the pre-Industry 4.0 period laid the groundwork by emphasizing innovation ecosystems and institutional frameworks, the post-Industry 4.0 phase integrates these elements into a cohesive model that prioritizes performance, adaptability, and sustainability. This transition demonstrates how the emphasis has shifted from foundational concepts and broad institutional frameworks to more integrated and performance-oriented themes, reflecting the increasing complexity and interconnectedness of innovation systems in the Industry 4.0 era. These evolving clusters also underscore the critical role of High-Growth Firms as drivers of innovation, linking their rapid scalability to strategic use of resources, systemic support structures, and long-term market evolution. This study illuminates the transformative journey of high-growth firms (HGFs) as they navigate an increasingly complex industrial landscape. In the pre-Industry 4.0 phase, research centred on foundational strategies – value creation, resilience, and resource management – that underscore the significance of internal capabilities and adaptive strength for sustainable growth. With the onset of Industry 4.0, however, the focus shifted toward the integration of advanced technologies and external ecosystems, highlighting concepts such as absorptive capacity, co-development and eco-innovation. This shift reflects a broader redefinition of competitive advantage and firm performance, where HGFs leverage digital transformation and sustainability to remain agile and impactful. Our findings are in line with the topic addressed by Alfio Cariola in the last years. His papers focused on the co-development of innovation, on the role of open innovation in the perspective to improve firm performance. As an engineer, Alfio was always interested to the theme of new technologies. In the last years, he also focused the attention on some issues related to Industry 4.0, by producing also papers and conference contributes. He was a meticulous researcher and he liked to understand in deeply all the phenomenon; for this reason, co-citation analysis was among the literature review who preferred in the last years of his research activity. Alfio we miss you.

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Reflective vs. Formative Measurement Models in Operations and Supply Chain Research

*Pietro De Giovanni**

Abstract

This research seeks to highlight a common mistake that researchers in the area of Operations and Supply Chain Management (O&SCM) make when selecting the measurement models in Structural Equation Modelling. In fat, the unproper selection of a measurement model in Structural Equation Modeling (SEM) research can lead to issues of model misspecification and non-valid findings. Therefore, this is the first study in O&SCM that highlights the differences between reflective and formative measurement models in SEM and invites researchers in this field to reflect and pay attention to the measurement model selection before diving into a statistical analysis.

Keywords: Structural Equation Modeling, Formative Models, Reflective Models, Misspecification.

Modelli di misurazione Riflessivi vs. Formativi in Operations e Supply Chain

Sommario

Questa ricerca si propone di evidenziare un errore comune commesso dai ricercatori nel campo dell'Operations e Supply Chain Management (O&SCM) nella

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scelta dei modelli di misurazione all'interno della Structural Equation Modeling (SEM). Infatti, una scelta inappropriata del modello di misurazione nella ricerca basata sulla SEM può condurre a problemi di misspecification del modello e a risultati non validi. Pertanto, questo è il primo studio nel campo dell'O&SCM che mette in luce le differenze tra i modelli di misurazione riflessivi e formativi nella SEM, invitando i ricercatori in questo filone a riflettere e a prestare la dovuta attenzione alla selezione del modello di misurazione prima di procedere con l'analisi statistica.

Parole chiave: Structural Equation Modeling, Modelli Formativi, Modelli Riflessivi, Specificazione del modello.

1. Introduction

Recent research in various fields has highlighted the scarce attention in choosing the proper measurement model in Structural Equation Modelling (SEM) (e.g., Jarvis *et al.*, 2003; Petter *et al.*, 2008). The correct correspondence between constructs and measures is a needed prerequisite to develop theories through a correct research hypotheses testing and thus avoid misspecification concerns. The classical test theory assumes causality between a construct and its measures, thus a change in the construct *causes* a change in the related measures (Bollen, 1989). Although this assumption holds in many instances, it turns out to be inappropriate in all cases when a construct can be seen an index made by some observable variables rather than being considered as their cause. Technically, this difference consists of the right selection of the measurement models, which can be either reflective or formative. Formally, the model misspecification leads to several problems such as: different assumptions, different interpretation of relationships and, most importantly, different statistical results.

Choosing the measurement can lead to serious concerns. As highlighted by Jarvis *et al*. (2003), 29% the articles in marketing has wrongly selected the measurement models for their empirical studies. Similarly, Petter *et al*. (2008) highlighted the common mistake that empirical research shares in the field information systems: a three-year analysis of the literature has revealed the scarce attention paid by researchers in the analysis and selection of measurement models. Podsakoff *et al*. (2006) show inappropriate modeling for 62% of constructs published in three major strategic management journals, while Podsakoff *et al*. (2003) report a misspecification rate of 47% for leadership research. In this research, I wish to put a lent on the same concern for Operations and Supply Chain Management (O&SCM) research.

The use of reflective measurement seems to be more a methodological tradition than being supported by robust theoretical motivations. For

instance, all constructs related to the various forms of O&SCM (e.g., Operational practice, SC Integration, SC Management) have used reflective measures while Yeung (2008) used formative indicators to model O&SCM construct. A few questions need to be answered:

"Which approach (reflective or formative) should researchers then adopt? Which of these is the most appropriate? How can technical problems be overcome?".

In this paper, I wish to put light into this type of decisions, in which the usage of reflective model is either a tradition or a way for escaping some technical restrictions due to a covariance-based approach (Lisrel). I supply a list of criteria and suggestions that researchers in O&SCM domain can follow when they set up the conceptual and the measurement models. I also provide an example in Green SC research to demonstrate that a correct model specification leads to correct findings.

The paper is organized as follows. In section 2, I develop a literature review on the use of measurement models in the field of O&SCM. Afterwards, in section 3, I introduce the differences between formative and reflective models and highlight the technical concerns related to their application. In section 4, I provide an example of misspecification problems as well as an example, while section 5 concludes reporting both managerial insights and research advices.

2. Literature Review and Reflections on the Measurement Model

Empirical research in O&SCM using SEM has mainly focused on the use of reflective scales to model relationships between a construct and its underlying measures. Notwithstanding, researchers should start modeling a problem looking into the relationships between constructs and variables. Although the answer for this question seems to be extremely easy for some constructs, it is not always the case for some others. Conceptually, one should think at the problem: *who comes first? Chicken or eggs?* Therefore, the selection of the right model passes through a similar question, that is: *who comes first? The construct or the manifest variables?*

When the latent variable comes for first, it exists independently of its measures. In such a case, a reflective model should be selected. Instead, the manifest variables come first when the construct does not exist without these items. In such a case, the model is formative because each measure contributes to *form* the construct, which is now called composite variable.

To better understand the selection process, I take the example of the construct Economic Performance, which is commonly used in O&SCM research as an endogenous construct. Figure 1 displays the construct measured through a reflective and a formative model in which the indicators are market share, profits, and sales. These measures of Economic Performance are really common in O&SCM research. Yet, the question that researchers should ask is: *Which model should one select?*

Figure 1 – Reflective vs. Formative measurement models for EP
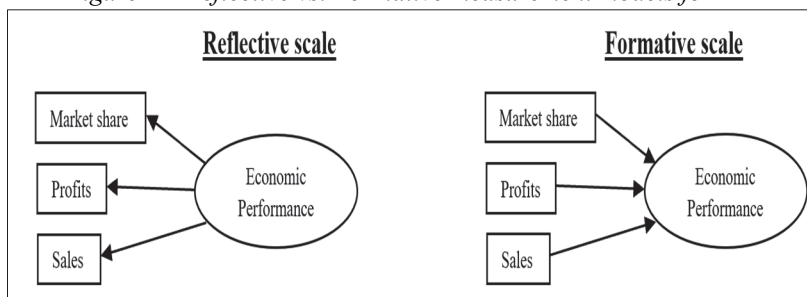
Author's development

The literature in O&SCM has used both approaches described in Figure 1. For example, De Giovanni (2020), Roh *et al*. (2022), Alsheyadi *et al*. (2024) and many others used reflective models to measure Economic Performance. Differently, Chand *et al*. (2022), Malesios *et al*. (2020), De Giovanni and Vinzi (2012), De Giovanni (2012), Xu *et al*. (2019), Wallenburg and Weber (2005) and Garver (2019) used the formative models to measure Economic Performance. To properly choose the model, one should keep in mind that the directions of arrows alone are not at all sufficient to clearly identify the most appropriate model. Rather, researchers should better think about the meaning of a construct, what it does represent, what its role is inside the conceptual model, and what type of information one would obtain. Any time research seeks to investigate Economic Performance as a global indicator of economic value that a firm gains in a given instant of time, a formative model should be selected. In this case, in fact, profits, market share, and sales provide a contribution to form the firms' economic performance. With the elimination of one of these variables, for instance, profits, I do eliminate an important dimension of Economic Performance and the meaning of the construct may completely change.

However, most of the research in O&SCM studied performance as a reflective latent variable. In this case, a reflective measurement model allows the investigation of a soft and intangible asset, which a firm possesses

independently of any other factor, for instance, the *Firms' Capability to create Economic Value*. In such case, the meaning of the construct is absolutely different from the concept emerged when using a formative measurement model.

In fact, a reflective measurement model studies a capability, an attitude, an ability to produce satisfactory economic outcomes. The firm obtains some profits because it possesses the capability to perform from an economic perspective. Therefore, causality goes from the construct to the measure and a reflective scale is the most appropriate. The construct comes before the measures as it exists even without its measures. In contrast, a formative measurement model allows the identification of a global indicator of Economic Performance, in which the construct is a composite index. The firm`s economic results are determined by its indicators and causality goes from the measures to the construct. The measures come before the construct as the latter does not exist without its measures.

Table 1 – Types of errors in scale selection

		Measurement model needed	
		Reflective	*Formative*
Measurement model adopted	*Reflective*	Correct model specification	Error of Type I
	Formative	Error of Type II	Correct model specification

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These distinctions can make a great difference in O&SC studies. While a conceptual and theoretical discussion should precede the model selection, researchers need to identify and clearly state the purposes of each construct inside the research. Not only the interpretation of a construct is different, but also the research hypotheses characterization as well as the results obtained in the confirmatory and structural analyses. Many problems of misspecification may occur at this stage. Diamantopoulos and Siguaw's (2006) referred to Error of Type I and II the adoption of erroneous measurement models. Specifically, the adoption of reflective indicators where formative indicators would be appropriate leads to Error of Type I; the adoption of formative indicators where reflective indicators would be appropriate leads to Error of Type II.

The identification of these misspecification cases affects on model estimates and fit statistics, thus influencing the conclusions about the theoretical relationships among the constructs drawn from the research (Jarvis *et al.*,

2003). Only a few papers made a reflection on the measurement model selection in O&SCM. For example, Chand *et al*. (2022) measure the impact of complexity on performance by only using formative measurement models for the constructs: External supply chain complexity, Supply chain performance, Upstream supply chain complexity, Operational supply chain complexity, Downstream supply chain complexity. Similarly, Malesios *et al*. (2020) use the formative model Supply Chain Sustainability, following the previous papers by De Giovanni and Vinzi (2012) and De Giovanni (2012) exhorting the use of formative models for the whole area of sustainability in operations management.

Unlike traditional SEM applications that rely on reflective indicators, Xu *et al*. (2019) argue for the importance of formative constructs in measuring complex constructs like quality management and supply chain performance. They provide empirical evidence supporting the idea that formative models can better capture cause-effect relationships in operations management. The study by Wallenburg and Weber (2005) proposes an empirical analysis using formative measurement models in SEM, which is defined as to be crucial for supply chain research by the authors.

Accordingly, the use of formative measurement models allow one to demonstrate that logistics service quality (timeliness, flexibility, and reliability) contributes more to financial and strategic performance than cost-cutting measures. According to Garver (2019), the misuse of reflective and formative measurement models in SEM leads to the improper construct specification and misleading conclusions. For example, if "supply chain agility" is driven by indicators like speed, flexibility, and adaptability, treating it as reflective distorts its theoretical foundation.

Park *et al*. (2023) examine how supply chain agility impacts firm performance while defining agility as an organization's ability to sense changes in the market and respond effectively. They use formative models even for the second-order factor constructs. Considering the various use of both formative and reflective models, the next section introduces the differences between the two measurement scales.

3. Differences between Reflective and Formative Scales

Table 2 summarizes the technical and conceptual differences between reflective and formative measures. It intends to drive researchers in O&SCM during the selection of the measurement model to be selected.

Table 2 – Differences between reflective and formative models

	Reflective	Formative
Direction of causality	From the construct to the measures	From the measures to the construct
Correlation among items	Measures expected to be correlated. Measures should possess internal consistency reliability	Measures expected not to be correlated. Internal consistency is not implied
Importance of items	Dropping an item from the scale does not change the meaning of the construct	Dropping an item from the scale may imply a change in the meaning of the construct
Measurement error	Accounted at the variable level	Accounted at the construct level
Interchangeability of items	Items are interchangeable	Items are not interchangeable
Covariation among items	Indicators are expected to covary with each other	Indicators are expected not to necessarily co-vary with each other
Nomological net (indicators have the same antecedences and consequences)	Should not differ	Differ
Multicollinearity	Required	It is a serious concern

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The main assumption behind the usage of reflective measurement models consists of having a set of measures whose covariance is caused by a variation in latent variable. The causality relationship goes from the construct to the variables, thus the model is reflective because the constructs reflects the manifest variables (Fornell and Bookstein 1982). In contrast, a formative model assumes that all measures have an impact on – and thus cause – the construct and jointly determine its meaning (Bollen and Lennox, 1991; Fornell and Bookstein, 1982). Causality goes from the indicators to the construct, measures do not covary and are not at all correlated. Therefore, internal consistency does apply for reflective models while it does not for formative ones.

The concern around the selection of a measurement model in O&SCM research emerges from the first steps of an empirical research project. According to the selected mode, the researcher will define the wording of each question. Questions will be stated in a passive form when the measurement model is reflective, and in an active form for a formative measurement model. For instance, to measure the level of integration with suppliers, De Giovanni (2020) used (among others) the measure *sharing demand forecasting* whose information has been obtained through the question:

«We share our demand forecasting with our major suppliers» (De Giovanni, 2020).

Should the causality relationship go from the construct (integration with suppliers) to the measure (sharing demand forecasting) or *vice versa*? While the author used a reflective measurement model, researchers should devote more attention to the sense and meaning of the question to correctly obtain the needed information. The following doubts emerge:

Is a company integrated with suppliers because it shares demand forecasting?

or

Because a company is integrated with suppliers then it shares demand forecasting?

In the former case, a formative model should be selected, in the latter case a reflective model is the most appropriate. The problem does not only rely on the way of wording the question, but also on how it is perceived from the interviewed person. The answer should be given according asking "*who comes for first? Integration with suppliers or sharing demand forecasting?*". Indeed, leaving this lack of details increases the biasness on the obtained information and the accuracy of derived results.

Along with the causality direction, also the number of items to be included in the scale assumes a peculiar importance. Missing one or more indicators under a formative mode can be a serious concern because an important part of a construct can be disregarded and its meaning can be completely different. A census of all possible measures to include in the scale should be carried out before start the data collection (Bollen and Lennox, 1991) while the elimination and the inclusion of a measure must be theoretically justified. Because each indicator contributes to create (form) the construct, measures are not expected to covary but rather to be independent dimensions. The standard scale development procedures (for example, dropping items that possess low inter-item correlations) does not apply in formative models as some items can be dropped, although they provide an extremely important contribution in the formation of a construct. This confirms the inappropriateness of internal consistency reliability for formative models and leads indicators not to be interchangeable.

In a formative measurement model the errors are associated with the construct rather than with the items while, in contrast, errors are associated with the items rather than with the construct in reflective scales. The error term supplies information on the appropriateness of the selected measures. According to MacKenzie *et al.* (2005, 712) the error term captures the

invalidity of the set of measures caused by measurement error, interactions among the measures, and/or aspects of the construct domain not represented by the measures. Diamantopoulos (2006) demonstrates that the error term does not represent measurement error because formative indicators are specified to be error-free; rather, it represents the impact of all remaining causes other than those represented by the indicators included in the model. Therefore, it results that a reflective treatment of a formative construct reduces the variance of the construct because the variance of a reflective construct equals the common variance of its measures, while the variance of a formative construct includes the total variance of its measures. Consequently, if a misspecification reduces the variance of the exogenous variable while the level of the variance of the endogenous variable is maintained, the parameter estimate for their relationship increases. In contrast, if a misspecification reduces the variance of the endogenous variable while the variance of the exogenous variable is unchanged, the relevant structural parameter estimate decreases. Finally, model misspecification leads to an over or to an underestimation of structural parameters, which brings undesirable effects on the interpretation of findings.

In contrast with reflective models, multicollinearity among indicators can be a significant problem in formative scales, therefore high inter-item correlations may imply a drop off of items. See Bollen and Lennox (1991), Diamantopoulos and Winklhofer (2001), and Diamantopoulos and Siguaw (2006) to check how multicollinearity can be handled. Errors during the scale development and purification leads to high parameter bias because omitting an indicator in formative mode can lead to a completely different construct. Under this perspective, knowing that this analysis only leads to indicator elimination on purely statistical basis and given the possible alteration in the meaning of a construct, Diamantopoulos and Winklhofer (2001) suggest that indicator «elimination should never be divorced from conceptual considerations when a formative measurement model is involved» (Diamantopoulos and Winklhofer, 2001, 273).

Finally, the vast majority of models incorporating misspecified measurement models show high acceptable values for chi-square per degree of freedom, CFI, GFI, SRMR, and RMSEA (Diamantopulos *et al*., 2008). These indexes are not suitable to detect the correctness of a measurement scale thus a good fit should not mislead researchers from a correct model specification.

*Figure 2 – Various combinations of models and errors*
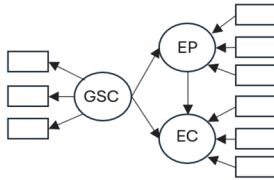
Model 1. Correct model specification

Research hypothesis	Standardized coefficient	p-value	Result
GSC ->EP	0.516	<0.05	Supported
GSC ->EC	0.283	<0.05	Supported
EP -> EC	0.473	<0.05	Supported
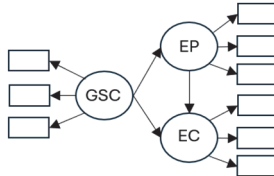
Model 2. Error of Type I on Performance

Research hypothesis	Standardized coefficient	p-value	Result
GSC ->EP	0.588	<0.05	Supported
GSC ->EC	0.596	<0.05	Supported
EP -> EC	0.212	>0.05	Non-Supported
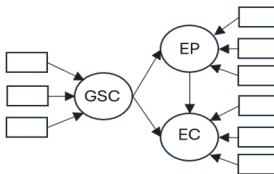
Model 3. Error of Type II on GSC

Research hypothesis	Standardized coefficient	p-value	Result
GSC ->EP	0.554	<0.05	Supported
GSC ->EC	0.285	<0.05	Supported
EP -> EC	0.460	<0.05	Supported
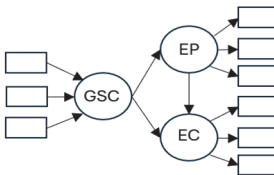
Model 4. Error of Type II on GSC and Type I on Performance

Research hypothesis	Standardized coefficient	p-value	Result
GSC ->EP	0.470	>0.05	Non-Supported
GSC ->EC	0.230	>0.05	Non-Supported
EP -> EC	0.473	<0.05	Supported

Author's development

4. An Example of Model Misspecification in O&SCM

Hereby, I provide an example to demonstrate the changes in the empirical results according to the measurement models selected. Specifically, I analyze the impact of *environmental collaboration with suppliers* (Green SC, GSC) on Environmental Performance (EP) and economic performance (EC). Please, check De Giovanni and Cariola (2020) for a complete overview on the research hypotheses and scale development. For a correct identification of the model, GSC should be measured through a reflective scale, while EP and EC should be measured through a formative measurement model. I have taken the data displayed in the correlation table in De Giovanni and Vinzi

(2012) to run the empirical analysis and to develop the four cases reported in Figure 2.

This example supplies information on the possible consequences due to an inappropriate selection of the measurement models. Specifically:

a) *Model 1*. The exogenous construct GSC is correctly specified through a reflective model; both the constructs of performance are correctly specified through formative scales. Hence, the model is correctly specified and the results of the hypotheses are reliable;

b) *Model 2* highlights misspecification in the endogenous constructs linked to Performance, which are modelled in a reflective mode rather than in a formative mode. This generates the hypothesis EP→EC to be non-significant, while it results to be significant when correctly specified as in Model 1;

c) *Model 3* has misspecification in the exogenous construct linked to GSC. This leads to an interpretation error of the meaning of the constructs and the effects; for example, since all constructs are reflective, GSC influences positively the firms' capacity to increase the economic and the environmental performance. Instead, the interpretation of the Model 1 is different: GSC influences positively the firms' economic and environmental performance. In sum, Model 3 insists on the firms' "capacity" to perform while Model 1 works on the firms' "performance" itself. Therefore, the use of different models, being both highly significant, impacts importantly on their meaning and interpretation;

d) *Model 4* presents misspecification in both the exogenous construct of GSC and the endogenous constructs of Performance. Notice that GSC→EP and GSC→EC have different results with respect to Model 1; hence, the findings obtained are not reliable.

The distinction between reflective and formative measurement models in SEM is rooted in their foundational assumptions about causality, indicator relationships, and statistical methodologies for estimation and validation. These models necessitate distinct approaches to handling data distribution, estimation methods, and the application of specific fit indices for model assessment.

Reflective models are very popular since they conceptualize latent constructs as underlying causes that manifest through observed indicators. The relationship is mathematically represented in matrix form as $X = \Lambda \xi + \varepsilon$, where X represents the matrix of observed indicators, Λ is the matrix of loadings that link the latent variables ξ to the indicators, and ε is the vector of normally distributed error terms for each indicator. This model structure leads to the covariance matrix of X being modeled as $\Sigma = \Lambda \Phi \Lambda^{\wedge} T + \Theta$, where Φ is the covariance matrix of the latent variables, and Θ is the diagonal

matrix containing variances of the error terms. Estimation techniques such as Maximum Likelihood (ML) or Generalized Least Squares (GLS) are used, assuming multivariate normality of the indicators, which can be validated using tests such as Kolmogorov-Smirnov or Shapiro-Wilk. Model evaluation for reflective models employs fit indices including the Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), alongside residual-based measures such as the Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR). These indices measure how well the proposed model's covariance matrix (Σ) reproduces the observed data's covariance matrix. Internal consistency is checked using Cronbach's Alpha and Composite Reliability (CR), ensuring the indicators reliably reflect the latent construct.

In contrast, formative models define latent constructs as composites formed by their indicators, expressed in vector form as $\xi = \pi^{\wedge}T\ X + \delta$, where π represents the row vector of weights assigned to each indicator in X, and δ is the error term at the construct level. This structure does not assume normal distribution of errors, reflecting the non-causal nature of the relationship between indicators and the construct. Formative models typically use Partial Least Squares (PLS), a method focusing on maximizing explained variance in dependent constructs without requiring distributional assumptions, suitable for complex model estimations where traditional covariance-based methods might fail. Multicollinearity among indicators is a critical consideration in formative models, assessed using the Variance Inflation Factor (VIF). Unlike reflective models, formative models do not utilize traditional goodness-of-fit indices due to the absence of a latent variable causing the observed indicators. Instead, model validation focuses on the significance and relevance of the weights (π) calculated for each indicator, often evaluated using bootstrap techniques to provide non-parametric confidence intervals.

Indeed, differently from reflective models, the formative models generate a certain amount of technical issues: these do probably suggest to the O&SCM to go for reflective options since there are no so many technical challenges. Beyond the t-rule and the scaling rule conditions requested by reflective models (Diamantopulos *et al*., 2008), the rule requiring at least two emitted paths must also apply (Bollen and Davis, 1994). It consists on having two leaving arrows from the formative model, which allow the identification of the disturbance term. The two arrows may go either to other measures or to other constructs (Bollen and Davis, 1994) or to both (Jöreskog and Goldberger, 1975). As for the multicollinearity, adding arrows only for identification reasons puts the model specification into question if these outcomes are not theoretically supported. Instead of struggling with the inclusion of improbable research hypotheses, a different estimation method may substantially

help. For instance, being a component-based estimation method, the Partial-Least Square (PLS) represents a valid alternative to estimate empirical models while eliminating the technical restrictions imposed by Lisrel, which is instead a covariance-based estimation method (CVA). The approach uses an iterative combination of principal components analysis and regression to explain the variance of each construct. Because PLS makes no distributional assumptions, traditional parametric significance testing procedures are not appropriate.

Table 3 – Comparison of PLS and CVA

Criterion	PLS	CVA
Objective	Prediction oriented	Parametric oriented
Approach	Variance based	Covariance based
Assumptions	Nonparametric	Parametric
Parameter estimates	Consistent at large	Consistent
Latent variable scores	Explicitly estimated	Indeterminate
Model complexity	High	Small to moderate
Minimum sample size	20-100	200-800

Author's development

Table 3 reports the key differences among component- (PLS) and covariance-based (CVA) approaches. PLS seeks to maximize prediction in the endogenous constructs rather than estimating covariances among latent variables. It is generally used for predicting behavior, with the final purpose to explain the model variance. PLS substantially helps when models are really complex to estimate as well as sample sizes are really small. The algorithm converges in a few iterations independently of measuring constructs through reflective or formative scales. A small sample size does imply any identification problem while large size increases the consistency of PLS estimations. Formally, PLS should be used any time requirements for multinormality, large sample size, and good model specification cannot be met. Due to PLS bias, structural estimations are understimaned while measurement model relationships are overestimated. CVA should be used when the goal is theory testing, theory confirmation, or the comparison of alternative theories, errors require additional specification (e.g., covariation), and the research requires a global goodness-of-fit criterion.

5. Conclusions

This research aims to contribute to a major and common error among researchers in the field of Operations and Supply Chain Management (O&SCM) and related to choosing the right measurement models in

accordance with Structural Equation Modeling (SEM). A substandard or incorrect choice of a measurement model according in SEM may lead to misinterpretation of the findings, and erroneous conclusions drawn from the research. This is the very first-time research in O&SCM has elaborated on the differences between reflective and formative measurement models used in SEM, as well as notifying the researchers in this area and making them conscious and careful about the construction and selection of the measurement model before they embark in statistical analysis. Therefore, this research makes an original contribution to the body of knowledge in the O&SCM area and invitation to growth in the right direction.

5.1 Insights for firms and practitioners

The results of this research suggest that enterprises and professionals of O&SCM face a challenge when selecting a model to analyze a business phenomenon: the appropriate incorporation and application of measurement models under the SEM framework can deeply impact the preciseness of the strategic decisions that are made based on analytics. For example, employing a formative model for production efficiency, which is a composite indicator derived from several operational metrics (e.g., material cost, scrap rate, and energy consumption), ensures that the decision-makers do not overlook vital dimensions of performance. Additionally, the use of reflective models might enable in the better understand of the underlying latent constructs such as organizational culture or customer satisfaction which are reflected across various observable indicators. Therefore, firms can benefit greatly by using these models through the right methods for making their strategies and work by correctly interpreting the data.

5.2 Insights for research and academia

This research reveals an important evidence in the academic literature in O&SCM with respect to the right SEM measurement models selected by researchers. Therefore, this paper challenges the academic community to improve their methodological rigor not only by choosing the right measurement models but also by having a clear understanding of the theoretical basis that justifies their choice. Researchers are advised to look into SEM intricacies, which are a basis for more reliable and more credible research findings. The study also indicates the need for educational curricula to include the construction and analysis of advanced statistical techniques, given the close

relationship between these decisions and research outcomes. In fact, the selection of the measurement model in O&SCM research should be driven by theoretical foundation rather than being thoughtlessly carried out through reflective scales.

This would lead research to a correct model specification, that is, to a truthful establishment of the nature and direction of relationships between constructs and measures. The consequences of measurement model misspecification consist of serious under- or overestimations of parameters due to misidentified causality, wrong purification procedures, or a combination of both. Such biases may in turn lead to incorrect conclusions on tested hypotheses. This is especially true in the light of the fact that a satisfactory overall model fit does not guarantee a correct specification while misspecifications are not detected by poor fit index values. Hence, research in O&SCM should devote more attention to the measurement model selection to final deliver valid contributions to the literature and truthful findings.

Acknowledgement

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Value Creation in Tradition-led Industries:
The Role of Innovative Practices.
The Empirical Evidence from the Italian Wine Industry

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Abstract

In this study, we investigate whether firms create value in a tradition-led setting, through innovative efforts. Prior research has observed that in such a setting some actors opt for a creative representation of established products (i.e., a song, an opera, a piece of art, a fashion item, and so on); in contrast, others rely on a more traditional interpretation of the same products. Less investigated, to date, has been whether the decision to opt for an innovative behavior in a tradition-led context leads to value creation, or not. To this end, we conducted research in the Italian wine industry between 1999 and 2009 to investigate whether adopting innovative practices (i.e., aging wine in barrique), led to value creation and what other occurrences intervened in the value creation dynamic. Our findings suggest that innovation sustains value creation and that, in a tradition-led context, a firm's portfolio breadth negatively moderates the above relationship.

Keywords: Value creation, Tradition-led setting, Innovation, Italian wine industry.

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La creazione di valore nei settori tradizionali: il ruolo delle practice innovative. L'evidenza empirica nell'industria italiana del vino

Sommario

In questo studio, analizziamo se le imprese possano creare valore in un contesto guidato dalla tradizione attraverso l'innovazione. Le ricerche precedenti hanno evidenziato che, in tali contesti, alcuni attori scelgono di reinterpretare creativamente prodotti consolidati (ad esempio, una canzone, un'opera, un'opera d'arte, un capo di moda, ecc.), mentre altri si affidano a un'interpretazione più tradizionale degli stessi prodotti. Tuttavia, finora è stato meno esplorato se la scelta di adottare un comportamento innovativo in un contesto dominato dalla tradizione conduca effettivamente alla creazione di valore. Per rispondere a questa domanda, abbiamo condotto una ricerca nell'industria vinicola italiana tra il 1999 e il 2009, analizzando se l'adozione di pratiche innovative (ad esempio, l'invecchiamento del vino in barrique) abbia portato alla creazione di valore e quali altri fattori abbiano influito su questa dinamica. I nostri risultati suggeriscono che l'innovazione favorisce la creazione di valore, ma che, in un contesto guidato dalla tradizione, l'ampiezza del portafoglio di un'azienda modera negativamente questa relazione.

Parole chiave: creazione di valore, contesto guidato dalla tradizione, innovazione, industria vinicola italiana

1. Introduction

Tradition-led settings have gained growing interest, in the last decades, from studies in different disciplines such as strategic management, organization theory, and sociology which provided a detailed examination of how revered traditions and cherished rituals have been preserved and maintained over time (Dacin and Dacin, 2008; Lok and deRond, 2013), meanwhile addressing those issues that have led to their disruption and those contingencies that engendered either the adoption of novel practices or their rejection (Cattani, Ferriani, and Lanza, 2017; Sasaki *et al.*, 2019).

However, while these studies have explored a variety of issues that helped us understand whether and under what contingencies traditions either persist or fade away, they fall short of providing a useful conceptual lens to understand whether innovations in tradition-led settings create value and what intervene in this, often, contested and controversial phenomenon. In particular, while we concur that innovative practices can be carried out, too, in a setting characterized by the preeminence of a body of binding traditional practices and rituals, we argue that it should be investigated whether this effort leads

to value creation; besides, we posit that it should be explored what other firm-level phenomena intervene in this relationship.

To fulfill this goal, we conducted research in the Italian wine industry between 1999 and 2009, a suitable setting for our research since winemaking dates back over two millennia and Italy is home to the largest vine and grape variety on Earth; thus, virtually every province in Italy has its cherished local wine whose origin often can be traced to the Medieval epoch.

Our study makes several contributions to studies on innovation, tradition, and value creation; first, we explore whether innovation in the context of a tradition-led setting leads to value creation, thus extending the scope of strategic, organizational, and sociological studies on tradition; besides, we investigate those phenomena that intervene in the relationship between innovation and value creation in tradition-led contexts, thus providing a fine-grained understanding of what firm-level issues affect this relationship; finally, by investigating value creation dynamics in a tradition-led setting, we open an interesting dialogue between value creation and tradition research areas.

This study is organized as follows; first, we offer the study's theoretical background along with its research hypotheses; then, we provide the methodological and results sections; subsequently, we discuss our main findings; finally, we give some theoretical and managerial implications.

2. Theory and Hypotheses

Drawing from seminal research (Shils, 1981; Soares, 1997), recent developments in tradition-inspired research have emphasized the inherent complexity that underpins innovative efforts in the context of a tradition-led setting (Cancellieri, Cattani, and Ferriani, 2023; Lanza and Simone, *forthcoming*) and observed that innovative stances in traditional settings are either stifled or rejected (Sasaki *et al.*, 2019), also assuming that tradition represents a malleable and dynamic body of competencies, principles, beliefs, and behaviors, rather than just a sticky set of prescriptions. Other scholars, subsequently, observed that the preservation of a given tradition often depends on custodians and other dedicated individuals, whose main goal is to maintain, adjust, and repair it thus allowing for change and evolution, and, ultimately guaranteeing its survival (Dacin, Dacin, and Kent, 2019).

Although these studies provided important insights, especially regarding change in the context of traditional settings, they fall short of providing an adequate understanding of whether change and innovation in these settings create value. We maintain that overlooking this issue represents a critical

void since value creation represents one of the main tasks for organizations (Damodaran, 2012), and by neglecting this point they fail to provide important prescriptions for scholars and managers coping with change in a traditional context. Accordingly, we maintain that addressing this issue and exploring what other phenomena intervene in the relationship between innovation and value creation, represents a valuable contribution to both tradition-motivated research and value creation studies.

Pioneering research on innovation has put forth the inherent risk of undertaking explorative efforts that diverge from established trajectories (Abernathy and Utterback, 1985; March, 1991). Subsequent research has clarified that especially in those contexts characterized by the presence of critical stakeholders and social audiences, innovators must pay attention to the requests of these entities to gain their attention and support and to receive resources and acknowledgment (Hargadon and Douglas, 2001; Cattani *et al.*, 2008).

Also, innovators can face further obstacles when trying to offer novel ideas and products in a tradition-led setting, since their innovation can be hindered by other organizations whose goal is to defend tradition from modernism (Negro, Hannan, and Rao, 2011) and they may struggle to position their effort in the context of a business rooted in a family's multigenerational path (De Massis *et al.*, 2016; Sasaki *et al.*, 2019); besides, they may be at odds with customers' main expectations and perceptions and, thus, opt for retrenchment in more traditional niches (Cattani, Dunbar and Shapira, 2017); furthermore, in the presence of an established body of practices and revered principles, an innovator may be not provided with adequate knowledge of these practices and principles and, thus, his/her innovative efforts may be rejected regardless of its inherent value (Cattani, Ferriani, and Lanza, 2017); finally, novel formats and ideas may not receive a favorable reception from those audiences more accustomed with traditional offerings (Durand, Rao, and Monin, 2007; Cancellieri, Cattani, and Ferriani, 2023).

In sum, the extant research on innovation in the context of a tradition-led setting seems to suggest that often these endeavors are doomed to be either hindered or rejected, and, thus, to fail in the goal of creating value.

We argue, instead, that adopting an innovative stance in a traditional setting does not necessarily lead to a negative outcome, from a value creation perspective because, even in a tradition-led setting, it has been observed that products, services, formats, and rituals undergo frequent occasions of change that often lead to the evolution of the main offerings (Negro, Hannan, and Rao, 2011; Cancellieri, Cattani, and Ferriani, 2023); besides, it has been argued that market segments are not completely homogeneous and that some niches, within a given market, could favorably receive a novel product (Ertug

et al., 2016; Cattani, Falchetti, and Ferriani, 2020); additionally, innovators may scout novel market spaces thanks to counterfactual strategy (Gaglio, 2004) for their offerings, through which achieving a better positioning in a less explored segment.

Therefore, we maintain that adopting a novel format and promoting an innovative offering in a tradition-led setting can create value since traditions should not be considered stiff repositories of rituals and principles. Rather, they can be conceived as a malleable body of competencies, relationships, beliefs, and behavior whose evolution depends also on the exploration of novelty.

In particular, we posit that novelty contributes to value creation, especially when it speaks to specific audiences and scouts novel market spaces. The conceptual motivation for this value creation process relies on innovation's positive effect on the existing products.

More precisely, we suggest that adopting an innovative stance will positively affect an organization's existing products since the favorable response characterizing such a novelty may reverberate to the entire organization. This can happen because the adoption of innovative practice (or technique) leads the whole organization's offering to enjoy a positive positioning reverberation, which, in turn, instigates an increase in the price of the entire product portfolio. Previous research on brand extension has investigated the positive connections between successful products and new offerings carrying the same brand name (halo effect – Beckwith and Lehmann, 1975; Keller and Lehmann, 2006). The positioning reverberation effect that we advance, instead, suggests a different type of connection, thanks to which, the adoption of a novel technique is capable of engendering a positive effect on existing products, thus, it is the opposite of the halo effect.

We surmise that positioning reverberation may happen, for example, because adopting a novel technique is highly appreciated by the industry's experts and gatekeepers whose positive evaluations may reflect on the whole product portfolio; also, adopting an innovation may signal a firm's commitment to investing in quality and, as a result, the entire organization and its offerings enjoy the positive consequences of this occurrence; furthermore, customers and dealers may be positively influenced by innovative conduct in the context of a traditional setting, thus rewarding this stance by acknowledging a better positioning to a firm that adopts such conduct. In sum, we posit that adopting an innovative technique in a traditional setting is likely to engender a positive positioning reverberation, thanks to which the whole portfolio of products benefits from a price increase, which we assume is a proxy of value creation. Accordingly, we hypothesize as follows

Hp 1 The adoption of an innovative practice, in the context of a tradition-led setting, is positively associated with value creation.

So far, we have posited that innovative efforts and stances may lead to value creation even in a tradition-led setting, under specific circumstances. However, we surmise that other phenomena could intervene in the relationship between innovation and value creation at the organizational level. In particular, we maintain that a firm's breadth of product portfolio could affect the above relationship, for many reasons. First, we suggest that a firm that has developed over time a large portfolio of products in a tradition-led setting has achieved visibility and attention through the years, thus creating in a setting's main audiences a set of expectations as concerns its conduct and, consequently, its positioning; under such a contingency, adopting an innovative practice may represent an inconsistent behavior, which, in turn, may damage the value creation process (Hsu, 2006).

Also, a broad portfolio of products is likely to be associated with a multi-segment marketing strategy, which, in turn, is associated with a multivalent identity (i.e., generalist), whereas, instead, innovators are often characterized by a focused (i.e., specialized) identity (Zuckerman *et al.*, 2003); in this case, generalist organizations do not receive the same attention and support that, usually, specialists enjoy, and this may influence negatively value creation. Besides, in the presence of a large portfolio of products rooted in a cherished tradition, an innovative offering could confer an image of obsolescence to existing products, thus undermining the overall value creation dynamic, since obsolete products usually command decreasing prices. In sum, we posit that all these contingencies may negatively influence the relationship between novelty and value creation. Therefore, we hypothesize as follows

Hp 2 The breadth of a firm's product portfolio negatively moderates the relationship between the adoption of innovative practices and value creation.

3. Methods

3.1 Research setting

We conducted our study in the Italian wine industry, between 1999 and 2009. Winemaking in Italy dates back over two millennia and since it is home to the largest grape and vine variety in the world (Robinson, 1982; Fregoni, 2004; Bastianich and Lynch, 2005), virtually every province in Italy cherishes its autoctone vine and grape and enjoys and reveres its traditional local

wine. As a result, winemaking in Italy is characterized by a locally embedded, long-lasting tradition that has crossed the centuries (Belfrage, 2009). Previous research on the Italian wine industry observed that the adoption of novel ideas and practices in such a context instigated conflict and uncertainty (Lanza, 2011; Negro, Hannan and Rao, 2011; Lanza and Simone, *forthcoming*), thus, we posit that it represents a most suitable context for examining whether and how organizational value creation is affected by novelty, and what other phenomena intervene in this dynamic.

3.2 Data

We collected data and information from a plurality of sources. Concerning the importance of tradition in Italian winemaking we draw information from Johnson (1989); Robinson (1982); Bastianich and Lynch (2005); Belfrage (2009); Antinori (2011); regarding the relevance of enological procedures and practices in Italy we rely on Fregoni (2005); Calò and Costacurta (2004). Besides, we collect data and information about wine characteristics, price, and portfolio breadth from *Le Guide di Veronelli,* between 1999 and 2009; founded by Luigi Veronelli, the father of contemporary Italian enology, it is unanimously considered the most accurate and authoritative guide on Italian wines (Negro, Hannan and Rao, 2011). We collected data in this specific time window because in 1998 the Italian parliament issued a major reform of the 1963 law that had introduced denominations (i.e., DOCG – *Denominazione di Origine Controllata e Garantita* / Controlled and Guaranteed Denomination of Origin; DOC – *Denominazione di Origine Controllata* / Controlled Denomination of Origin). The 1998 reform introduced a novel category, IGT (*Indicazione Geografica Tipica* / Typic Geographic Indication), that, differently from DOCG and DOC, allowed freedom of maneuvering as concerns grape blending and aging techniques and procedures. Before the introduction of IGT, those wines that blended autoctone and international grapes and adopted novel enological procedures could no longer affiliate with local DOCG or DOC and were forced to report the ambiguous Table Wine description on their labels, in fact, a non-denomination. Therefore, it seems appropriate to begin data collection from 1999, to appraise the impact of the novelty allowed by the reform on value creation dynamics.

Finally, to triangulate our information, we conducted interviews with vintners, dealers, and experts, in three different periods (2008-2011; 2015-2018; 2019-2023). These interviews buttressed the view that aging wine in barrique represented an innovative practice in the tradition-driven Italian wine industry and that on several occasions this practice instigated conflicts

and disputes between and among heterogeneous actors (i.e., vintners, dealers, experts, critics, sommeliers, restaurant owners, and many others).

4. Measures

4.1 Dependent Variable

Value Creation. To measure value creation, we gauge the price increase of all labels comprehended in the firm's portfolio after the adoption of a novel practice (i.e., aging wine in *barrique*). Established literature has adopted a product's price as a fair measure of its value (see Damodaran, 2012 for a comprehensive examination); research in the wine industry has assumed price as a suitable proxy for a wine's value, too (Benjamin and Podolny, 1999; Roberts and Reagans, 2007). Therefore, an increase in a wine's price (and in a portfolio of wines) represents a fair proxy for value creation.

4.2 Independent Variable

Novelty. To assess novelty, we observed the adoption of a novel practice (i.e., aging wine in barrique) at the organizational level. A consolidated body of research considers the adoption of novel practices and techniques as a suitable measure of novelty (March, 1991; Hargadon and Douglas, 2001). In the context of tradition-led research, too, the adoption of new practices or ideas represents an adequate measure of novelty (Cancellieri, Cattani, and Ferriani, 2023).

4.3 Moderating variable

Breadth of product portfolio. To measure this variable, we count the number of existing labels comprehended in a firm's product portfolio, considering the available varieties of wine (i.e., red, white, rosé).

4.4 Control variables

Firm's Wine Rating. This variable captures the highest evaluation a company received in the Veronelli guide. Specifically, it was calculated using the

ratings conferred to all wines considered by the Veronelli Guide for each firm and then taking the maximum score awarded to any firm.

Number of "Da Tavola" wines. This variable is calculated as the number of labels classified as "da Tavola", produced by each firm and reported in the Veronelli Guide; because the Veronelli Guide reviews only high-quality wines, the higher the number of "Da Tavola" labels reported and reviewed by this guide for a given firm, the higher its innovative attitude, given that otherwise these wines would carry either the DOCG or the DOC affiliation, if they could, but in fact they cannot, because they do not comply with the local *disciplinare*. Nonetheless, Veronelli Guide reviews these wines, as well.

DOCG wine ratio. This variable represents the "DOCG labels" to "all the number of labels" ratio calculated at the firm level and can be considered a proxy of traditionalism, since the higher this ratio the higher the respect for tradition at the firm level.

Number of IGT Labels in the district. This variable represents the total count of wines in a specific geographic area (i.e., province or district in our case) that have been affiliated with the local IGT and reflects the extent to which producers in that area have adopted the IGT category. We use this variable to account for a district's propensity to adopt a new category.

5. Model

This study explores the relationship between the adoption of innovative practices and value creation in a tradition-led setting, operationalized through firm-level pricing dynamics. Additionally, we examine the moderating role of a firm's product portfolio breadth in this relationship. More specifically, the research employs random-effects (RE) panel regression models. Random-effects (RE) option is employed based on the results of the Hausman test. In this study, the Hausman test fails to reject the null hypothesis, indicating no significant correlation between the individual effects and explanatory variables. Thus, the RE model is appropriate, as it allows us to capture both within-group and between-group variations while maintaining efficiency in estimation. The vce (robust) option is used to ensure the reliability of standard errors by accounting for potential heteroskedasticity and serial correlation in the panel data. Panel data often exhibit heteroskedasticity (i.e., non-constant variance of errors) or serial correlation (i.e., errors

correlated over time within entities), which can invalidate standard inference. Robust standard errors mitigate these issues since they produce estimates of the variance-covariance matrix that remain consistent even when the assumptions of homoscedasticity or independence are violated.

6. Results

Table 1 and Table 2 report descriptive statistics and correlation analysis, respectively. The variance inflation factor (VIF) values for all variables across all samples are below 5, as suggested by prior guidelines (Neter, Wasserman, Kutner, 1983; Wooldridge, 2002). Additionally, the observed correlations align with the expected ones.

Table 1 – Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Value Creation	5414	15.428	10.019	1.75	85
Novelty	5426	.788	.409	0	1
Breadth of product portfolio	5426	4.565	2.792	1	22
Number of Da tavola wines	5426	.249	.709	0	9
DOCG wine ratio	5426	.186	.289	0	1
Number of IGT Labels in the district	5426	53.688	83.92	0	301
Firm's Wine Rating	5426	1.828	1.087	0	4

Table 2 – Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Value Creation	1.000						
(2) Novelty	0.070*	1.000					
	(0.000)						
(3) Breadth of pro~o	0.080*	0.221*	1.000				
	(0.000)	(0.000)					
(4) Number of da t~s	0.040*	0.026	0.227*	1.000			
	(0.003)	(0.058)	(0.000)				
(5) DOCG wine ratio	0.244*	-0.063*	-0.059*	-0.080*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)			
(6) Number of IGT ~	0.256*	0.021	-0.206*	-0.087*	0.433*	1.000	
	(0.000)	(0.120)	(0.000)	(0.000)	(0.000)		
(7) Firm's Wine Rat~g	0.316*	0.108*	0.423*	0.119*	0.175*	0.046*	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	

*** p<0.01, ** p<0.05, * p<0.1*

Using random-effects panel regressions, we test our hypotheses and report the findings in Table 3. Model 1 (Table 3) shows the baseline effect of innovative practices, represented by the adoption of a novel technique (Novelty). Our results indicate a strong, positive relationship with the Value Creation (β = 2.068, t = 6.50), thus supporting the hypothesis that such an innovation fosters value creation across the firm's portfolio. In Model 2 (Table 3), we incorporate control variables to capture the effects of additional firm and market characteristics. The significant relation observed above persists in Model 2 (Table 3), further validating "Hypothesis 1". These results underscore how innovative conduct in a tradition-driven industry can trigger positive stakeholder evaluations, thus enhancing the firm's positioning.

Table 3 – Regression Analyses

	(Mod 1) Value Creation	(Mod 2) Value Creation	(Mod 3) Value Creation	(Mod 4) Value Creation
Novelty=1	2.068***	1.618***	2.762***	2.538***
	(6.50)	(5.39)	(4.13)	(4.00)
Number of da tavola wines		0.134		-0.0579
		(0.47)		(-0.20)
Firm's Wine Rating		1.524***		1.342***
		(11.96)		(9.89)
DOCG wine ratio		2.403**		2.421**
		(2.79)		(2.81)
Number of IGT Labels in the district		0.0354***		0.0367***
		(10.05)		(10.40)
Breadth of product portfolio			0.646***	0.493***
			(5.17)	(4.08)
Novelty=1 # Breadth of product portfolio			-0.257*	-0.275*
			(-2.03)	(-2.27)
Constant	13.62***	9.056***	11.24***	7.487***
	(41.19)	(28.55)	(18.48)	(13.83)
Observations	5414	5414	5414	5414

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Models 3 and 4 (Table 3) introduce the moderating effect of a firm's product portfolio breadth (Breadth of product portfolio) on the "innovation-value creation" relationship. The interaction term is negative and statistically significant in both models (β = -0.259, t = -2.05 in Model 3; β = -0.278, t = -2.28 in Model 4). This suggests that broader product portfolios mitigate the positive impact of adopting innovative practices on value creation (Hypothesis 2).

These findings are consistent with our theoretical framework, which posits that firms with a wide portfolio may face challenges in aligning innovation with stakeholder expectations, for several reasons; first, firms with broader portfolios often create expectations rooted in tradition, and any deviations from these expectations through innovation may be perceived as inconsistent conduct potentially eroding stakeholders and gatekeepers' trust; second, a multi-segment strategy associated with broad portfolios may dilute the focused identity often attributed to successful innovators, reducing the potential for value creation; finally, introducing innovation in such settings may inadvertently signal obsolescence for traditional products, negatively impacting their perceived value.

7. Discussion

In this study, we have empirically observed that adopting innovative practice in a tradition-led setting creates value for the organization promoting this creative effort, but also that the breadth of the product portfolio negatively affects value creation. Our study contributes to tradition-motivated research, innovation studies, and value-creation inquiry in several ways. The first contribution regards the positive effect of novelty on value creation. Previous research in the context of tradition-inspired settings had empirically observed that novelty affects negatively the performance of social actors and organizations that diverge from the paths suggested by revered rituals and cherished beliefs (Sasaki *et al.*, 2019; Cancellieri, Cattani, and Ferriani, 2023). Instead, we have empirically observed in the context of the Italian wine industry, that employing a novel and diverging practice (i.e., aging wine in barriques) positively affects value creation since tradition-led products cannot be considered solely as ossified bodies of revered practices, but also as malleable and dynamic repositories of know-how and competencies. Therefore, tradition-led industries should not be regarded as homogenous entities, rather they are complex settings populated by heterogeneous segments, niches, and stakeholders. As a result, if novelty is appropriately addressed toward favorable social audiences, novel practices will engender positive results in traditional settings, too. Also, the exploration of new market segments and niches in the context of a tradition-led setting may lead to positive results since it resembles a sort of counterfactual reasoning, given that the majority of producers in such a context are more inclined to exploit traditional formats, thus leaving unexplored and underexploited new market niches, thereby providing opportunities for value creation.

Our novel conceptual explanation for this value creation dynamic is that the adoption of a novel practice engenders a positive positioning reverberation, thanks to which all the products that are enclosed in a winemaker's product portfolio enjoy an increase in their price. Previous research in brand management and brand extension labels this dynamic as the halo effect (Beckwith and Lehmann, 1975; Keller and Lehmann, 2006), that is, the positive response of customers to a company's brand extension strategy, thanks to which new products exploit the positive associations deriving from existing offerings' brand equity. The concept of positioning reverberation differs from the halo effect since the former deals with the positive influence of a novel practice on existing products, whereas instead, the halo effect concerns the positive effect of existing successful products on new products carrying the same brand name and identity. We suggest that the concept of positioning reverberation represents a valuable conceptual contribution to tradition studies, innovation research, and value creation examination, since, differently from the extant pieces of evidence, we empirically demonstrated the existence of an unintended consequence stemming from the adoption of an innovative stance, whose main result is price increase of a firm's existing offerings. In particular, by observing that in a tradition-led setting, adopting a novel practice rather than being a disqualifying conduct constitutes a suitable strategy for value creation, we argue that it can be conceived as a reflected reputation achieved by existing offerings that reverberates from the credit gained by novel offerings.

The second contribution of this study concerns the negative moderating effect of the product portfolio breadth. We maintain that under this contingency, several negative consequences may affect the value creation dynamic. First, the broader a firm's product portfolio, the higher the probability that it has created over time an established positioning and a clear set of expectations concerning a firm's competitive conduct; these occurrences (i.e., positioning and conduct) may be at odds with the adoption of an innovative stance by the same organization, since this may instigate ambiguity regarding the firm's overall strategy, which, in turn, is likely to negatively affect value creation processes. Also, a broad product portfolio, usually, confers to a focal organization a generalist identity, whereas, instead, innovators are often associated with a specialized identity (Swaminathan, 2001); this contrasting identity may instigate uncertainty in both specialized and lay audiences, thus undermining value creation dynamic. Another critical occurrence that intervenes in the relationship between innovation and value creation because of the presence of a broad product portfolio is that the existing offerings may suffer from a sort of inducted obsolescence due to the presence of innovative practice and know-how at the organizational level; this

contingency may counter the positive reverberation that innovation had brought to existing products, thus stifling value creation. Finally, the available know-how associated with a broad product portfolio rooted in a tradition-led setting will be characterized by loyalty and acquiescence to cherished recipes and revered practices, whereas instead, the novel know-how characterizing an innovative stance will diverge from these recipes and practices, which, in turn, may instigate a conflict between existing and novel know-how. All in all, we suggest that the examination of the role of portfolio breadth in the relationship between innovation and value creation represents quite an interesting contribution concerning tradition-motivated research and at the same time provides a fresh conceptual insight for strategic management and organization studies.

Another interesting contribution of our research is represented by the dialogue our study has opened between tradition-motivated research and value-creation dynamics. We posit that our main findings provide a better understanding of value creation dynamics and may help open a fruitful dialogue between tradition-motivate research and those disciplines (for instance, strategic management, finance, and accounting) that, usually, adopt value creation as one of their main measures. We are confident that our study may suggest to scholars of these disciplines to consider tradition-related issues, measures, and contingencies as an interesting set of variables and boundary conditions, thereby introducing new and useful research questions.

Our research provides, also, some implications for future studies as well as for managerial practice; concerning the former, we suggest extending the investigation of our main contribution, positioning reverberation, to other research settings, both traditional and non-traditional, to corroborate the insights of our study and to scout what other organizational factors, beyond product portfolio, affect the value creation process; regarding the latter, we invite managers and entrepreneurs operating in tradition-led settings to pay attention to the importance of innovation and to exploit the positive consequences of novel practices on existing offerings' reputation and positioning.

Our study carries some limitations, too. For instance, we could not control for organizations' age and size; also, we had no access to firms' governance and managerial team characteristics; however, we are confident that this does not undermine the overall validity of our findings and that, instead, it constitutes a fruitful occasion for extending the scope of the research field of innovation in tradition-inspired settings.

8. Conclusion

In this study, we have empirically observed that even in the context of a tradition-led setting novelty can create value for the entire organization, thanks to the positive reverberation that it exerts on the whole portfolio of existing products; but we have also shown that a broad portfolio of products negatively moderates the above relationship. We hope that our research will open a fruitful dialogue between tradition-inspired studies and value creation dynamics, especially concerning the role of organizational and governance variables in these dynamics.

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Financial Performance and the Circular Economy: The Moderating Role of the CSR Committee[♦]

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Abstract

The purpose of this paper is to investigate the relationship between corporate circular economy (CE) practices and financial performance, and the moderating effect of corporate social responsibility (CSR) committee among European listed companies.

Based on a sample of 567 firms over the period 2019–2023, the study found that financial performance is positively associated with CE scores, suggesting that it is an important driver of CE practices.

Furthermore, the study found that CSR committee positively moderate the association between financial performance and CE scores, facilitating the integration sustainability into companies.

Keywords: Circular Economy, CSR, Financial Performance, Listed Companies, Europe.

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Performance finanziaria ed economia circolare: il ruolo moderatore del Comitato CSR

Sommario

Lo scopo di questo articolo è investigare la relazione tra le pratiche aziendali di economia circolare (EC) e la performance finanziaria, considerando l'effetto di moderazione del comitato CSR (Corporate Social Responsibility) nel contesto delle società europee quotate.

Analizzando un campione di 567 imprese nel periodo 2019-2023, lo studio mostra come la performance finanziaria sia positivamente associata ai livelli di EC, suggerendo che essa sia un importante fattore trainante delle pratiche di EC.

Inoltre, lo studio rileva che i comitati CSR moderano positivamente l'associazione tra la performance finanziaria e i livelli di CE, facilitando l'integrazione della sostenibilità nelle strategie aziendali.

Parole chiave: Economia Circolare, RSI, Performance Finanziaria, Società Quotate, Europa.

1. Introduction

Recent events have highlighted the need to reshape traditional management methods, prompting companies to align their production processes with sustainability principles (Sciarelli, 2018). Value chains are experiencing a sustainability transition, with governments and global regulations imposing environmental restrictions and closely monitoring the adoption of ecological practices (De Giovanni and Cariola, 2021).

The circular economy (CE), rooted in the principles of reduce, reuse, recycle, and recover (4Rs), has emerged as a strategic approach to align economic growth with environmental sustainability (Kirchherr *et al*., 2017).

The European Commission has adopted strategic actions aimed at stimulating the transition to a circular economy, a model that promotes resource efficiency and long-term sustainability.

These initiatives align with the United Nations' 2030 Agenda for Sustainable Development, which sets global goals to reduce environmental impact and promote inclusive, green growth.

In addition to this, the European Commission has developed its own strategy, the European Green Deal, which aims to achieve ambitious sustainability targets. These include reaching the goal of zero pollution, promoting sustainable industrial practices, and designing products with longer lifespans that can be easily reused or recycled.

In 2020, the European Commission adopted an updated Circular Economy Action Plan (CEAP), which further encouraged specific initiatives to support the long-term transition to a circular economy. This revised plan introduced more targeted measures to promote sustainability in key sectors, including production, waste management, and consumption.

Despite growing pressure, the application of CE practices remains limited to a few companies and sectors.

In this context, there is scientific interest in understanding the factors that can facilitate the implementation of CE practices.

The purpose of this manuscript is to explore potential drivers of CE practices: financial performance and CSR committee.

In particular, the study aims to investigate the relationship between corporate CE practices and financial performance, considering the moderating effect of corporate social responsibility (CSR) committee among European listed companies.

This paper is organized as follows. Section 2 presents the literature review and research hypotheses, section 3 explains the methodology, section 4 describes the results, and section 5 concludes.

2. Theoretical Background and Research Hypotheses

2.1 CE and Corporate Financial Performance

The adoption of CE practices has been shown to influence corporate financial performance (CFP) through mechanisms such as cost reduction, improved operational efficiency, and enhanced reputation (Rodríguez-González *et al.*, 2022). Mazzucchelli *et al.* (2022) demonstrated that waste treatment and recycling initiatives contribute to financial performance by fostering positive stakeholder perceptions. Moreover, Esposito *et al.* (2024) identified the role of stakeholder engagement as a critical multiplier in realising CE benefits.

Despite these promising findings, the relationship between CE and CFP in assessment processes remains complex (Sciarelli *et al.*, 2023; Berg *et al.*, 2022; Landi *et al.*, 2022). Some studies have suggested that the adoption of CE entails significant initial costs and operational adjustments that may offset potential financial gains in the short term (Blasi *et al.*, 2021; Esposito *et al.*, 2024). Moreover, empirical evidence on the long-term financial outcomes of CE practices is mixed, with several studies highlighting both positive effects (Rodríguez-González *et al.*, 2022) and limited impacts (Sarfraz *et al.*, 2023). These discrepancies underscore the need to investigate

the mediating and moderating factors that influence the success of CE initiatives (Palea *et al*., 2023; Kwarteng *et al*., 2022).

2.2 The Role of CSR and Stakeholder Engagement

CSR plays a central role in embedding CE principles within broader corporate strategies. CSR initiatives provide a framework for integrating environmental and social objectives into business practices, thereby enhancing the credibility and effectiveness of CE efforts (Mazzucchelli *et al*., 2022; Esposito *et al*., 2024).

Governance mechanisms, such as CSR committees, are relevant in this process, ensuring alignment between sustainability goals and corporate strategies (Elamer and Boulhaga, 2024). According to Mazzucchelli *et al*. (2022), CSR committees act as key enablers by institutionalising sustainability practices and facilitating their communication with external stakeholders, thereby enhancing a firm's market reputation.

Stakeholder engagement is essential for legitimising CE practices and ensuring stakeholder management approaches (Mazzucchelli *et al*., 2022; Esposito *et al*., 2024). Firms that actively engage stakeholders in their CE strategies not only gain their trust but also benefit from improved collaboration and reduced resistance to change. For instance, Esposito *et al*. (2024) highlighted that stakeholder engagement amplifies the financial and reputational benefits of CE initiatives, while Rodríguez-González *et al*. (2022) emphasised the role of sustainable supply chain management in reinforcing these outcomes. Furthermore, the role of organisational culture in supporting CE adoption cannot be overlooked. Kwarteng *et al*. (2022) noted that a strong organisational culture-characterised by adaptability, shared values, and internal cohesion-facilitates the successful implementation of CE practices. This is consistent with the findings of Blasi *et al*. (2021), who demonstrated that CE communication strategies, such as transparent reporting and stakeholder dialogue, significantly improve financial performance by aligning internal and external stakeholder expectations.

2.3 Gaps in the Literature

The following table summarises the main gaps identified in the literature on the relationship between CE practices and CFP.

These gaps highlight the need for further research to take a more holistic approach, integrating insights from CSR, stakeholder theory, and organisa-

tional behaviour, while using standardised metrics to better understand the dynamics of CE practices and their financial implications.

The existing literature highlights the potential of CE practices to improve financial performance (Mazzucchelli *et al*., 2022; Esposito *et al*., 2024). However, mixed empirical evidence has suggested that while CE can enhance operational efficiency and reputational capital, its financial benefits often depend on specific contextual and organisational factors, such as corporate governance and stakeholder dynamics (Kwarteng *et al*., 2022; Sarfraz *et al*., 2023, Vuppuluri *et al*., 2024). It is critical to understand the role of CSR governance, particularly CSR committees, in shaping these outcomes. As highlighted by Mazzucchelli *et al*. (2022) and Esposito *et al*. (2024), CSR committees serve as important governance bodies that institutionalise sustainability practices and align them with financial objectives, thereby promoting both legitimacy and trust among stakeholders.

Table 1 – Gaps

Gap	Remarks	References
Inconsistent evidence on financial outcomes	Mixed evidence on the financial impact of CE practices, with challenges arising from high implementation costs and context-specific factors.	Mazzucchelli *et al*. (2022) Esposito *et al*. (2024) Sarfraz *et al*. (2023)
Limited research on mediating and moderating factors	Few studies have investigated how brand reputation, CSR committees, organisational culture, and stakeholder engagement influence the CE–CFP relationship.	Mazzucchelli *et al*. (2022) Kwarteng *et al*. (2022) Esposito *et al*. (2024)
Fragmented metrics for measuring CE performance	Lack of standardised tools, such as ESG-based indices, to compare companies across sectors and territories.	Esposito *et al*. (2024) Kirchherr *et al*. (2017) Landi *et al*. (2022)
Underexplored governance mechanisms	Insufficient focus on the role of CSR committees, sustainability managers, and other governance models in the adoption of CE to amplify its financial impact.	Mazzucchelli *et al*. (2022) Esposito *et al*. (2024) Elamer and Boulhaga (2024)
Geographical and contextual limitations	Predominantly focused on developed economies, with limited insights into emerging markets and resource-constrained contexts where CE adoption faces unique challenges.	Kwarteng *et al*. (2022) Sarfraz *et al*. (2023) Berg *et al*. (2022) Sciarelli *et al*. (2023)

Building on these insights, this study seeks to address two key research questions. First, it examined whether financial performance is positively associated with CE practices, given the existing but fragmented evidence on this relationship.

Hp1: Financial performance is positively associated with CE.

Second, it explored whether CSR committees positively moderate this association by improving the financial outcomes of CE practices by ensuring their alignment with organisational strategies and stakeholder expectations.

Hp2: The CSR committee positively moderates the association between financial performance and CE.

By addressing these questions, the research aimed to fill critical gaps in the literature, particularly the limited exploration of moderating factors such as CSR governance, and to provide a more nuanced understanding of the dynamics among CE, financial performance, and governance models. These research questions not only involved a more holistic approach to the study of CE (Palea *et al.*, 2023; Blasi *et al.*, 2021) but also sought to contribute to the ongoing debate on the strategic integration of sustainability practices within corporate frameworks.

3. Research Design

3.1 Sample and Data

The hypotheses were tested using a sample of nonfinancial listed EU firms, considering a five-year period (from 2019 to 2023). Data were collected from the from LSEG database (formerly known as Refinitiv Eikon database). After excluding companies with missing data, the final sample consisted of 567 firms with 2,835 firm-year observations. The research steps for sample selection are reported in Table 2.

Table 2 – Sample selection

Panel A: Steps of sample construction		
Research construction steps	Banks	Bank-year observations
Non-financial EU firms with no missing data for binary variables used to measure CE score	1,242	6,210
Missing data for interest and control variables	675	3,375
Final sample	567	2,835

Notes: Table 2 provides the research steps of the sample selection procedure.

3.2 Regression Model

The hypotheses were tested by estimating an ordered logit regression model, as follows:

$CE_{it} = \beta0 + \beta1 FP_{it} + \beta2 CSR\ COMMITTEE_{it} + \beta3 FP_{i,t}{}^{*}CSR\ COMMITTEE_{it} + \beta4 SIZE_{it} + \beta5 LEVERAGE_{it} + \beta6 BOARD_{it} + \beta7 INDEPENDENT_{it} + \beta8 BGD_{it} + \beta9 CEO\ DUALITY_{it} + \sum Sector + \sum Country + \sum Year + \varepsilon_{it}$ (1)

To measure the dependent variable, four binary variables were considered separately, equal to 1 if a firm adopted an environmental supply chain policy, a water efficiency policy, an energy efficiency policy, and a resource reduction policy. The comprehensive CE score (CE_{it}) was the sum of all four binary variables and ranged from 0 to 4.

The independent variable for testing Hp1 was financial performance (FP_{it}), alternatively proxied by the return on asset ratio (ROA_{it}) as an accounting-based measure and market value per share ($MVPS_{it}$) as a market-based measure. In doing so, we captured different perspectives on financial performance, given the historical performance (ROA_{it}) and future investor expectations ($MVPS_{it}$) (Florio and Leoni, 2017). Consistent with Hp1, we expected a significant positive coefficient on FP_{it}.

Table 3 – Variables

Variable		Definition
$CE_{i,t}$	=	Equal to the sum of four binary variables linked to the adoption of certain CE policies (environmental supply chain policy, water efficiency policy, energy efficiency policy and resource reduction policy)
$FP_{i,t}$	=	Equal to returns on assets or market value per share
CSR $Committee_{i,t}$	=	Equal to 1 if the firm has a committee focused on CSR initiatives and to 0, otherwise.
$Size_{i,t}$	=	The natural logarithm of total assets.
$Levearge_{i,t}$	=	The ratio of total debt scaled by total assets.
$Board_{i,t}$	=	The natural logarithm of the total number of directors on board.
$Independent$ $directors_{i,t}$	=	The percentage of independent directors scaled by the total number of directors on board.
$BGD_{i,t}$	=	The percentage of women directors scaled by the total number of directors on board.
$CEO\ duality_{i,t}$	=	Equal to1 if the separation of the chief executive officer and board chairperson exists and to 0, otherwise.

To test Hp2, we included the CSR committee dummy variable (CSR COMMITTEE$_{it}$) and its interaction with FP_{it} ($FP_{it}{}^{*}$CSR COMMITTEE$_{it}$). We expected a significant and positive coefficient on the interaction term, consistent with the assumption that the relationship between FP_{it} and CE_{it} is stronger when a CSR committee is appointed on the board. The model also included two sets of control variables that may affect the CE score. The first

set included financial indicators, namely firm size (SIZEit) and leverage (LEVERAGEit). The second set of control variables took into account corporate governance mechanisms, including the number of board directors (BOARDit), the percentage of independent directors (INDEPENDENTi,t), the percentage of female members (BGDit), and CEO duality (CEO DUALITYit). All variables included in the model are defined in the Table 3.

4. Empirical Results

Table 4 shows the descriptive statistics for the dependent and independent variables. The mean value of CE_{it} is 3.428, suggesting that most of the sampled firms developed policies in line with CE practices. Regarding FP_{it}, we found that ROA_{it} is on average equal to 3%, while $MVPS_{it}$ is on average equal to 72.774. The mean value of CSR COMMITTEE$_{it}$ is 79.9%, suggesting that most of the sampled firms had a committee specialising in CSR initiatives.

Table 4 – Descriptive statistics

Variable	N	SD	Mean	P25	P50	P75
CE_{it}	2,835	0.927	3.428	3	4	4
ROA_{it}	2,835	0.154	0.030	0.013	0.039	0.070
$MVPS_{it}$	2,835	39.101	72.774	8.064	21.265	55.162
$CSR\ COMMITTEE_{it}$	2,835	0.401	0.799	1	1	1
$SIZE_{it}$	2,835	1.698	22.194	21.127	22.228	23.278
$LEVERAGE_{it}$	2,835	0.231	0.296	0.169	0.285	0.398
$BOARD_{it}$	2,835	0.384	2.278	1.945	2.302	2.564
BGD_{it}	2,835	12.974	33.967	27.270	33.330	42.860
$INDEPENDENT_{it}$	2,835	27.960	48.460	26.710	44.710	70.000
$CEO\ DUALITY_{it}$	2,835	0.436	0.255	0	0	1

Table 5 presents the Pearson correlation matrix for the variables included in the multivariate analysis. Since the correlations between independent variables are below 0.80 (Gujarati and Porter, 2009), we concluded that there was no multicollinearity effect in Model (1).

Table 6 shows the regression analysis for testing the study hypotheses. The results show a significantly positive coefficient on FP_{it} for both proxies [see Columns (1) and (3)], suggesting that financial performance is a key driver of CE practices at the firm level. We found support for Hp1. Regarding the CSR COMMITTEE$_{it}$ variable, we observed a positive and statistically significant coefficient on β2 [see columns (2)– (4)].

Table 5 – Correlation matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) CE_{it}	1								
(2) ROA_{it}	0.190*	1							
(3) CSR COMMITTEE$_{it}$	0.412*	0.129*	1						
(4) $SIZE_{it}$	0.451*	0.175*	0.382*	1					
(5) $LEVERAGE_{it}$	0.022	-0.455*	0.033	0.063*	1				
(6) $BOARD_{it}$	0.345*	0.063*	0.289*	0.564*	0.077*	1			
(7) BGD_{it}	0.176*	0.046*	0.181*	0.137*	0.017	0.137*	1		
(8) $INDEPENDENT_{it}$	-0.017	-0.038*	0.059*	0.048*	-0.017	-0.213*	-0.005	1	
(9) CEO DUALITY$_{it}$	0.085*	0.032	0.093*	0.081*	0.008	0.165*	0.120*	-0.090*	1

Notes: This table reports correlation matrix. *denotes significance at the 5 percent level (two tailed).

Table 6 – Results

	$FP_{it} = ROA_{it}$				$FP_{it} = MVPS_{it}$			
	(1)		(2)		(3)		(4)	
Variable	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.	Coeff.	t-stat.
FP_{it}	1.038***	3.400	0.751***	3.230	0.940***	2.940	0.582***	2.810
CSR COMMITTEE$_{it}$			0.884***	7.630			0.874***	7.690
FP_{it}* CSR COMMITTEE$_{it}$			0.754***	2.790			1.309***	2.580
$SIZE_{it}$	0.522***	13.630	0.467***	12.030	0.519***	13.430	0.467***	11.940
$LEVERAGE_{it}$	0.264	1.360	0.199	1.030	0.242	1.210	0.158	0.810
$BOARD_{it}$	0.681***	4.400	0.555***	3.580	0.703***	4.530	0.573***	3.680
BGD_{it}	0.015***	3.890	0.014***	3.720	0.016***	4.010	0.015***	3.810
$INDEPENDENT_{it}$	0.004**	2.480	0.002	1.500	0.004**	2.420	0.002	1.460
CEO DUALITY$_{it}$	0.219*	1.870	0.196	1.670	0.216*	1.840	0.185	1.570
Sector fixed effect	Yes		Yes		Yes		Yes	
Country fixed effect	Yes		Yes		Yes		Yes	
Year fixed effect	Yes		Yes		Yes		Yes	
Pseudo R^2	0.205		0.217		0.202		0.210	
N	2,835		2,835		2,835		2,835	

Notes: This Table reports results of Model (1). The t-statistics are reported in parentheses. ***, **, and * denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

This indicates that the presence of such a committee is also a key determinant of CE practices at the firm level. More importantly, we found a positive and statistically significant coefficient on β3, indicating that the association between FP_{it} and CE_{it} is stronger when a CSR committee is appointed on the board. As a result, the CSR committee positively moderates the association. We also found support for Hp2.

Regarding the control variables, we found that CE_{it} is positively and significantly associated with $SIZE_{it}$, $BOARD_{it}$ and BGD_{it}.

To strengthen the causality between the independent and dependent variables and to address endogeneity concerns (Richardson *et al.,* 2013; Godos-Díez *et al.,* 2018), we reran Model (1) using the one firm-year lag values of the independent variable FP_{it}. The results are reported in Table 7.

Table 7 – Robustness test

	CE_it							
	$FP_{it-1} = ROA_{it-1}$				$FP_{it-1} = MVPS_{it-1}$			
	(1)		(2)		(3)		(4)	
Variable	*Coeff.*	*t-stat.*	*Coeff.*	*t-stat.*	*Coeff.*	*t-stat.*	*Coeff.*	*t-stat.*
FP_{it-1}	1.078***	3.550	0.072***	2.790	1.015***	3.880	0.719***	2.650
CSR COMMITTEE_it			0.862***	7.480			0.870***	7.650
FP_{it-1}*CSR COMMITTEE_it			1.349**	2.400			1.454**	2.150
SIZE_it	0.540***	14.270	0.479***	12.520	0.522***	13.580	0.465***	11.940
LEVERAGE_it	-0.065	-0.410	-0.020	-0.130	0.205	1.090	0.162	0.880
BOARD_it	0.651***	4.220	0.529***	3.420	0.680***	4.390	0.576***	3.690
BGD_it	0.016***	4.070	0.015***	3.780	0.015***	3.970	0.015***	3.830
INDEPENDENT_it	0.004**	2.170	0.002	1.300	0.004*	2.410	0.002	1.470
CEO DUALITY_it	0.232*	1.980	0.195	1.660	0.220*	1.880	0.178	1.510
Sector fixed effect	Yes		Yes		Yes		Yes	
Country fixed effect	Yes		Yes		Yes		Yes	
Year fixed effect	Yes		Yes		Yes		Yes	
Pseudo R^2	0.203		0.216		0.200		0.209	
N	2,835		2,835		2,835		2,835	

*Notes: This Table reports results of robustness test controlling for potential endogeneity issue of the main empirical model. The t-statistics are reported in parentheses. ***, **, and * denote significance at the 1 percent, 5 percent, and 10 percent levels, respectively.*

The lag test largely confirmed the main results. More importantly, we observed a positive and significant coefficient on FPit and the interaction variable (FPit*CSR COMMITTEE$_{it}$). As there were qualitatively unchanged inferences, we concluded that endogeneity issues were not critical in the sample.

5. Conclusion and Implications

The research shows interesting implications both theoretical and managerial. From a theoretical perspective, the study enriches studies on corporate governance mechanisms and sustainability showing how they may be tools to facilitate the implementation of the circular economy (Vuppuluri *et al*., 2024). Moreover, it advances studies on the relationship between the circular economy and financial performance (Blasi *et al*., 2021; Rodríguez-González *et al*., 2022; Esposito *et al*., 2024).

This research provides valuable insights for managers and decision-makers seeking to integrate CE practices. The positive link between corporate financial performance and CE practices suggests that firms with stronger financial positions are better able to implement sustainable business models. Financial health is relevant not only for shareholder value but also for the transition to circular business models. Financially strong firms can invest in research, innovation, and technologies that support resource efficiency and waste reduction. In addition, the CSR committee plays a positive role as a moderator between financial performance and CE practices. Managers should establish or strengthen CSR committees to integrate sustainability goals into their decision-making processes. These committees foster a sustainability-oriented corporate culture, increase internal accountability, and improve communication with external stakeholders. The findings of this study provide compelling evidence for the reverse causality between corporate sustainability and financial performance, as the analysis indicates that the availability of financial resources significantly enables a company to improve its sustainability performance.

Therefore, managers should recognise the combined role of financial resources and governance mechanisms in adopting CE practices that can support the transition to sustainable models while achieving long-term profitability and competitive advantage.

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6. Limits and Future Research

This research provides valuable insights into the relationship between financial performance and the adoption of CE practices, but it has certain limitations. The CE score used may not fully capture the complexity of the practices adopted by firms and may overlook qualitative factors, such as innovation in business models or the long-term impact of strategies. Future research could address these limitations by including qualitative variables, such as sustainability culture, environmental leadership, and intellectual capital. In addition, future studies could explore other corporate governance tools, such as sustainability-linked compensation or specialised environmental management roles.

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Quantifying Social and Environmental Impacts through the Life Cycle Assessment

Pietro De Giovanni*, Michele Costabile**

Abstract

This paper presents an overview of the measures linked to social and environmental sustainability. Then, it proposes an empirical analysis of these impacts with an example of cotton production in India. The application of the Life Cycle Assessment (LCA), as outlined by ISO 14040, allows one to quantify both the social and the environmental impact and define a strategy to mitigate both of them simultaneously. Hence, the paper presents a set of trade-offs emerging when companies seek to optimize both environmental and social impact of their businesses**.** We demonstrate that, through the adoption of LCA, the pair social and environmental impact can be simultaneously optimized and sustainable strategies can be effectively created.

Keywords: Environmental impact, Social Impact, Performance, LCA.

Quantificare gli impatti sociali e ambientali attraverso il Life Cycle Assessment

Sommario

Questo articolo presenta una panoramica delle misure legate alla sostenibilità sociale e ambientale, proponendo un'analisi empirica di questi impatti con un esempio

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della produzione di cotone in India. L'applicazione del Life Cycle Assessment (LCA), come delineata dalla norma ISO 14040, permette di quantificare sia l'impatto sociale che quello ambientale e di definire una strategia per mitigarli entrambi simultaneamente. Pertanto, l'articolo analizza una serie di trade-off emergenti quando le aziende cercano di ottimizzare contemporaneamente sia l'impatto ambientale che quello sociale delle proprie attività. Si dimostra che, attraverso l'adozione della LCA, gli impatti legati agli aspetti sociali e ambientali possono essere ottimizzata simultaneamente attraverso strategie sostenibili efficaci.

Parole chiave: Impatto ambientale, Impatto Sociale, Performance, LCA.

1. Introduction

Recently, some firms faced accusations of greenwashing since their decarbonization plans failed to report credible sustainable initiatives (Johnsson *et al.*, 2020). These criticisms highlight the absence of a thorough and verifiable approach in substantiating the environmental benefits claimed in their sustainability initiatives. Firms are mandated to draft their decarbonization plans to achieve both the 2030 and the 2050 targets, necessitating the quantification of their CO2 emissions and the identification of initiatives to reduce these emissions (Pollok *et al.*, 2021). To accomplish this target, the Life Cycle Assessment (LCA) can be effective in enabling companies to create credible and effective decarbonization plans by providing a comprehensive analysis of environmental impacts across the entire life cycle of their products and services (Finkbeiner and Bach, 2021). In fact, the integration of sustainability and LCA methodologies has been proposed as a pathway for addressing the complexity of greenwashing issues in many heavy industries such as textiles (Mousavi *et al.*, 2024).

The whole process of LCA analyzes various "impact categories", each of which uses certain indicators to calculate potential impacts, making it possible to evaluate the effects of production, utilization, and disposal of products on the environment. Accordingly, firms can set environmental strategy to manage products sustainably. In detail, the most common impact categories are Global Warming Potential (GWP), which tracks the emissions of greenhouse gases and the effects of these gases on earth's temperature, and Ozone Depletion Potential (ODP), which determines the substances reducing the ozone layer (McClelland *et al.*, 2018). However, other measures like Human Toxicity Potential (HTP) consider the possible harmful effects of a specific environmental pollution on human health along with Ecotoxicity, which accounts for the impact of biological, chemical, or physical factors on the ecosystems (Raymond *et al.*, 2020). Furthermore, Acidification Potential (AP)

involves emissions that contribute to the depletion of rain, which is an important factor as air, farm soil, and water bodies get affected, along with Eutrophication Potential (EP), which includes the nutrients that travel through discharges that over-fertilize the water bodies. Subsequently, the water bodies become overloaded with algae, and oxygen will be reduced (Pennington *et al*., 2004). The negative list, as reported by the ISO 14040, also includes the Photochemical Ozone Creation Potential (POCP), which measures emissions for ground-level ozone formation, a major component of smog (Guinée, 2015). Also, Resource Depletion shows the depletion of finite resources, whereas the Water Use and Land Use categories evaluate the water resources and biodiversity and ecosystem services respectively (Hauschild *et al*., 2013). Finally, the ISO 14040 requires the quantification of the Particulate Matter Formation, including the emissions that make air quality and health suffer (Rigon *et al*., 2019). Recent developments in the field highlight advancements in assessing these categories to ensure sustainability (Finnveden *et al*., 2009).

Along with the environmental impact, the LCA can also be used to assess the social impact, through its variant, the Social Life Cycle Assessment (S-LCA). The S-LCA presents the social effects from the manufacturing to the disposal of products, which draw the attention of stakeholders and the ecosystem (D'Eusanio *et al*., 2022). CSR is often the first place to look for lists of "social impact categories", since it directly links to ethics and human rights firms consider in their sustainable strategies (Tsalidis *et al*., 2021). As ISO 26000 outlines a set of practices and patterns crucial for organizations to adhere to for their sustainability, S-LCA represents a structured tool to evaluate the social impacts of products during their entire life cycle (Bhatnagar and Niinimäki, 2024).

Both S-LCA and ISO 26000 are based on analyzing the consequences that firms can have on stakeholders like workers, communities, consumers, and the surroundings. With the help of this analysis, firms can reinforce social accountability and transparency (Pollok *et al*., 2021). Finally, the integration of S-LCA with ISO 26000 principles not only endorses a thorough approach to sustainability but also results in more ethical, responsible, and sustainable business practices (Ilhan and Tanyer, 2019). In fact, these methodologies aid firms in aligning with social responsibility standards (Norris and Norris, 2014), and advances a deeper understanding of social impacts (Tsalidis *et al*., 2021).

Given its amplitude and complexity, this paper measures social sustainability in terms of: a. *Child Labor*, which measures the extent to which children are employed in the production process (D'Eusanio *et al*., 2022); b. *Fatal Accidents*, which tracks the number of lethal accidents occurring within

the production chain and reflects the safety standards and working conditions (Bhatnagar and Niinimäki, 2024); c. *Life Expectancy at Birth*, which reflects the long-term health impacts of working in the industry (e.g., exposure to pesticides and other chemicals can affect workers' health severely) (Pollok *et al.*, 2021); d. *Expenditure on Education*, which reports the investment made in education for communities involved in production (Ilhan and Tanyer, 2019); and e. *Violation of Employment Laws*, which assesses compliance with local and international employment laws, including those relating to wages, working hours, and working conditions (Tsalidis *et al.*, 2021).

This paper seeks to provide a deep examination of the social and environmental sustainability by considering the production of cotton in India as reference product. The study uses the LCA framework of the ISO 14040 standard to quantify the environmental impacts along with some parts of the ISO 26000 to address the social aspects, thus helping to form combined strategies to mitigate both. Using the Ecoinvent dataset, we demonstrate how LCA can quantify the impact and, consequently, help identifying how to write decarbonization plans; specifically, we seek to answer these two research questions (RQ):

RQ1. Which input contributes the most to social and environmental impacts in the cotton production process?

RQ2. What measures can be implemented to mitigate the adverse social and environmental impacts associated with the key input identified in cotton production?

These research questions encourage the identification of specific solutions for life-threatening functioning processes in the cotton industry, which has significant social and environmental impact and focuses in one of the most important agricultural sectors. Through the identification of the main ingredients, this research makes sure that the discussion around sustainability continues to be not only theoretically robust but also practically relevant, identifying actionable recommendations and giving the necessary space for the industry shareholders and policymakers for ad hoc interventions, while contributing to the wider context of sustainable development and responsible resource management.

Therefore, the paper proposes an objective approach to quantify both the social and the environmental impacts that firms should definitely embrace to create effective and credible sustainable strategies. This paper is structured as follows. Section 2 introduces a literature review on the topic of measuring the performance. Then, Section 3 describes the source of data and Section 4

proposes an empirical analysis using LCA methodology. Finally, Section 5 briefly concludes.

2. Literature Review on Cotton Environmental and Social Impacts along the Life Cycle

The quantification of social and environmental impacts is a central topic in sustainable development discourse. This short review, proposed with the only aim to better framing the focus of the paper, explores initiatives to measure and mitigate the above-mentioned impacts, integrating insights on technical quantification methods, and specific industrial supply chain applications such as cotton production.

Cotton is among the most extensively cultivated crops globally, serving as a cornerstone for the textile industry and supporting millions of smallholder farmers across numerous countries. Its significant contribution to global economies and livelihoods underscores its importance (Nikam *et al.*, 2022).

The cotton industry employs 250 million people globally, with 7% of the labor force in developing countries. It is the leading non-food agricultural commodity, with five countries producing 74% of global output. Supporting 150 million livelihoods in 75 countries, the sector is vital to developing economies and the 2030 Sustainable Development Agenda.

However, the cultivation and processing of cotton present severe environmental and social challenges, including excessive water consumption, reliance on pesticides, and labor inequities. These issues have prompted an urgent shift toward sustainable practices in the sector.

LCA has become a crucial tool for evaluating and addressing the environmental impacts of cotton production. By analyzing resource use and emissions throughout the cotton lifecycle – from cultivation to disposal – LCA provides valuable insights for developing sustainable policies and practices. This approach helps pinpoint key areas for improvement, such as reducing water and pesticide use while promoting environmentally friendly technologies (Zhang, 2015). LCA further empowers stakeholders to make data-driven decisions to pursue, also through digitalization, resource efficiency and promoting a transition toward more sustainable models (Maleki Vishkaei and De Giovanni, 2025).

This analysis places particular emphasis on India, a leading cotton producer, exploring the social and environmental initiatives aimed at fostering sustainability. Programs like farmer education and integrated pest management (IPM) are highlighted for their role in reducing input costs and

improving yields. Simultaneously, LCA applications demonstrate the potential to optimize resource efficiency and minimize ecological footprints, advancing the cotton sector toward a more sustainable future and promoting durable ecological stewardship and social empowerment (De Giovanni, 2025).

As previously stated, cotton production in India plays a significant role in the agricultural and textile sectors, providing livelihoods to millions of farmers (Nikam *et al.*, 2022). Various social initiatives aim to address challenges such as low productivity, resource inequity, and the exploitation of labor. Many programs promote farmer education, equitable labor practices, and sustainable livelihoods.

Organizations like Better Cotton Initiative (BCI) work extensively in India to train farmers on sustainable farming practices, focusing on reducing input costs and improving yields while safeguarding worker rights. The BCI framework emphasizes equitable labor practices and empowers smallholder farmers by providing access to resources and knowledge on pest management and water conservation.

However, social barriers such as gender disparities continue to hinder progress. Women, who perform most of the labor-intensive tasks like planting and harvesting, are often excluded from decision-making roles. These inequities limit resource access and sustainable farming practices adoption (Omollo, 2023). Studies have recommended community development programs to address these disparities and enhance the overall sustainability of the sector (Omollo, 2023).

India's cotton sector also faces significant environmental challenges, including high water usage, pesticide dependency, and soil degradation. Various initiatives have been launched to promote eco-friendly farming methods. For instance, organic cotton farming practices have gained traction, reducing dependency on chemical fertilizers and pesticides. These practices also help in conserving soil health and reducing water consumption.

Efforts to mitigate environmental impacts also include the promotion of integrated pest management (IPM) and biological control techniques. IPM reduces pesticide use and improves ecological balance, though adoption rates remain low due to the high costs and limited awareness among smallholder farmers. Furthermore, environmental non-governmental organizations (NGOs) have advocated for the adoption of drip irrigation and laser leveling to enhance water efficiency. These practices have shown promising results in reducing resource consumption, though scalability remains a challenge (Nikam *et al.*, 2022).

LCA is a critical tool for understanding the environmental impacts of cotton production across its entire life cycle, from cultivation to disposal.

Studies conducted in India have highlighted key hotspots in the cotton production chain, such as water consumption, pesticide use, and energy-intensive processing stages like dyeing (Zhang, 2015).

In the agricultural phase, excessive use of fertilizers and pesticides contributes to eutrophication and soil acidification. LCA studies indicate that water consumption during irrigation accounts for a significant proportion of the environmental burden in cotton cultivation. Transitioning to more efficient irrigation methods and using organic farming techniques could substantially reduce these impacts (Zhang, 2015; Abagnato, 2024).

The processing phase, including dyeing and fabric finishing, is another significant contributor to environmental degradation. These processes are energy-intensive and rely heavily on non-renewable resources. Studies have shown that adopting renewable energy sources and low-impact dyeing methods can significantly reduce greenhouse gas (GHG) emissions (Semba, 2024; Zhang, 2015).

LCA of cotton reveals that irrigation, pesticide implementation and dyeing processes constitute substantial sources of environmental impact. However, it is essential to recognize that these elements cannot be assessed in isolation, as their repercussions extend to water management and the textile waste cycle.

To address these issues and mitigate the overall impact of the textile sector, complementary solutions are required. These include wastewater treatment and the adoption of circular economy approaches (De Giovanni and Ramani, 2024). The analysis further emphasises the significance of integrated solutions, as evidenced by the comparison between conventional and biological approaches, in reducing greenhouse gas emissions and minimising resource consumption.

The wastewater management research on wastewater treatment in India's textile industry demonstrates that advanced treatment technologies like reverse osmosis and ultrafiltration can mitigate water pollution (Nakhate, 2020); while the circular economy approaches focus on circular practices, such as recycling textile waste into new fabrics or biochar, have shown potential for reducing environmental impacts (De Giovanni and Folgiero, 2023). Studies reveal that recycling pre-consumer textile waste has lower impacts compared to post-consumer waste due to its consistent composition (Abagnato, 2024).

Finally, studies on comparative impact assessment comparing organic versus conventional cotton highlight that organic practices result in lower GHG emissions and reduced water consumption. However, organic yields are generally lower, requiring more land to produce the same amount of cotton (Zhang, 2015; Abagnato, 2024).

3. Data and Methodology

The data that was taken from Ecoinvent to assess both areas social and environmental. This database gives a deep insight into the life cycle of a product, for many processes and products. Ecoinvent is highly recognized worldwide as LCA databases since it includes more than 5000 firms around the world. The database has life cycle inventory data related to international industrial energy supply, resource extraction, material supply, chemicals, metals, agriculture, waste management services, and transport services. As of now, the database has more than 20000 reliable datasets in it.

The database really is transparent and consistent and each data set is served as a unit process and as an aggregated system process. Ecoinvent is a Zurich, Switzerland-based non-profit organization that is dedicated to guaranteeing the availability of high-quality data for sustainability assessments all over the world. Its mission is to address environmental data dissemination and exchange issues, such as life cycle inventory data compilation, linking and distribution, and data and database management. Ecoinvent coordinates various initiatives aiming at promoting awareness and good practices in the creation and use of life cycle inventories around the world, making data available and involving policy-makers, private enterprises, NGOs, and the academic community globally to update and enrich it. The dataset is available at https://ecoinvent.org/.

4. Analysis of a Reference Product

Indeed, to make the quantification of both the social and environmental impact, we selected a reference product to analyze. Considering the data available, we focus on the production of 1kg of cotton in India. In the context of cotton production, the electricity, fertilizer, pesticides, and tractors represent various inputs and resources that are essential for the cultivation and harvesting processes, which are therefore important components of the bill-of-material as displayed in Figure 1. Each of them has a distinct role and impact on both the crop yield and the environmental and social footprint of cotton farming, as specified below:
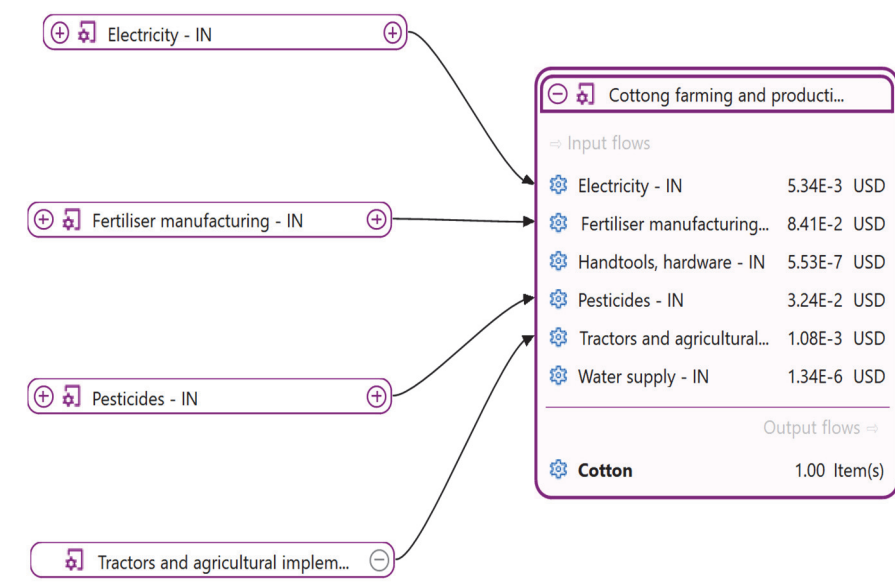- **Electricity**. Among the primary ways one can use electricity in cotton production are running irrigation systems, providing light, and feeding the equipment. The energy used for the different stages of the cotton farming process includes the water pumps that are powered for irrigation to the ginning and pressing process. The type of energy used and its efficiency is one of the aspects that are likely to affect the impact of this

process. For instance, the use of electricity with low emissions and low energy consumption may decrease the environmental impact of cotton fabric production process;

- **Fertilizer**. Fertilizers are products that are given to plants in order to help them grow faster and better. They are substances such as nitrogen, phosphorus, and potassium that plants need to grow and are, as a rule, rich in nutrients. As regards cotton farming, fertilizers are the major player in delivering the desired crop which can only be achieved through high yields and proper plant health. Nevertheless, the production, transportation, and application of synthetic fertilizers are accompanied by water pollution due to the release of runoff, soil degradation, and the emission affecting the climate it causes. The demand for these chemicals is also affected, especially in relation to the health risks for farmworkers who get in contact with them;
- **Pesticides.** Pesticides, which are chemicals used to kill or control pests that damage or inhibit plant growth, are the cause of the problems. In cotton farming, pesticides make the cotton plant resistant to a wide range of insects, weeds, and diseases. Moreover, the pesticides used were also very effective in improving crop productivity and reducing losses through pest control, but they have led to various health problems, such as water pollution, the reduction of vital species (not only harmful insects, but also beneficial insects), and the decline in the biodiversity. Furthermore, the long-term exposure to these chemicals can increase health risks by the eco-system;
- **Tractors and farming equipment**. Tractors and other agricultural machinery are most likely adopted in cotton farming to plow, plant, spray fertilizers, and pesticides, and harvest. These machines greatly diminish the amount of labor while augmenting their efficiency. Nevertheless, their use involves the burning of fossil fuels, thus, reducing the emissions of greenhouse gases and particulates. Besides, the production and maintenance of agricultural machinery lead to resource depletion and environmental pollution.

Figure 1 – LCA boundaries

⊕ 🗗 Electricity - IN	⊕

⊖ 🗗 Cottong farming and producti...	
⇒ Input flows	
🔅 Electricity - IN	5.34E-3 USD
🔅 Fertiliser manufacturing...	8.41E-2 USD
🔅 Handtools, hardware - IN	5.53E-7 USD
🔅 Pesticides - IN	3.24E-2 USD
🔅 Tractors and agricultural...	1.08E-3 USD
🔅 Water supply - IN	1.34E-6 USD
Output flows ⇒	
🔅 **Cotton**	1.00 Item(s)

4.1 ISO 14040 and the environmental impact

A comprehensive approach that incorporates the most critical environmental sources is indeed necessary for cotton production in India to have an innovative environmental impact harnessing in full its potential. Figure 2 displays the impact category reported in the ISO 14040 and the impact of each operational component. As it emerges from Figure 2, the first task is to reduce the use of pesticides, which are the major problem in many areas, contributing 43% to Ecotoxicity, 40% to Human Toxicity Potential (HTP), and 36% to both Eutrophication Potential (EP) and Acidification Potential (AP), by improving the utilization of integrated pest management (IPM) strategies. Clearly, IPM emerges as the ideal solution as it harnesses the power of nature and thus at the same time decreasing the dependence on artificial chemical pesticides, generating an improvement of the quality of the environment as well.

Figure 2 – Analysis of the Environmental impacts

Figure 2 – Analysis of the Environmental impacts
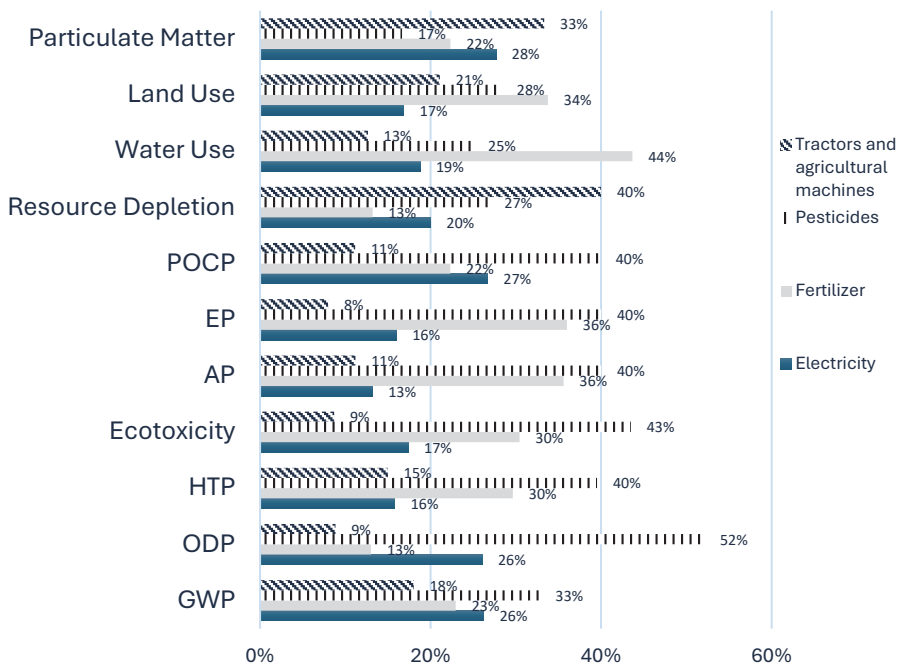
On the one hand, fertilizers, which dominate the environmental impact by 44% in Water Use, 34% in Land Use, and 36% in EP, are the primary factors that may have an effect on aquatic ecosystems. Improving efficiency with the help of smart agriculture tools like those for precision application of fertilizers is vital in that the amount of fertilizers used, runoff, and overheating of the soil are concerns. Thus, the strategy of large-scale irrigation and the application of chemical fertilizers for a prolonged period of time would be rather obsolete, if no rescue strategy is applied.

The general effects of energy, particularly in terms of the Global Warming Potential (52% from Electricity) and the Photochemical Ozone Creation Potential (40% from Electricity), might be solved by using energy from renewable sources like solar and wind power. This would of course make existing electric "dirty" technologies obsolete but at the same time render the overall ecological footprint smaller.

Tractors and other types of agricultural machinery cause resource depletion (40% contribution from tractors and machinery) and release particulate matter into the atmosphere (33% contribution from tractors and machinery). Converting to more electric and fuel-efficient models can definitely reduce

the amount of resource and emissions. Constant machinery service to enhance the performance of machinery and the implementation of no-till farming methods also can reduce the usage of heavy machinery, thus, the negative impact on particulate matter and land use.

4.2 Social impact

To address the social impacts of cotton production in India, it is important to consider the specific challenges posed by various inputs such as electricity, fertilizers, pesticides, and tractors & agricultural machines. Each of those inputs will affect different social and labor conditions, they will need specific strategies for mitigation.

Electricity, a vital input in cotton production, has been associated with significant life expectancy exposures of 33% and labor violations of 29%. The measures to curb these effects would be better safety standards for electrical installation and enhancing workers' safety, as well as the use of cleaner energy instead of those derived from fossil fuels. Also, the companies need to be strict about safety protocols and train the workers on how to maintain a clean workplace, and then, the workers will benefit a comprehensive working environment along with fewer legal violations.

Figure 3 – Analysis of the Social impacts
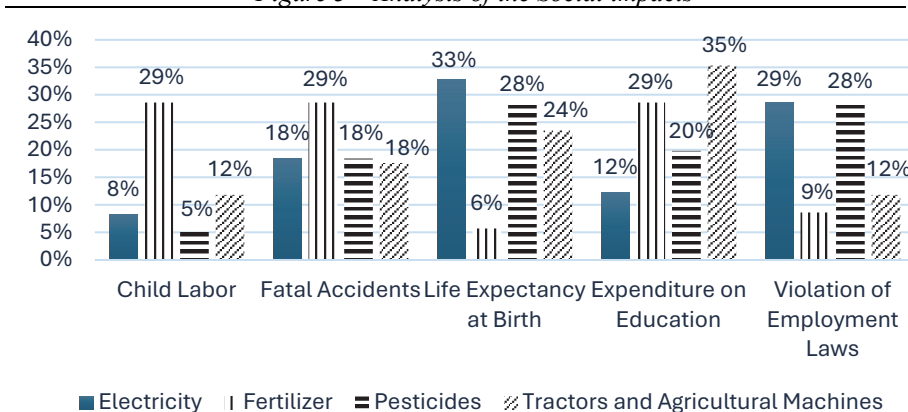
Fertilizers, which are indispensable for crop growth, have serious risks, equitably dividing contributing factors between the child labor and the fatal accidents (29% each). The replacement of the hazardous chemical fertilizers by non-harmful organic substances that are eco-friendly can lessen the risks

associated with health and child labor abuses. The insistent safety rules and incessant sessions of training are key requirements to decreasing accidents and ensuring the safety of all workers.

Pesticides, often applied to keep the crops healthy, have a negative effect on life expectancy at birth (28%) as well as being often the cause of violating employment laws (28%). The switch to integrated pest management methods can lessen the usage of harmful chemical pesticides. It is also very important to do regular audits and to punish hazardous conditions and exploitation of workers through employment laws.

Tractors and other heavy equipment required for modern farming are, however, not only rather costly in terms of health expenditure and life expectancy from birth. Investing in community education programs on vehicle and machine operations safety and providing high-tech machinery should be the primary route to the prevention of accidents and casualties among workers, ultimately leading to decreased injuries. Besides, these actions will also strengthen the life expectancy of the workers right from the point of future generations, which will be a safer and more efficient one.

5. Conclusions

This paper reviews both the social and the environmental initiatives that are currently running in the cotton production sector in India. Our main goal is to examine and evaluate both the social and environmental benefits that result when decarbonizing the operations. We use the LCA to quantify and analyze the impacts resulting from each stage of the cotton production process. Our results demonstrate that practices such as organic farming techniques can lead to a significant reduction of the negative effects of synthetic chemicals and harmful pesticides that are the main factors in environmental degradation and human health. Organic methods, on the other hand, usually require less water and energy, solving issues like water use and greenhouse gas emissions.

As a result of the social impact analysis, strict regulations on labor practices should be implemented to favor sending children to school instead of working in unclear conditions, avoiding accidents and investing in worker education and health. Therefore, the education programs can educate on safe handling of the agricultural chemicals, proper using of the machinery and informed workers' rights. This, in turn, directly impacts the life expectancy of workers and reduces the violations of the employment laws. Fostering new technologies such as those to reduce the necessity of labor and exposure to

dangerous substances can make the workers' environment safer, as well as help nature, as the impact from the very beginning to the very end of a life cycle can be reduced. The use of technologies like drip irrigation and solar-powered systems makes it possible to owe the same job to a lower possible number of people, while providing ecological benefits.

Through this study, we can identify some recommendations for policy makers:

- Promote the use of integrated pest management (IPM) in order to reduce the amount of chemical pesticides used, and therefore decrease ecotoxicity and human toxicity, while at the same time, maintaining worker health at a safe level, and community safety and well-being improvement;
- Sponsor the use of precision agricultural methods for the application of fertilizers can produce the maximization of resource use, the minimization of environmental runoff, the preservation of aquatic ecosystems, as well as the reduction of the risks of car accidents;
- Take offshore energy sources such as solar and wind energy to endorse the decrease of greenhouse gas emissions, and improve air quality of the surroundings, consequently, the diminishing of environmental impacts and the minimal exposure of the workers to hazardous conditions;
- One of the steps to technological advance of agriculture is the use of power machines that run on biofuels and electricity because it allows for the lowering of resource depilation and air pollution. Thus the operation of safe machinery is assured;
- Ensure the adoption of safety protocols and continuous staff training at every production process to change the perception of environmental management and worker satisfaction, and, therefore, to build up a sustainable culture.

This paper has some limitations, which are taken here to inspire future research projects. The reliability of the environmental and social impact data produced by the LCA and its variations is very much dependent on the accuracy of the data, which requires further investigation confronting the Eco-invent dataset with other sources. Besides that, the intrinsically dynamic nature of agriculture – where technologies, practices, and regulations are in constant flux – makes these findings temporary valid. Bringing in a wider variety of cotton sorts and looking at the issue from a more global perspective would profit the study by providing a deeper understanding of the global cotton market. Furthermore, future research should delve into the transition to sustainable technologies by linking sociological and financial strategies, thus providing a more holistic perspective of the most efficient sustainability practices. While this case study application offers a new view for analyzing

sustainability, more cases and empirical studies are required to generalize the findings and make the recommendations more robust.

Acknowledgement

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