The Sustainability of the Factoring Chain in Europe in the Light of the Integration of ESG Factors

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THE SUSTAINABILITY OF THE FACTORING CHAIN IN EUROPE IN THE LIGHT OF THE INTEGRATION OF ESG FACTORS

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Abstract. The competitiveness of financed intermediaries cannot be based exclusively on financial sustainability, i.e. the ability to create profit, but it is also necessary to acquire a transversal vision of sustainability focused on the three ESG dimensions. The paper intends to propose a reflection on the main impacts of the integration of ESG factors on business decision-making and operational processes in the financial sector. In this context, we try to understand what role FinTech can play in favor of greater sustainability. Furthermore, through an empirical analysis, some determinants relating to social, environmental, and governance issues are identified which influence the volume of financial resources moved in the factoring market at a European level. Machine learning models are also proposed to estimate the volume

Keywords: Sustainability, Factoring, ESG, FinTech, Machine Learning, Clusterization

JEL CLASSIFICATION: G00, G2, G21

1.INTRODUCTION

This paper is included in a three-year research project of the Department of Economics and Business of the University of Catania entitled "Fintech, Development Finance and Factoring".
This paper originates from the belief that safeguarding sustainable development processes represents the only solution to reduce the negative effects of various environmental problems (Schoenmaker & Schramade, 2018, Gutterman 2021). In this way, human beings avoid depleting natural resources to achieve their goals.
In particular, new development policies such as the 17 sustainable development goals of Agenda 2030 have given a significant acceleration to the interest in sustainability perceived not only as financial sustainability. Greater access to financing services such as loans, deposits and payment systems may be a factor facilitates the implementation of the Agenda for Sustainable Development (Ferrata 2019; Demir et al. 2022). According to this author, finance is heavily involved in at least nine of the 17 SDGs, with a direct impact on life-related issues Economic conditions and development. The use of digital technologies in the financial sector reduces factors such as information asymmetries, market segmentation, and high transaction costs which traditionally prevent access to credit for the poorest non-bankable subjects without guarantees (Morawczynski, 2009; Ouma et al., 2017). Rather, greater transversality has been Makina given to the concept of sustainability which, to be a strategic lever for the competitiveness of businesses, credit institutions, and public administrations, must also look at ESG issues. a transversality. In particular, financial intermediaries, being distributors of financial resources, which if scarce can hinder the transition to a sustainable, green, and inclusive economy, are among the local actors particularly interested in managing the new forms of finance that are emerging and which make the more competitive credit market (Kaur & Kautish 2022).

Trough this paper we intends to answer the following research questions:

1. *How important can the adoption of the ESG approach be for greater sustainability of the factoring supply chain?*
2. *Can greater integration with FinTech make factoring more competitive in Europe compared to the traditional banking channel?*

To answer the aforementioned questions, within the structure of the paper, we are proceeding with three subsequent steps. The first intends to offer a description of the main theories that interpret ESG issues as strategic components of long-term success. In particular, in this section, we intend to describe the impacts of the integration of ESG profiles on the choices of operators in the factoring supply chain in terms of their organization, compliance, environmental and social aspects, personnel management, focus on business segments, and management practices. risk management. Concerning the second research question, factoring operators could benefit from an easier way of accessing financing as well as higher rates favorable through diversification: using, for example, forms of bank lending that exploit synergies with Fintech, as well as the issuing of bonds linked to sustainability objectives. These instruments make it possible to obtain potentially favorable conditions in terms of prices and resulting issuance costs. The second step is closely related to the previous one and has an empirical nature using the World Bank database relating to environmental, Social, and Governance data for European countries in the period between 2016 and 2022. In particular, econometric models will be proposed to estimate the impact of the E, S, and G components on the Total Factoring Volume (TFV) together with clustering and predictions with machine learning algorithms. Specifically, four different types of econometric approaches namely: Pooled Ordinary Least Squares OLS, WLS Weighted Least Squares, LAD Minimum Absolute Deviations, and Quantile Estimates. Specifically, we estimated three different equations thus considering the impact of the TFV within the E-Environment component of the ESG model, within the S-Social component, and the G-Governance component. The third step concludes.

2. THE FINTECH AND ESG: A REVIEW

2.*1 The links between FinTech and ESG*

Wang et al. (2022) explore the impact of FinTech on corporate ESG performance in emerging markets, specifically addressing how technological advancements in financial services can contribute to sustainable business practices. Their study finds that FinTech innovations, such as blockchain and AI-driven analytics, provide companies with enhanced capabilities to track and report ESG metrics more accurately. This increased transparency and accountability can drive better environmental and social outcomes, as corporations are more likely to adhere to sustainable practices when their activities are under closer scrutiny. In a similar vein, Ding et al. (2024) examine how FinTech influences ESG sustainable development in China. Their research underscores the role of FinTech in facilitating access to green financing and promoting investments in sustainable projects. By leveraging digital platforms, companies can more easily secure funding for environmentally friendly initiatives, thereby contributing to the broader goal of sustainable development. The authors argue that FinTech not only improves financial inclusion but also accelerates the transition towards a greener economy by supporting ESG-compliant business activities. Atayah et al. (2023) delve into the relationship between sustainability, market performance, and FinTech firms. They highlight that FinTech companies are often at the forefront of integrating ESG considerations into their operations, given their reliance on innovative technologies and data-driven decision-making. This proactive approach not only enhances their market performance by attracting ESG-conscious investors but also sets a benchmark for traditional financial institutions. The study suggests that the adoption of sustainable practices by FinTech firms can have a ripple effect, encouraging the broader financial sector to follow suit. King (2023) discusses the synergistic relationship between FinTech and ESG, proposing that the

union of these two domains can drive significant advancements in sustainable finance. He argues that the digital transformation facilitated by FinTech enables more efficient allocation of resources towards sustainable projects, thus fostering a more resilient and responsible financial ecosystem. This chapter underscores the potential of FinTech to not only revolutionize banking but also to support the achievement of global sustainability goals. Finally, Macchiavello and Siri (2022) provide a preliminary assessment of green FinTech and sustainable digital finance. They explore how technology can contribute to achieving environmental objectives, emphasizing the role of digital finance in supporting climate action and environmental protection. Their study highlights various FinTech solutions, such as carbon trading platforms and sustainability-focused investment algorithms, which can significantly enhance the efficacy of environmental initiatives.

Sergeeva et al. (2023) examine the impact of green FinTech solutions on achieving ESG principles. They argue that green FinTech, characterized by innovations such as blockchain for supply chain transparency and AI for predictive analytics in environmental management, plays a crucial role in enhancing corporate adherence to ESG criteria. Their research highlights that these technologies not only streamline ESG reporting and compliance but also enable companies to proactively address sustainability challenges, thus fostering a culture of continuous improvement in ESG performance. Wang et al. (2023) provide a comprehensive overview of ESG in FinTech, mapping out the landscape and identifying key trends and challenges. Their work synthesizes insights from various case studies and empirical research, illustrating how FinTech companies integrate ESG considerations into their operations. The authors note that FinTech firms, by leveraging big data and machine learning, can offer more personalized and transparent financial services that align with ESG goals. This complex overview underscores the strategic importance of ESG integration for the future competitiveness and sustainability of FinTech enterprises. Bonfanti (2023) focuses on ESG-driven innovation within the FinTech industry. His analysis underscores the role of ESG as a catalyst for innovation, driving the development of new financial products and services that meet the growing demand for sustainable investing. He posits that FinTech firms, through ESG-driven innovation, are well-positioned to disrupt traditional finance by offering solutions that not only meet regulatory requirements but also resonate with the ethical values of modern consumers and investors. This perspective highlights the dual benefit of ESG integration: compliance and market differentiation. Gupta and Chaudhary (2024) explore the application of FinTech in promoting ESG and circular economy principles. They emphasize the role of AI and machine learning in optimizing resource use and reducing waste, thus supporting circular economy models. Their discussion points to specific FinTech applications, such as digital platforms for recycling and sustainable consumption, that illustrate the practical implications of integrating ESG principles with advanced technologies. This integration is presented as a pathway to achieving more sustainable and resilient economic systems. Shala and Berisha (2024) discuss the broader impact of FinTech on achieving ESG goals. They argue that FinTech can significantly contribute to the attainment of the UN Sustainable Development Goals (SDGs) by enhancing financial inclusion, promoting transparency, and facilitating sustainable investments. Their analysis suggests that FinTech can bridge gaps in traditional financial systems, providing tools and platforms that support the efficient allocation of capital towards ESG-aligned projects and initiatives.

Mokhtar and Alam (2023) investigate the mediating role of FinTech on ESG and bank performance. They argue that FinTech acts as a bridge that not only enhances the operational efficiency of banks but also aligns their activities with ESG principles. By incorporating FinTech solutions, banks can achieve better transparency, reduce operational costs, and improve customer engagement, all while adhering to sustainability goals. This dual benefit underscores the transformative potential of FinTech in the financial sector, making it a critical tool for achieving ESG objectives. Chueca Vergara and Ferruz Agudo (2021) explore whether FinTech and sustainability affect each other. Their findings suggest a symbiotic relationship where FinTech innovations drive sustainable practices, and sustainability imperatives, in turn, influence the

development of new financial technologies. This bidirectional influence highlights the integrated nature of modern financial systems where technological advancements and sustainable development goals mutually reinforce each other. The study emphasizes that regulatory frameworks and market incentives need to support this interplay to maximize the positive impacts of FinTech on sustainability. Liu et al. (2021) examine the relationship between corporate social responsibility (CSR) and financial performance, with a focus on the moderating role of FinTech. Their study finds that companies leveraging FinTech solutions tend to exhibit better financial performance while fulfilling their CSR commitments. FinTech technologies facilitate efficient resource management, enhanced reporting capabilities, and improved stakeholder engagement, all of which contribute to better financial outcomes and stronger CSR performance. This highlights the role of FinTech as a catalyst for aligning corporate profitability with social and environmental responsibilities. Kazachenok et al. (2023) discuss the economic and legal approaches to the humanization of FinTech in the AI-driven economy through the integration of blockchain into ESG finance. They propose that blockchain technology, with its inherent transparency and immutability, can significantly enhance the credibility and effectiveness of ESG finance. By ensuring that ESG data is accurate and tamper-proof, blockchain can help build trust among stakeholders and promote more sustainable investment practices. This approach underscores the importance of integrating advanced technologies like AI and blockchain to humanize and legitimize the FinTech industry in the context of ESG. Trotta et al. (2024) use a bibliometric perspective to explore the linkages between FinTech and ESG. Their analysis reveals a growing body of literature that underscores the increasing recognition of the importance of FinTech in driving ESG outcomes. They identify key trends, influential papers, and emerging research areas, providing a roadmap for future studies. This bibliometric analysis demonstrates that the integration of FinTech and ESG is not only a contemporary research focus but also a rapidly evolving field with significant implications for both academia and industry.

Wang et al. (2022) discuss the concept of ESG Data Commons for FinTech startups, emphasizing the importance of collective efforts in achieving sustainability. They propose that FinTech startups can significantly benefit from shared ESG data resources, which enhance transparency and foster innovation in sustainable finance. By creating a collaborative data environment, these startups can leverage comprehensive ESG information to develop more effective and reliable financial products that meet sustainability standards. This approach not only democratizes access to ESG data but also promotes a culture of collective responsibility among FinTech companies. Liu and Li (2024) explore the impact of bank FinTech on ESG greenwashing. They highlight a critical issue wherein some banks may use FinTech innovations to create an illusion of sustainability without genuinely integrating ESG principles into their operations. The study warns that while FinTech has the potential to enhance ESG performance, it also provides tools that can be misused for deceptive practices. Therefore, the authors call for robust regulatory frameworks and stringent oversight to ensure that FinTech advancements are used to genuinely improve ESG standards rather than to mask non-compliance. Du et al. (2022) investigate whether FinTech can enhance corporate ESG performance by addressing internal financing constraints and leveraging external fiscal incentives. Their findings suggest that FinTech can indeed facilitate better ESG performance by improving access to funding and incentivizing sustainable practices through innovative financial solutions. By reducing the barriers to financing for sustainable projects and aligning financial incentives with ESG goals, FinTech can play a crucial role in driving corporate sustainability from both internal and external fronts. Rousseau et al. (2021) analyze the attractions and challenges of ESG Tech for FinTechs during the COVID-19 pandemic. They argue that the pandemic has accelerated the adoption of ESG technologies among FinTech companies, driven by increased awareness of social and environmental issues. However, the authors also point out significant challenges, such as the need for regulatory clarity, the risk of data privacy breaches, and the potential for market fragmentation. Despite these challenges, the study highlights the resilience and adaptability of FinTechs in integrating ESG considerations into their business

models. Zhu et al. (2024) provide evidence from China on the impact of FinTech on corporate ESG performance. Their study underscores the substantial role that FinTech can play in enhancing ESG metrics, particularly in emerging markets. By leveraging advanced technologies such as big data analytics and AI, Chinese companies have been able to improve their ESG reporting and compliance, thus fostering greater transparency and accountability. The authors suggest that the insights gained from the Chinese context can inform broader strategies for integrating FinTech and ESG globally.

Kwong et al. (2023) highlight Green FinTech innovation as a promising direction for future research. They explore the intersection of green finance and FinTech, identifying key trends, influential publications, and emerging research areas. Their study underscores the rapid growth and academic interest in Green FinTech, suggesting that it holds substantial potential for driving environmental sustainability through technological advancements in financial services. The authors call for more focused research to harness the full potential of Green FinTech innovations. Trinh et al. (2023) navigate through sustainable capital markets, examining ESG and CSR research in the context of FinTech and blockchain. Their review synthesizes findings from various studies, illustrating how these technologies can enhance transparency, efficiency, and accountability in ESG and CSR reporting. They highlight blockchain's role in providing immutable records and FinTech's ability to facilitate more inclusive and efficient capital allocation towards sustainable projects. This review provides a comprehensive understanding of how FinTech and blockchain are reshaping sustainable finance. Addy et al. (2024) delve into data-driven sustainability, focusing on how FinTech innovations support green finance. They argue that data analytics, AI, and machine learning are pivotal in assessing and managing environmental risks, optimizing resource allocation, and enhancing ESG performance. Their study demonstrates that FinTech solutions can provide robust tools for measuring and improving sustainability metrics, thereby supporting the transition to a green economy. The authors emphasize the need for continuous innovation and regulatory support to maximize the impact of these technologies. Jin and Zhai (2023) investigate whether the application of FinTech in corporate ESG attracts higher market attention, with evidence from China. Their findings suggest that companies leveraging FinTech for ESG reporting and compliance tend to receive more positive market responses, indicating investor preference for transparency and sustainability. This study highlights the market advantages of integrating FinTech with ESG initiatives, suggesting that such integration can enhance corporate reputation and investor confidence. Khalil et al. (2023) explore the relationship between ESG, FinTech, green finance, innovation, and sustainability in Gulf countries. Their study reveals that FinTech innovations are instrumental in advancing green finance and sustainability initiatives in this region. They highlight the role of regulatory frameworks, technological infrastructure, and market dynamics in shaping the effectiveness of FinTech-driven ESG strategies. The authors argue that a collaborative approach involving policymakers, financial institutions, and technology providers is crucial for achieving sustainable development goals.

Dicuonzo et al. (2024) examine the interplay between ESG variables, governance, and FinTech. Their study finds that robust governance structures are crucial for maximizing the benefits of FinTech innovations in enhancing ESG performance. Effective governance can ensure that FinTech tools are used responsibly and transparently, thereby fostering greater accountability and sustainability in corporate practices. This research underscores the importance of aligning governance frameworks with technological advancements to achieve sustainable business outcomes. Cao et al. (2024) explore the relationship between ESG investment and bank efficiency in China. They provide evidence that banks with higher ESG investments tend to be more efficient, largely due to the improved risk management and operational efficiencies brought about by ESG-aligned practices. The integration of FinTech further amplifies these benefits by streamlining processes and enhancing data analytics capabilities. This study highlights the synergistic effects of ESG investments and FinTech adoption in enhancing the performance and sustainability of financial institutions. Giakoumelou et al. (2024) investigate ESG and FinTech funding within the European Union. Their findings indicate that increased funding for FinTech startups with strong

ESG credentials not only promotes sustainable financial innovation but also attracts significant investor interest. The study suggests that the EU's regulatory environment, which increasingly emphasizes sustainability, plays a critical role in driving this trend. By fostering a supportive ecosystem for ESG-focused FinTech ventures, the EU is positioning itself as a leader in sustainable financial innovation. Agudo (2021) examines whether FinTech and sustainability affect each other. His research reveals a bidirectional relationship where FinTech innovations promote sustainable practices, and sustainability imperatives drive the development of new FinTech solutions. This mutual influence suggests that the growth of FinTech and the pursuit of sustainability goals are closely intertwined, with each driving progress in the other. Agudo's study highlights the potential for FinTech to facilitate more inclusive and efficient capital markets that prioritize sustainability. Ferilli et al. (2024) investigate the impact of FinTech mergers and acquisitions (M&As) and ESG policies on the banking industry in their paper available on SSRN. They find that banks engaging in FinTech M&As and implementing robust ESG policies tend to experience enhanced market performance and investor confidence. This dual strategy of embracing technological innovation and committing to ESG principles helps banks navigate the evolving financial landscape and meet the expectations of increasingly ESG-conscious stakeholders. The study underscores the strategic importance of integrating FinTech and ESG considerations in the banking sector to achieve competitive advantage and long-term sustainability.

Goud et al. (2021) explore the relationship between Islamic Fintech and the achievement of Maqasid Al-Shariah, which refers to the goals and objectives of Islamic law. They highlight how Fintech can be utilized to meet ESG goals while adhering to Islamic ethical principles. They argue that the integration of technology in financial services can help in promoting economic justice, environmental stewardship, and social welfare, thus fulfilling the Maqasid principles. This work is pivotal in demonstrating that Islamic finance principles are not only compatible with but can also enhance the pursuit of ESG objectives. Palmaccio et al. (2023) provide an empirical analysis of the relationship between ESG and Fintech. Their research examines how Fintech companies incorporate ESG factors into their operations and the impact of these practices on their performance and reputation. The findings suggest that Fintech firms that prioritize sustainability and ethical practices tend to perform better and attract more investment, thereby reinforcing the importance of ESG considerations in the Fintech sector. El Khoury et al. (2023) investigate the spillover effects between Fintech, ESG, and renewable energy indices, especially in the context of geopolitical instability like the Russia–Ukraine war. Their study reveals significant interactions among these indices, indicating that events impacting one sector can have profound effects on others. This research underscores the interconnectedness of global financial markets and the importance of integrating ESG considerations to mitigate risks and enhance stability in turbulent times. Agarwal and Nath (2023) discuss how Fintech is reshaping the landscape of financial growth and sustainability. They emphasize that Fintech innovations are driving sustainable business practices by improving access to financial services, enhancing transparency, and fostering inclusive growth. This perspective highlights the transformative potential of Fintech in promoting sustainable economic development. Merello et al. (2022) examine whether the sustainability profiles of Fintech companies are key drivers of their value. Their study finds that Fintech firms with strong sustainability profiles tend to have higher valuations and better market performance. This research illustrates the growing market preference for companies that adhere to ESG principles and the positive financial implications of such adherence.

Li et al. (2023) examine the influence of external attention on Fintech's role in corporate green innovation. This study reveals that heightened scrutiny and stakeholder interest in Fintech companies compel these firms to prioritize green innovations. The findings suggest that external attention acts as a catalyst, pushing Fintech companies to adopt environmentally friendly technologies and practices. This highlights the importance of visibility and accountability in promoting sustainability within the Fintech sector. Najaf et al. (2024) analyze the impact of Fintech on corporate governance during financial crises. Their study demonstrates that Fintech solutions

can significantly enhance corporate governance by improving transparency, efficiency, and decision-making processes during turbulent times. The research underscores that Fintech tools enable companies to maintain robust governance frameworks, even under financial stress, thereby ensuring stability and resilience. This work highlights Fintech's potential to strengthen governance structures during periods of economic uncertainty. Jaiwant and Kureethara (2023) discuss the integration of green finance and Fintech to create a more sustainable financial system. They argue that Fintech innovations are crucial for the development and implementation of green finance instruments. The integration of Fintech with green finance can streamline sustainable investments and enhance the efficiency of environmental projects. This perspective underscores the transformative potential of Fintech in driving systemic changes toward sustainability in the financial sector. Del Gaudio et al. (2023) explore the relationship between banks and ESG scores. Their study finds that banks with higher ESG scores tend to perform better and are more resilient to financial shocks. The research suggests that Fintech can play a pivotal role in helping banks improve their ESG performance through innovative solutions and enhanced data analytics. This study highlights the importance of ESG considerations in the banking sector and the role of Fintech in enhancing these metrics. Walker et al. (2023) provide an overview of how Fintech can address environmental and societal challenges. They highlight various case studies where Fintech innovations have led to improved environmental outcomes and greater social equity. The authors argue that Fintech has the potential to revolutionize the delivery of financial services, significantly impacting sustainability. This work underscores the broad and transformative potential of Fintech in promoting sustainable development.

Bayram et al. (2022) examine the potential of Fintech to promote sustainable finance in Turkey. Their study investigates the policy implications and practical outcomes of integrating Fintech into sustainable finance frameworks. The research concludes that Fintech can significantly enhance sustainable finance by improving access to financial services, increasing transparency, and facilitating efficient capital allocation to green projects. The case of Turkey demonstrates that supportive regulatory environments and strategic government policies are crucial for maximizing the benefits of Fintech in advancing sustainability goals. Macpherson et al. (2021) delve into the implications of artificial intelligence for ESG data. Their study show the transformative impact of AI on the collection, analysis, and utilization of ESG data. The authors argue that AI technologies can enhance the accuracy and reliability of ESG reporting, enabling better decision-making and fostering greater accountability. This research underscores the synergy between AI and Fintech in driving improvements in ESG data management, which is essential for sustainable finance practices. Gholap et al. (2024) provide a comprehensive review of the integration of ESG factors in Fintech and sustainable finance. Their review highlights the growing importance of incorporating ESG criteria into financial technologies. The authors emphasize that ESG integration in Fintech can lead to more responsible and ethical financial practices, ultimately contributing to broader sustainability objectives. This review underscores the need for ongoing research and development in ESG integration within the Fintech sector. Mu et al. (2023) investigate the relationship between digital finance and corporate ESG performance. Their study explores how digital financial technologies influence corporate sustainability practices. The findings indicate that digital finance can enhance corporate ESG performance by improving transparency, reducing costs, and facilitating better stakeholder engagement. This research highlights the positive impact of digital finance on corporate sustainability, emphasizing the role of technological innovation in achieving ESG goals. AlMaeeni and Nobanee (2022) explore the effect of sustainable practices on business performance in the banking and financial sector, with a focus on the impact of green Fintech. Their research suggests that adopting sustainable practices and green Fintech solutions can lead to improved business performance by enhancing efficiency, reducing risks, and increasing competitiveness. The authors argue that the financial sector can benefit significantly from integrating green technologies and sustainable practices, which not only improve environmental outcomes but also drive financial performance.

The impacts of ESG: the bank's point of view

The relationship between ESG factors and financial performance in banks is a complex topic explored by numerous studies. El Khoury et al. (2023) investigate the ESG-financial performance linkage in the MENAT region, revealing a concavity-convexity pattern. They found that ESG investments improve financial performance to a point, after which the benefits diminish. The governance pillar showed a concave relationship with accounting performance, while the environmental pillar had a convex relationship with market returns, emphasizing the need for banks to optimize their ESG investments for efficient returns. Tóth et al. (2021) focus on the contribution of ESG information to the financial stability of European banks. They argue that ESG disclosures enhance transparency, leading to greater stability and resilience in the banking sector. This study highlights the positive impact of robust ESG practices on financial stability, underlining the importance of comprehensive ESG reporting in European banks. Houston and Shan (2022) delve into the interplay between corporate ESG profiles and banking relationships. Their research indicates that banks with strong ESG profiles tend to have better relationships with their stakeholders, which in turn enhances their financial performance. This study underscores the strategic advantage that banks gain by integrating ESG factors into their core operations and relationship management. Simsek and Cankaya (2021) examine the link between ESG scores and financial performance in banks within G8 countries. They find a positive correlation, suggesting that higher ESG scores are associated with better financial outcomes. This research supports the notion that ESG considerations are not just ethical or regulatory obligations but also beneficial for financial performance. La Torre et al. (2021) discuss whether banks follow market trends or regulatory requirements regarding ESG drivers. Their findings indicate that banks are increasingly aligning their strategies with market expectations and regulatory demands, enhancing their ESG performance. This alignment is crucial for maintaining competitive advantage and fulfilling regulatory compliance.

Azmi et al. (2021) explore this relationship in the context of emerging economies, demonstrating that banks engaged in robust ESG activities tend to perform better financially. Their study presents international evidence that underscores the positive correlation between ESG efforts and enhanced banking performance. This finding is significant as it highlights the potential for ESG activities to contribute to financial stability and growth in developing markets, where economic and regulatory conditions may differ considerably from those in more developed regions. Similarly, Menicucci and Paolucci (2023) focus on the Italian banking sector, investigating how different dimensions of ESG impact bank performance. Their empirical study finds that Italian banks with higher ESG scores generally exhibit better financial outcomes. This research emphasizes the importance of integrating ESG considerations into corporate governance frameworks, suggesting that doing so can lead to improved financial performance and sustainability for banks operating in Italy. Liu et al. (2023) investigate the specific impact of ESG performance on the incidence of non-performing loans (NPLs) within banks. Their study reveals that banks with superior ESG performance tend to have lower levels of NPLs. This correlation suggests that strong ESG practices may enhance risk management and operational efficiency, thereby reducing the likelihood of loan defaults. Such insights are crucial for banks aiming to improve their asset quality and financial health. Murè et al. (2021) address the reputational benefits of ESG engagement, particularly in the context of Italian banks that have faced sanctions. Their research indicates that banks with strong ESG profiles tend to recover more swiftly from reputational damage associated with sanctions. This finding underscores the protective and rehabilitative role of ESG practices in maintaining and restoring stakeholder trust and market reputation. Lastly, Ersoy et al. (2022) explore the impact of ESG scores on the market value of US banks. Their study demonstrates that higher ESG scores are associated with increased market valuation. This relationship is particularly evident in the US banking industry, suggesting that investors are increasingly valuing and rewarding sustainable and responsible banking practices. Such insights are vital for banks looking to enhance their market value through ESG integration.

El Khoury et al. (2023) examine the determinants of ESG in the banking sector within the MENA region, questioning whether ESG adoption is merely a trend or a necessity. Their study identifies key drivers behind ESG integration in these banks, highlighting regulatory pressures, stakeholder demands, and competitive advantages as significant motivators. The research underscores that ESG practices are becoming increasingly essential for banks in the MENA region, aiming to enhance their competitiveness and sustainability. Chiaramonte et al. (2022) investigate whether ESG strategies enhance bank stability during periods of financial turmoil in Europe. Their findings suggest that banks with robust ESG strategies are better equipped to withstand financial instability, thereby enhancing overall stability. This research highlights the protective role of ESG practices during economic downturns, suggesting that banks incorporating ESG considerations are more resilient in the face of financial crises. Andrieș and Sprincean (2023) explore the relationship between ESG performance and banks' funding costs. They find that higher ESG performance is associated with reduced funding costs for banks, indicating that investors and creditors are increasingly valuing ESG credentials. This suggests that banks with better ESG practices can access capital at lower costs, providing a financial incentive for banks to improve their ESG performance. Arun et al. (2022) discuss ESG issues in emerging markets and the role of banks in their handbook chapter. Their analysis underscores the unique challenges and opportunities faced by banks in these regions regarding ESG integration. They highlight that banks in emerging markets play a critical role in promoting sustainable development and can leverage ESG strategies to drive economic growth and stability. Lastly, Bruno and Lagasio (2021) provide an overview of European policies on ESG in the banking sector. They discuss how regulatory frameworks and policies in Europe are shaping the ESG landscape for banks, emphasizing the importance of compliance and proactive ESG strategies. Their analysis shows that European banks are increasingly required to adopt ESG practices not only to meet regulatory requirements but also to satisfy stakeholder expectations and enhance their market positioning.
Saif-Alyousfi et al. (2023) investigate the relationship between bank diversification and ESG activities from a global perspective. Their study reveals that banks engaging in diversified activities tend to have better ESG performance. This suggests that diversification strategies might enable banks to allocate more resources towards sustainable practices, thereby improving their overall ESG scores and contributing to their long-term viability and competitiveness. Galletta, et al. (2022) conduct a bibliometric analysis of ESG performance in the banking industry, highlighting the current status and future directions. Their research provides an extensive review of existing literature on ESG in banking, identifying key trends and gaps. This analysis is crucial for understanding the evolving landscape of ESG practices and pinpointing areas where further research and development are needed to enhance ESG integration in the banking sector.

Further exploring the impact of ESG on banking, Galletta et al. (2023) examine how ESG factors affect bank reputation and operational risk. Their study finds that banks with higher ESG scores tend to experience lower operational risks and enhanced reputational standing. This relationship underscores the importance of ESG activities in mitigating risks and building trust with stakeholders, thereby ensuring more stable and resilient banking operations. Izcan and Bektas (2022) focus on the Eurozone, analyzing the relationship between ESG scores and firm-specific risk of banks. Their research indicates that higher ESG scores are associated with reduced firm-specific risks. This suggests that robust ESG practices can serve as a buffer against various risks, contributing to the overall financial stability of banks in the Eurozone. The findings highlight the critical role of ESG in risk management and underscore its significance for banks operating in highly regulated and economically integrated regions. Finally, Aevoae et al. (2023) examine the link between ESG and systemic risk in the banking sector. Their study demonstrates that banks with better ESG performance are less likely to contribute to systemic risk. This finding is particularly important in the context of financial stability, as it suggests that promoting ESG practices within banks can lead to a more stable and resilient financial system overall.

Galletta and Mazzù (2023) investigate the relationship between ESG controversies and bank risk-taking behaviors. They find that banks embroiled in ESG controversies are more likely to engage in higher risk-taking activities. This suggests that negative ESG incidents can undermine a bank's risk management protocols and lead to more aggressive and potentially hazardous financial practices. The study underscores the importance of maintaining robust ESG standards to mitigate risk and ensure sustainable banking operations. Bernardelli et al. (2022) examine the impact of fossil fuel financing on banks' ESG ratings. Their research reveals that banks financing fossil fuel projects tend to have lower ESG ratings. This correlation indicates that involvement in environmentally harmful industries can detrimentally affect a bank's reputation and perceived commitment to sustainability, emphasizing the need for financial institutions to reconsider their investment portfolios in light of growing environmental concerns. Wang (2023) explores the transmission effects of ESG disclosure regulations through bank lending networks. The study finds that ESG disclosure regulations can significantly influence lending practices, as banks subjected to these regulations tend to extend credit more cautiously. This ripple effect highlights the regulatory impact on the broader financial ecosystem, where enforced transparency and accountability in ESG practices contribute to more prudent and responsible lending behaviors. Agnese et al. (2023) delve into the link between ESG controversies and governance within the banking industry. Their findings indicate that banks experiencing ESG controversies often have weaker governance structures. This relationship suggests that robust governance mechanisms are crucial for preventing ESG controversies and managing their fallout effectively. Strengthening governance frameworks can thus enhance overall ESG performance and mitigate risks associated with ESG lapses. Gurol and Lagasio (2022) investigate the impact of women board members on ESG disclosure in the European banking sector. Their research finds that increased female representation on bank boards is positively correlated with more comprehensive ESG disclosures, particularly in environmental and social dimensions. This finding underscores the value of gender diversity in enhancing transparency and accountability in ESG reporting, suggesting that diverse leadership can drive better ESG performance (Gurol & Lagasio, 2022).

Gutiérrez-Ponce and Wibowo (2023) examine the effect of sustainability activities on the financial performance of Indonesian banks. Their research indicates that Indonesian banks engaging in comprehensive sustainability activities tend to achieve better financial performance. This correlation underscores the importance of sustainability initiatives in enhancing the financial health and competitive edge of banks in emerging economies like Indonesia, where sustainable practices can drive long-term growth and stability. Yuen et al. (2022) investigate the impact of ESG activities on profitability in the global banking sector during the COVID-19 pandemic. Their study reveals that banks with robust ESG practices were better able to maintain profitability amidst the pandemic's disruptions. This finding highlights the resilience conferred by strong ESG frameworks, suggesting that such practices are vital for navigating crises and ensuring financial stability under adverse conditions. Erhemjamts et al. (2024) explore the relationship between climate risk, ESG performance, and ESG sentiment in US commercial banks. Their research demonstrates that banks with higher ESG performance and positive ESG sentiment are better positioned to manage climate-related risks. This study underscores the critical role of ESG practices in mitigating the impacts of climate risk, thereby enhancing the overall resilience and sustainability of banks in the face of environmental challenges. Chang et al. (2021) analyze the use of ESG and financial indicators to measure bank cost efficiency in Asia. Their findings suggest that incorporating ESG metrics alongside traditional financial indicators provides a more comprehensive assessment of bank efficiency. This approach allows for a better understanding of how sustainable practices contribute to cost management and operational efficiency, highlighting the multifaceted benefits of integrating ESG considerations into banking operations.

Rastogi and Singh (2022) investigate the impact of ESG on bank valuation, specifically examining the moderating role of Information and Communication Technology (ICT). Their research finds that banks with strong ESG practices tend to have higher valuations, and this positive effect is further enhanced by the adoption of advanced ICT. The synergy between ESG and ICT facilitates

better transparency, efficiency, and stakeholder engagement, thereby boosting the overall valuation of banks. This study highlights the importance of integrating technology with sustainable practices to maximize financial outcomes. Ji et al. (2023) explore the relationship between ESG factors and market efficiency in China's commercial banks under market competition. Their study reveals that banks with robust ESG practices exhibit higher market efficiency, especially in competitive markets. This finding suggests that ESG integration can enhance operational effectiveness and market responsiveness, enabling banks to perform better in competitive environments. The study underscores the role of ESG in fostering a more efficient and competitive banking sector in China. Citterio and King (2023) examine the role of ESG factors in predicting bank financial distress. They find that banks with higher ESG scores are less likely to experience financial distress. This relationship is attributed to the fact that strong ESG practices often correlate with better risk management, governance, and stakeholder trust, which collectively contribute to financial stability. The study highlights the predictive power of ESG metrics in assessing the financial health and resilience of banks, advocating for the integration of ESG considerations into financial risk assessments. Lupu et al. (2022) explore how ESG factors are reflected in European financial stability. They find that higher ESG scores contribute positively to the financial stability of European banks. The research indicates that banks with strong ESG commitments are better positioned to manage risks and sustain long-term financial health, thereby supporting the overall stability of the financial system. This study underscores the critical role of ESG in maintaining the stability and resilience of the banking sector in Europe.

Kalfaoglou (2021) addresses the emergence of ESG risks as a significant new source of challenges for the banking sector. The study highlights how ESG factors, including climate change, social responsibility, and governance issues, pose potential risks to banks' operational and financial stability. The research emphasizes that banks need to develop robust risk management frameworks to mitigate these ESG-related risks, which can impact creditworthiness, regulatory compliance, and overall market perception. This underscores the necessity for banks to integrate ESG risk assessments into their strategic planning and operational processes. Mallek et al. (2024) delve into the nuanced behavior of ESG returns in the context of large banks in the MENA region. Their study investigates the puzzling convex and concave patterns observed in ESG returns. The research finds that these patterns are influenced by various market and regulatory dynamics unique to the MENA region. The study highlights the complexity of ESG investments, noting that while ESG practices can lead to enhanced returns under certain conditions, they may also introduce volatility and unexpected performance patterns. This complexity underscores the importance of context-specific analysis when evaluating ESG investments in different regions. Gai et al. (2023) present a new scoring model for banks' ESG disclosure. The research proposes a comprehensive framework for assessing the quality and transparency of ESG disclosures by banks. This scoring model aims to standardize ESG reporting, making it easier for stakeholders to compare and evaluate banks' ESG performance. The study underscores the critical role of transparent and accurate ESG disclosures in enhancing trust and accountability in the banking sector. By improving disclosure practices, banks can better communicate their ESG efforts and risks to investors, regulators, and the public, thereby supporting informed decision-making and promoting sustainability within the financial industry.

Agnese and Giacomini (2023) explore the impact of ESG factors on bank funding costs. They find that banks with higher ESG ratings tend to benefit from lower funding costs. This correlation is attributed to the enhanced trust and reduced risk perceived by investors and creditors in banks that prioritize sustainable and responsible practices. The findings suggest that integrating ESG considerations into banking operations can lead to significant financial advantages by lowering the cost of capital. Gutiérrez-Ponce and Wibowo (2024) analyze the contribution of sustainability practices to the financial performance of banks in Southeast Asia. Their research demonstrates that banks engaging in comprehensive sustainability practices tend to exhibit better financial performance. This improvement is driven by enhanced operational efficiency, stronger stakeholder relationships, and a better risk management framework. The study highlights the financial benefits

of adopting sustainability practices in a region where economic and environmental challenges are particularly pronounced. Trinh et al. (2023) investigate the relationship between social capital, trust, and bank tail risk, focusing on the role of ESG ratings and the impact of crisis shocks. Their study finds that banks with higher ESG ratings tend to have lower tail risk, particularly during times of crisis. This suggests that strong ESG practices can enhance social capital and trust, providing a buffer against extreme negative outcomes. The research underscores the importance of ESG integration in mitigating risk and enhancing the resilience of banks in the face of economic shocks. Cicchiello et al. (2023) examine the effect of competition on ESG controversies within the banking industry. They find that increased competition among banks can lead to a higher incidence of ESG controversies. This is likely due to the pressure to cut corners and reduce costs in a highly competitive environment, which can lead to lapses in ESG standards. The study highlights the need for regulatory oversight and strong internal controls to ensure that competitive pressures do not undermine ESG commitments. Shin (2021) investigates the relationship between corporate ESG profiles, matching, and the cost of bank loans. The research reveals that banks providing loans to companies with high ESG profiles tend to incur lower lending costs. This reduction in costs is attributed to the lower risk associated with firms that adhere to strong ESG practices, which can lead to more favorable lending terms and reduced default rates. The study suggests that aligning bank loan portfolios with ESG principles can be financially advantageous for both banks and their clients.

Danisman and Tarazi (2024) explore the role of ESG activity on bank lending during financial crises. They find that banks with strong ESG practices tend to maintain more stable lending practices during financial turmoil. This stability is attributed to the robust risk management frameworks and enhanced stakeholder trust associated with high ESG standards. The study underscores the importance of ESG integration in promoting financial stability and resilience, particularly in times of economic uncertainty. Miranda et al. (2023) examine the impact of board characteristics and social trust on ESG performance in the European banking sector. Their research indicates that diverse and well-composed boards, characterized by a mix of skills, experiences, and gender diversity, positively influence ESG performance. Additionally, high levels of social trust within the community further enhance banks' commitment to ESG principles. The study highlights the critical role of governance structures and social capital in driving sustainable practices within banks. Lamanda and Tamásné Vőneki (2024) investigate whether ESG disclosure is associated with bank performance in the Visegrad Four countries (Czech Republic, Hungary, Poland, and Slovakia). Their study finds a positive association between comprehensive ESG disclosure and bank performance. The research suggests that transparent ESG reporting enhances investor confidence and stakeholder engagement, leading to better financial outcomes. This finding underscores the importance of transparency in ESG practices for achieving superior financial performance.

Bashatweh et al. (2021) focus on Sharia-compliant banks in Jordan, examining whether ESG disclosure adds firm value. Their research reveals that ESG disclosure significantly enhances firm value for Sharia-compliant banks. This enhancement is driven by the alignment of ESG principles with Islamic ethical values, which promotes trust and attracts socially responsible investors. The study highlights the synergy between ESG practices and Islamic finance principles in enhancing firm value. Maama (2021) explores the institutional environment and ESG accounting among banks in West Africa. The findings indicate that supportive institutional frameworks and regulatory environments are crucial for effective ESG accounting and reporting. The research emphasizes that robust institutional support can facilitate better ESG integration, leading to improved financial and non-financial outcomes for banks in West Africa.

3. THE ESTIMATION OF IMPACT OF THE ESG VARIABLES ON THE TOTAL FACTORING VALUE

3.1 The econometric model

Below we present an econometric analysis aimed at estimating the impact of ESG factors on the Total Factoring Value-TFV variable calculated at a European level. ESG data was acquired from the World Bank database. The European countries analyzed are 36[1]. The observation period is between 2016 and 2022. The econometric models used are indicated below: Pooled Ordinary Least Squares-POLS, Weighted Least Squares-WLS, Quantile Estimation-QE. In particular we estimated the following equation:

$$\boldsymbol{TFV_{it} = \alpha_{it} + \beta_1(ACF)_{it} + \beta_2(CDD)_{it} + \beta_3(EIL)_{it} + \beta_4(GI)_{it} + \beta_5(PUS)_{it} + \beta_6(PA65)_{it} + \beta_7(PD)_{it} + \beta_8(RTF)_{it} + \beta_9(SE)_{it}}$$

Where $\boldsymbol{i = 36}$ and $\boldsymbol{t = [2016; 2022]}$

Specifically, the variables applied to estimate the value of TFV are synthetized in the Table 1.

Table 1. Variables Used for the Econometric Model

Label	Variable	Abbreviations	Definitions
A	Total Factoring Value	TFV	
A1	Access to clean fuels and technologies for cooking (% of population)	ACF	Access to clean fuels and technologies for cooking is the proportion of total population primarily using clean cooking fuels and technologies for cooking. Under WHO guidelines. kerosene is excluded from clean cooking fuels.
A14	Cooling Degree Days	CDD	A measure of how hot the temperature was on a given day or during a period of days
A18	Energy intensity level of primary energy (MJ/$2017 PPP GDP)	EIL	Energy intensity level of primary energy is the ratio between energy supply and gross domestic product measured at purchasing power parity. Energy intensity is an indication of how much energy is used to produce one unit of economic output. Lower ratio indicates that less energy is used to produce one unit of output.
A26	Gini index	GI	The Gini index measures the extent to which the distribution of income or consumption among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality. while an index of 100 implies perfect inequality.
A46	People using safely managed sanitation services (% of population)	PUS	Population using an improved sanitation facility that is not shared with other households and where excreta are safely disposed of in situ or treated off site. Improved sanitation facilities include flush/pour flush to piped sewer systems. septic tanks or pit latrines; pit latrines with slabs (including ventilated pit latrines), and composting toilets.
A49	Population ages 65 and above (% of total population)	PA65	Population ages 65 and above as a percentage of the total population. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.
A50	Population density (people per sq. km of land area)	PD	Population density is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.
A56	Ratio of female to male labor force participation rate (%) (modeled ILO estimate)	RTF	Labor force participation rate is the proportion of the population ages 15 and older that is economically active: all people who supply labor for the production of goods and services during a specified period. Ratio of female to male labor force participation rate is calculated by dividing female labor force participation rate by male labor force participation rate and multiplying by 100.

[1] Austria, Belgium, Bosnia Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Moldova, Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom.

A63	School enrolment. primary and secondary (gross). gender parity index (GPI)	SE	Gender parity index for gross enrolment ratio in primary and secondary education is the ratio of girls to boys enrolled at primary and secondary levels in public and private schools.

SOURCE: Elaboration by authors

We find that the level of TFV is positively associated to:

- *GI:* is a variable that measures the extent to which the distribution of income or consumption among individuals or households within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality. There is a positive relationship between the value of the Gini index and the value of TFV.
- *RTF:* is the proportion of the population ages 15 and older that is economically active: all people who supply labor for the production of goods and services during a specified period. Ratio of female to male labor force participation rate is calculated by dividing female labor force participation rate by male labor force participation rate and multiplying by 100. There is a positive relationship between RTF and the value of TFV. The European nations in which the value of RTF is growing are also characterized by a growth in the value of TFV.
- *PA65:* represents the population ages 65 and above as a percentage of the total population. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. There is a positive relationship between TFV and PA65 value. European countries with a high level of PA65 also have high levels of TFV.
- *ACF:* represents the access to clean fuels and technologies for cooking is the proportion of total population primarily using clean cooking fuels and technologies for cooking. Under WHO guidelines, kerosene is excluded from clean cooking fuels. There is a positive relationship between the ACF value and the TFV value. The European nations where the value of ACF is growing are also characterized by a growing value in terms of TFV.
- *PD:* is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship-except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. In most cases the definition of inland water bodies includes major rivers and lakes. There is a positive relationship between the PD value and the TFV value. Regions in which the PD value tends to be high also have high TFV values.

A synthesis of the econometric results is showed in Table 2.

Table 2. Synthesis of the Econometric Results

Models	Values	const	A1	A14	A18	A26	A46	A49	A50	A56	A63
Pooled OLS	*Coefficient*	-283	2.07181	-0.0952	-24.214	16.478	-3.1781	19.0929	0.41555	2.69686	-548.66
	Std. Error	154.038	0.6686	0.02365	13.0659	2.25165	0.65546	4.2956	0.05031	1.56203	74.8832
	P-Value	*	***	***	*	***	***	***	***	*	***
WLS	*Coefficient*	-337.01	2.23342	-0.0475	-11.884	14.7805	-1.3844	13.959	0.40804	2.27861	-563.05
	Std. Error	59.3231	0.30268	0.0121	3.89792	0.9021	0.31927	1.19188	0.02498	0.4974	37.9866
	P-Value	***	***	***	***	***	***	***	***	***	***
Quantile Estimates	*Coefficient*	-909.17	0.80745	-0.032	-492.84	677.311	-0.4395	142.312	0.46612	214.912	-336.41
	Std. Error	252.113	0.10943	0.00387	213.849	0.36853	0.10728	0.70306	0.00823	0.25566	122.561
	P-Value	***	***	***	**	***	***	**	***	***	***

SOURCE: Elaboration by authors

Results show that the level of TFV is negatively associated to:

- *CDD:* is a measure of how hot the temperature was on a given day or during a period of days. There is a negative relationship between the value of CDD and the value of TFV. European nations in which the value of CDD tends to increase have decreasing values in terms of TFV.
- *PUS:* represents the population using an improved sanitation facility that is not shared with other households and where excreta are safely disposed of in situ or treated off site. Improved sanitation facilities include flush/pour flush to piped sewer systems. Septic tanks or pit latrines; pit latrines with slabs (including ventilated pit latrines), and composting toilets. There is a negative relationship between the PUS value and the TFV value. The European nations in which the PUS value tends to increase are also characterized by a decreasing TFV value.
- *EIL:* is the energy intensity level of primary energy is the ratio between energy supply and gross domestic product measured at purchasing power parity. Energy intensity is an indication of how much energy is used to produce one unit of economic output. Lower ratio indicates that less energy is used to produce one unit of output. There is a negative relationship between the value of TFV and the value of EIL. European nations characterized by increasing levels of EIL have decreasing values in terms of TFV.
- *SE:* is the gender parity index for gross enrolment ratio in primary and secondary education is the ratio of girls to boys enrolled at primary and secondary levels in public and private schools. There is a negative relationship between the value of SE and the value of TFV. The European nations in which the value of SE grows are characterized by a declining trend in the value of TFV.

Therefore, we can verify that overall the value of the aggregate impact of the ESG variables is negatively correlated with the value of TFV. However, if we reflect on the individual components we can notice that the E and G components are negatively connected to the value of TFV while the S component is positively connected to the value of TFV. We also note that the variables that have the greatest negative impact in terms of TFV are EIL and SE. Therefore, we can conclude that in an aggregate sense the value of TFV tends to grow as the aggregate value of ESG, calculated according to the variables indicated, decreases.

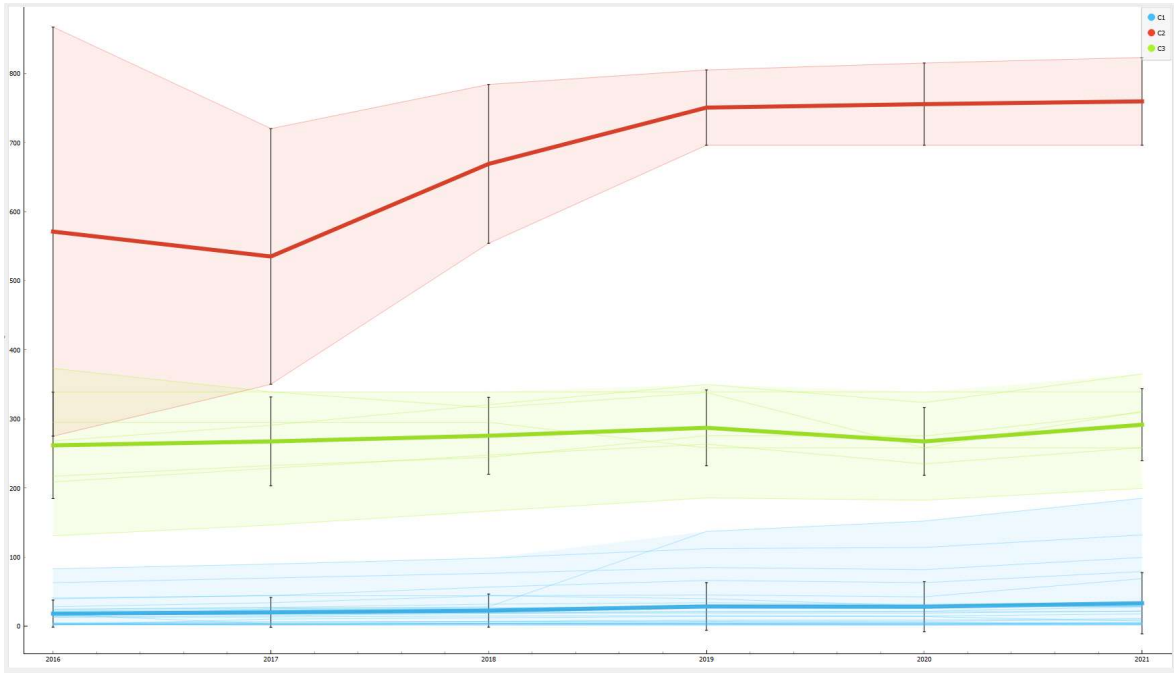
3.2 Clusterization with k-Means Algorithm Optimized with the Silhouette Coefficient for Verifying the Existence of Groupings among European Countries in terms of TFV

Below we present a clustering with k-Means algorithm optimized with the Silhouette coefficient. The data shows the presence of two clusters:

- Cluster 1: Greece, Hungary, Czech Republic, Denmark, Poland, Ukraine, Spain, Switzerland, Estonia, Bulgaria, Lithuania, Cyprus, Netherlands, Slovenia, Moldova, Austria, Croatia, Finland, Ireland, Romania, Slovakia, Serbia, Portugal , Belgium, Georgia, Norway.
- Cluster 2: Latvia, Malta;
- Cluster 3: France, United Kingdom, Luxembourg, Turkey, Germany, Italy, Sweden.

Considering the average of the clusters by TFV value we can note the following ordering: Cluster 2>Cluster 3>Cluster 1 (Figure 3).

Figure 3. Sorting of clusters based on the mean value. Cluster 2 composed of Malta and Lithuania dominates both cluster 3 and cluster 1. The hierarchy of clusters by TFV value is C2>C3>C1.



SOURCE: Elaboration by authors

We can therefore note that the diffusion of factoring is maximum in Latvia and Malta, two countries which alone constitute a single cluster and which they certainly are outliers. The countries of Cluster 3 follow. Cluster 3 is made up of a number of very heterogeneous countries from both a socio-economic and institutional point of view. In fact, on the one hand, there are countries with a medium-high per capita income such as France, the United Kingdom, Luxembourg, Germany and Sweden, and on the other hand, there are countries with a medium-low per capita income such as Italy and Turkey. Finally, there is the third cluster presence of TFV. This is a cluster made up of 27 very heterogeneous countries which however share low levels in terms of TFV. Specifically, we can note that the level of TFV tends to be medium-high in only 11 of the countries analyzed. Furthermore, it is not possible to identify strictly financial criteria for clustering. In fact, even highly developed countries from a financial point of view, such as the Netherlands and Switzerland, are present in the least performing cluster in terms of TFV. On the other hand, countries that have a basically traditionalist financial culture such as Italy and Turkey tend to have medium-high TFV levels. It follows that the choice to open a national economic system to growth or a reduction in terms of TFV tends to be connected to reasons detectable at country level which cannot be generalised. However, in a general sense, it is possible to state that, with the growth of per capita income, the distribution of the TFV value also tends to grow even if there are exceptions such as for example in the case of Ireland, the Netherlands and Switzerland.
Furthermore, if we consider the 2022 ranking we can see that in first place is Latvia with a TFV value of 920 units, followed by Malta with an amount of 696 units and the United Kingdom with 592 units. In the middle of the table are Spain with a value of 37.39 units, followed by Austria with 35.88, and Ireland with 28.62 units. Slovenia closes the ranking with an amount of 2.91 units, followed by the Netherlands with an amount of 2.53 units and Croatia with an amount of 1.37 (Figure 4).

Figure 4. TFV value for the European countries considered between 2016 and 2022.

SOURCE: Elaboration by authors

If we instead consider the European countries by value of the percentage change in the TFV value, we can note that in general the countries that have had low levels of TFV are also the countries that have grown the most. In particular, Georgia is the country that grew the most between 2016 and 2022 with a value equal to 1664.29% going from an amount of 14.00 units up to a value of 247 units. Poland follows with a growth of 428% from 1.55 units in 2016 up to a value of 8.19 units in 2022. In third place is Bulgaria with a variation of +290.29% corresponding to a variation from an amount of 1.95 units up to a value of 7.60 units. In the middle of the table are Austria with +82.9%, Lithuania with +77.42%, and Slovenia with +77.04%. The Netherlands closes the ranking with -6.50%, followed by Croatia with -51.68% and Moldova with -70.59%. Overall, between 2016 and 2022 the average value of the TFV in the European nations considered grew by 55.30% going from an amount of 98.35 units in 2016 up to an amount of 152.74 units in 2022.
Therefore, we can conclude that despite the generalized growth of the TFV value in the European nations considered between 2016 and 2022, there is still a significant distinction at the country level. First of all, an exception must be made for Malta and Latvia. In fact, the two small countries have very high TFV levels. This condition could be due to financial choices and international interests located at a national level. Secondly, we note that large European countries tend to have high TFV levels. However, most European countries have a medium-low level of TFV including

some high per capita income countries such as the Netherlands. Therefore, the choice to create markets at country level for factoring seems to be connected to contingent motivations of individual nations. In addition, even in the general growth of the level of TFV, many countries in Europe demonstrate low levels of the observed variable.

3.3 Machine Learning and Predictions for the Estimation of the Future Value of FTV

Below we present a machine learning analysis for estimating the future value of the FTV. A comparison between eight different machine learning algorithms is then proposed. Machine learning algorithms are trained with 70% of the data. The remaining 30% of the data is used for prediction. The ordering of the algorithms is made up by maximizing the R-Squared and minimizing the statistical errors MAE-Mean Absolute Error, Mean Squared Error-MSE, and Root Mean Squared Error-RMSE. The following indicators were therefore used:

- R Squared= $R^2 = 1 - \frac{SumSquaredRegression}{TotalSumOfSquares} = 1 - \frac{\sum(y_i - \hat{y}_i)^2}{\sum(y_i - \bar{y}_i)^2}$
- Mean Average Error= $MAE = \frac{\sum_{i=1}^{n} |y_i - \hat{y}_i|}{n}$
- Mean Squared Error=$MSE = \frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$
- Root Mean Squared Error=$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)\text{^}2}$

where $\boldsymbol{y_i}$ is the true value, $\hat{\boldsymbol{y}}$ =predicted value, and $\overline{\boldsymbol{y}} = \frac{\sum \boldsymbol{y}}{\boldsymbol{n}}$, **n**=sample size. A representation of the results obtained is shown in Table 3.

Table 3. Machine Learning Algorithms and Their Statistical Measures

	ANN	**PNN**	**Simple Tree Regression**	**Gradient Boosted Tree Regression**
R^2	0,988155	0,360706	0,990898	0,675033
MAE	0,021312	0,188744	0,015457	0,094033
MSE	0,001000	0,064223	0,001000	0,034747
RMSE	0,030899	0,253422	0,028466	0,186404
	Random Forest Regression	**Tree Ensemble Regression**	**Linear Regression**	**Polynomial Regression**
R^2	0,977286	0,838630	-0,837831	-1,096248
MAE	0,028389	0,076915	0,311631	0,440069
MSE	0,002197	0,013273	0,213026	0,225279
RMSE	0,046870	0,115208	0,461547	0,474635

SOURCE: Elaboration by authors

We therefore obtained the following ordering of the algorithms:

- Simple Regression Tree with a payoff value of 5;
- ANN-Artificial Neural Network with a payoff value of 7;
- Random Forest Regression with a payoff value of 12;
- Tree Ensemble Regression with a payoff value of 16;
- Gradient Boosted Tree Regression with a payoff value of 20;
- PNN-Probabilistic Neural Network with a payoff value of 24;
- Linear Regression with a payoff value of 28;
- Polynomial Regression with a payoff value of 32.

The results are shown in Table 4.

Table 4. Ranking of Algorithms for Predictive Performances

Table 5. Ranking of Algorithms for Predictive Performances					
Algorithm	**R^2**	**MAE**	**MSE**	**RMSE**	**Sum-Payoff**
Simple Tree Regression	1	1	2	1	5
ANN-Artificial Neural Network	2	2	1	2	7
Random Forest Regression	3	3	3	3	12
Tree Ensemble Regression	4	4	4	4	16
Gradient Boosted Tree Regression	5	5	5	5	20
PNN-Probabilistic Neural Network	6	6	6	6	24
Linear Regression	7	7	7	7	28
Polynomial Regression	8	8	8	8	32

SOURCE: Elaboration by authors

Therefore the most efficient algorithm in predictive terms is the Simple Regression Tree. By applying the Simple Regression Tree algorithm, it is possible to verify the existence of a group of countries for which a growth in the value of TFV is predicted, and a group of countries for which a reduction is predicted (Figure 5).

Figure 5. Results of the predictions obtained by applying the Simple Regression Tree algorithm.

SOURCE: Elaboration by authors

The countries for which TFV growth is predicted are given below i.e.:

- Croatia with +85.49% corresponding to a variation from an amount of 1.37 units up to a value of 2.53 units or equal to 1.17 units;
- Norway with +57.42% corresponding to a change from an amount of 163.66 units up to 257.64 units or equal to 93.97 units;
- Finland with +50.28% corresponding to a variation from 28.00 units up to 42.08 units equal to +14.08;
- Ireland with +47.04% corresponding to a variation from 28.62 units up to 42.08 units equal to 13.46 units;
- Malta with +32.18% corresponding to a variation from 696 units up to 920 units or equal to +224 units;
- Austria with +3.87% corresponding to a variation from 36.00 units up to 37.39 units or equal to an amount of 1.39 units.

Finally, there are a set of countries for which the Simple Tree Regression algorithm predicts a reduction in the TFV value, namely:

- Denmark with -7.93% equal to a variation from 25.53 units up to 23.51 units or equal to -2.03 units;
- Turkey with -10.32% corresponding to a variation from 378 units up to 338 units or equal to -39.00 units;
- France with -11.52% corresponding to a variation from 421.50 units up to 372.92 units equal to -48.58 units;
- Lithuania with -12.60% corresponding to a variation from 5.50 units up to 4.81 units or open at -0.69 units;
- Slovenia with -13.11% corresponding to a variation from 2.91 units up to 2.53 units equal to -0.38 units.

If we consider the average of the predictions, there is a variation from 162.46 units up to 185.86 units equal to +14.40%.

4. CONCLUSIONS

The literature review highlights that to build truly inclusive financial systems it is increasingly necessary to promote close links between the world of digital finance and ESG issues. Otherwise, for example, if credit institutions in their business models continue to consider the problem of reducing financial exclusion as a target to be achieved rather than an input throughout their entire supply chain, they appear increasingly distant from taking on a social role with important repercussions on the territories. The lack of integration of ESG factors in the credit chain hinders the role of finance as a facilitator of the 17 sustainable development goals of Agenda 2030 and therefore a greater interaction between economic growth and social growth processes.
The econometric results show that the TFV value tends to be positively associated with the S-Social variable and negatively associated with the E-Environmental, and G-Governance component of the ESG model. From the point of view of clustering analysis, the presence of three clusters is highlighted. A particular exception must be recognized in Malta and Lithuania, which together constitute the dominant cluster. However, the adoption of factoring appears to be independent of the degree of financial culture found at country level. In fact, some countries that also have high levels of financial culture, such as the Netherlands, Switzerland and Ireland, have a medium-low degree of TFV. The large European countries, namely France, Germany, Italy, and also Turkey, are instead in an intermediate position. However, in the period considered, i.e. between 2016 and 2022, the value of TFV grew in almost all European countries. Finally, machine learning analysis predicts growth in the value of TFV in the future. It is very likely that the adoption of TFV models is more widespread in countries where the level of repayment of bank loans tends

to be lower. That is, it is likely that in countries where debtors tend to be more timely in repaying debts, the level of TFV is lower. It is therefore necessary to further investigate the diffusion of the TFV level by also taking into consideration variables that consider the capacity of debtors to be more compliant with the obligations undertaken at country level.

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