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Course of Key Topics in Today's Strategic Management

# Digital transformation in the wine industry:

*How small wineries in Piedmont navigate barriers, opportunities, and the balance between tradition and innovation*


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# 1 Introduction and Research Framing

## *1.1 Problem Statement*

This chapter introduces the context, objectives, and relevance of this thesis, which explores the digital transformation and innovation processes in the wine sector. It provides an overview of the research problem, defines the specific research questions, and explains the importance of studying how small and medium-sized enterprises (SMEs), particularly in the wine industry, adopt digital technologies.

The chapter also outlines the structure of the thesis, offering a clear roadmap of the work. By framing the research within the broader context of technological change and sectoral challenges, this chapter sets the foundation for the subsequent literature review and empirical analysis.

The wine industry (and especially small and medium-sized firms) is undergoing a deep transformation thanks to digital innovation. Leveraging digital technologies, including blockchain, IoT, AI, and advanced data analytics, offers immense potential for transparency, efficiency, and sustainable practices, but their uptake across the sector has not been extensive (Costa et al., 2023; Dressler & Paunovic, 2021). This is especially true in Europe, where the wine industry is fragmented, monolithic, and dominated primarily by family-based SMEs.

Internal structural deficits hinder digitalization. SMEs commonly run on 'low-tech' systems, also known as legacy systems, which are incompatible with evolving digital infrastructure. The high costs of technology required for modernization (Omowole et al., 2024) also limit the capacity of small-scale businesses to invest further into technology. In addition, low absorptive capacity, that is, the inability to acquire and apply new knowledge, hampers the internalization of digital competencies that are necessary for transformation (Farahani, 2024).

In addition to technological and financial challenges, organizational and cultural challenges exacerbate the complications. Among these barriers is the resistance to change and to innovation, which is a common issue, being the disconnection between new generations and traditional generations within family firms, where old generation firm owners can be skeptical of digital technology, seeing it as a threat to traditional values and craftsmanship (Othman, 2025). A low level of digital skills within the workforce may

compound the situation, turning the technology adoption into not only a strategic but also an educational issue (Mola & Roffia, 2024). Moreover, the perception of some owners is that embracing digital systems could erode personal control of operations and weaken human relationships, which exactly represent their business model (Othman, 2025).

At a macro level, external pressures are mounting. Consumers are calling for increased transparency and sustainability, regulators are tightening traceability and environmental reporting requirements, and international competition is increasing (Waye et al. 2023). While public funding and guidelines are currently available (eg, NextGenerationEU, CAP, Horizon Europe), the implementation is still focused on part of the stakeholders, excluding in many cases the smaller or traditional actors (Alabrese & Saba, 2022).

Although there is a growing scholarly interest in digital innovation and agri-food supply chains, there is still a lack of research on digital innovation and the agri-food supply chain of wine SMEs in terms of specific challenges and their strategic responses. Previous literature at large tends to extrapolate across sectors or place too great emphasis on larger-scale producers. Rarer are studies that investigate how heritage-driven SMEs think, resist, adapt to, or exploit digital transformation (Costa et al., 2023; Dressler & Paunovic, 2021).

Insight into these dynamics is critical not just for facilitating economic resilience but also for maintaining the cultural heritage associated with wine production. Without targeted measures that consider the idiosyncratic organizational and cultural characteristics of wine SMEs, the digital divide within the sector looks set to grow, jeopardizing the future sustainability and competitiveness of one of Europe's most iconic industries.

### *1.2 Research Objectives*

Based on the issues and research gap described in the previous section, the purpose of this thesis is to explore the phenomenon of digital transformation in the wine SMEs context. The aim is to identify the barriers and opportunities, along with the strategic directions that enable the digitization and at the same time the maintenance of the cultural and artisan tradition of the wine industry.

Specific objectives of the study are as follows:

To investigate the perceived benefits and potential strategic options of digitalization for wine SMEs, such as improved transparency of supply chains, cost savings, access to markets, and new business model development.

To investigate the challenges that hinder the adoption of digital technologies in wine SMEs. These include internal barriers such as legacy systems, limited financial resources, low absorptive capacity, and resistance to change within family businesses. They also encompass organizational and cultural constraints, like the generational divide in family firms, a lack of digital skills, and fear of losing traditional values. On the external side, challenges stem from fragmented supply chains, inadequate digital infrastructures, limited institutional support, and the complexity of regulatory frameworks.

To assess which are the most frequent digital technologies used by wine SMEs, and what stages of the value chain do they cover.

To explore how family and heritage wineries balance the need for digital innovation with the preservation of traditional practices, brand authenticity and craftsmanship.

1. To assess the role of public policies and institutional initiatives in supporting the digital transition of SMEs in the wine sector, and to identify gaps between policy intentions and practical impacts on small producers.

To present some suitable strategic recommendations to policymakers, SMEs, and stakeholders, to promote a more inclusive, sustainable, and culturally tailored digital transformation in the wine industry.

In this way, the thesis has the ambition of enriching scientific understanding of digital transformation in traditional sectors and of providing practical suggestions for improving the competitiveness and resilience of SMEs immersed in the complex and fragmented system of the wine industry.

### *1.3 Research Questions*

According to the research objectives delineated in the introduction, the study is driven by the following research question:

***How do small and medium vineyards adopt digital transformation, and what strategies do they develop to overcome adoption barriers?***

To answer this primary question, the sub-questions below will be investigated:

*1. How do SMEs, such as those operating in the wine sector, perceive the strategic benefits of digital technologies in terms of value chain transparency, cost reduction, market access, and innovation in the business model?*

*2. Which are the most frequent barriers and challenges that hinder the digital transformation of wine SMEs (e.g., financial constraints, legacy systems, resistance to change, low digital skills, regulatory complexity)?*

*3. Which are the most frequent digital technologies used by wine SMEs, and what stages of the value chain do they cover?*

*4. How do small, family-owned, and heritage-based wineries resolve the tension between tradition and innovation in the pursuit of digital transformation?*

*5. How is it possible for wineries to develop the skills that are necessary to adopt and incorporate digital tools (e.g., collaboration agreements, cooperative networks, public support)?*

*6. Which tactics can be suggested to help the wine industry in its sustainable, inclusive, and culturally sensitive digital transition?*

These research questions are structured to address the multi-faceted challenges and opportunities of digital transformation in the conventional wine industry, particularly the SMEs in Italy and across the wider European region.

### *1.4 Scope and Limitations of the Study*

This thesis investigates the digital innovation in small and medium-sized enterprises (SMEs) in the wine industry, both at the Italian and more general European level. The findings will contribute to the knowledge of how SMEs perceive, use, and implement digital technologies, considering the sector-specificities of fragmentation, regional embeddedness, and strong links with cultural inheritance.

**Scope of the Study**

Geographically, the examination focuses more specifically on Italy (one of the world's dominant wine producers), especially on the Piedmont region, with its high density of family-owned SMEs and quality Protected Designation of Origin (PDO) wines. However, other relevant comparative perspectives from across other European wine regions – France, Spain, Portugal, etc., are also drawn upon as necessary to enhance the analysis and draw attention to broader continental patterns.

Temporally, the work focuses on the post-COVID-19 context (2020 onwards), driven by heightened momentum for digital transformation following global supply chain disruptions, changes in consumers' preferences, and growing public policy encouragements to technology (Alabrese & Saba, 2022; Waye et al., 2023). This time frame is also characterized by the launch of major European funding schemes, such as the NextGenerationEU and Horizon Europe, so it is an opportune moment to analyze digital acceleration in traditional sectors.

Thematically, the research focuses on the organizational behavior of SMEs in the digitalization process. This entails looking at a range of internal drivers (such as leadership, digital know-how, change barriers, and family dynamics) as well as external pressures (such as regulatory requirements, technology trends, and public investment programs). Technologies considered include blockchain technology, IoT (Internet of Things), AI (artificial intelligence), and data analytics as they pertain to business operations, supply chain, marketing, and customer relationships in the wine industry.

In particular, the research examines:

• Barriers to the adoption of digital across SME's.

• Opportunities for digital innovation for transparency, access to market, and business model diversification.

• The dynamics of traditional heritage, innovation, and strategic choice in family winemaking firms.

• The role of public policy measures in stimulating the digitalization of small and medium enterprises.

**Delimitations of the Study**

The study aims to gain an in-depth understanding of the digitalization efforts of wine SMEs; a few methodical delimitations have been made to keep analytical focus.

First, the research does not delve deeply into the technical analysis of the technology. For example, the details of blockchain protocols, IoT frameworks, and AI algorithms are not within the purview. This is a focus on the organizational and strategic consequences of the technology and how the technology has been configured, and not its technical configuration.

Secondly, the research does not consider the big international wine players who differ from smaller players in terms of resource profile and digital maturity level as well as

strategic placement. The motivations, barriers and dynamics of MNCs are different, so they merit a different investigation.

Thirdly, though the paper does explore several public policies such as NextGenerationEU, CAP, and Horizon Europe, it is not a thorough policy analysis. Instead, it examines wine SME (i.e., wine small and medium-sized enterprise) perceptions of the relevance and accessibility of initiatives.

Furthermore, there is no quantified modeling as well as econometric analysis of the effects of digital transformation in the study. It does not use any economic model but rather takes a qualitative and discerning perspective on the experience, ideas, and strategic thinking of SMEs in their general socio-economic environment.

Lastly, the analysis is confined to the context of European SMEs with a main emphasis on Piedmont, Italy. Although comparisons to non-European situations may sometimes be a useful device for illustration, such a comparison is hampered by systemic differences in market structures, regulatory circumstances and culture and, thus, the findings should be considered as most relevant for the wine industry in Europe.

Those delimitations are intended to make the study focused and cohesive and enable a thorough research of the key challenges of SMEs in managing the challenges of digital transformation in an extremely traditional industry.

### *1.5 Research Importance and Contribution*

The issue of digitalization in the wine industry, and particularly for SMEs, is of a growing importance from both academic and practical perspectives. Considering tighter global competition, regulatory pressures, and evolving customer demands within the industry, understanding SMEs' responses to technological innovation is now more imperative. This thesis adds to the literature a gap by providing insights that are of importance theoretically and for practice.

**Academic Contribution**

Academically, this article addresses a significant void in between macro-based discourse on digitalization strategies and the actual, micro-level experiences of SMEs in traditional industries. A great part of literature about digital transformation tends to deal with large companies or with sectors already completely digitized (Costa et al., 2023; Dressler & Paunovic, 2021). Research on family-owned heritage-based SMEs in the wine sector-

specific environment is still scarce, even though these businesses play a key role in regional economic development and cultural conservation.

This study provides the empirical base for how structural, organizational, and external forces interact to influence digital transformation processes within wine SMEs. In doing so, it contributes to the academic dialogue by offering a nuanced account of digital take-up, which not only accounts for technological preparedness but also for cultural, emotional, and identity-based aspects of institutional conduct.

Further, the research informs the wider literature on innovation resistance, absorptive capacity, and the digital divide to show that traditional sectors may need specialized and culturally specific digitalization models that are not tied to homogenizing one-size-fits-all approaches.

**Practical Contribution**

From an applied perspective, the results of this study are designed to provide practical implications for wine entrepreneurs, policymakers, and technology providers.

For entrepreneurs and managers, the study offers a better understanding of internal obstacles they may encounter in the process of digital transformation and suggests strategic pathways for them to overcome those, like stimulating intergenerational communication, training digital literacy, and benefiting from available public funding.

For the policy community, the analysis provides important feedback on the reach and impact of current efforts. It also underlines the requirement for more context-specific facilitators and vehicles of support for SMEs in culturally sensitive, resource poor settings.

For technology vendors and consultants, the findings highlight the need to develop solutions that combine advanced technology with simplicity of use, scalability, and that resonate with the values and traditions of the end users. In addition, knowing how the emotional and identity aspects underlying technological resistance matter can help in the development and marketing of digital products targeted at traditional sectors.

**Societal Impact**

This study also has practical implications beyond academia and the business sector. The digitalization of the wine sector in a sustainable and culture-respectful manner serves several objectives: enabling rural development, contributing to more environmental sustainability, and respecting the diversity of Europe's rich cultural heritage. By

facilitating the uptake of digital technologies within SMEs while maintaining their artisanal nature, the study can contribute to the resilience and vibrancy of the rural communities, where viticulture is often a main source of employment, tourism, and cultural expression.

Improved digital capabilities and inclusive innovation are also consistent with the European Union's wider objectives within the Digital Decade strategy and the Sustainable Development Goals (SDGs). The digital transformation of wine SMEs can therefore bring positive spillover effects across firms, by fostering economic inclusion and promoting regional cohesion, and help for the transition towards more sustainable and transparent food systems.

To conclude, the present study addresses a timely and multifaceted issue, presenting theoretical developments and practical suggestions for supporting a more inclusive, socially responsible, and culturally sensitive digital transformation of one of Europe's iconic traditional sectors.

### *1.6 Methodological Overview*

This study employs a qualitative research design to explore the processes of digital transformation as undertaken by SMEs in the wine business. Due to the intricate, multifaceted character of the researched phenomenon and the close relationship between technological change, organizational discourse, and cultural identity, qualitative methodologies serve as a valid tool to explore the rich and multifaceted experiences of the wine SMEs. Specifically, the study is defined as an exploratory qualitative study design based on semi-structured interviews with the managers and owners of wine SMEs and digital transformation consultants. Semi-structured interviews allow a researcher to explore themes in depth, but also allow participants to express those views in their own words. Additionally, the analysis of secondary information, including industry reports and corporate materials, will be performed to offset and to complement the primary data. Qualitative research methodologies are particularly suitable for the research question aimed at exploring the "how" and "why" of the spread of specific phenomena (Creswell, 2013). In this study, the aim is to ascertain the barriers, the motivational factors, and the strategic concerns underlying the uptake of digital technologies in the wine sector. Hence, the use of a qualitative lens provides the desired interpretative depth. This method was

considered preferable to a survey or a structured interview due to the need to elicit participants' unique experiences and to explore emergent themes. Perhaps, just as importantly, digital transformations in the traditional fields are heavily based on cultures of beliefs, for example, traditional knowledge and emotional attachments to the heritage drivers, which would be difficult to capture in a survey. A qualitative inquiry provides a more in-depth understanding of the various relationships between the constructs discussed.

This reference to SMEs, with their peculiarities as regards size, resource constraints, and forms of governance, provides further support for a qualitative stance. SMEs are highly heterogeneous, and a detailed study of several cases or biographical accounts is essential for capturing patterns, divergences, and context-specific strategies.

The interview transcriptions are the main data, and they are supported by documents such as organizational script, secondary literature as company web page, industrial reports, and governmental and trade press.

Owners, managers, and decision-makers of Italian wine SMEs are the interviewees. Digital consultants and technology vendors cooperating with SMEs, if there are any, can also be interviewed, where appropriate, to allow for further contributions.

Thematic analysis is conducted to determine patterns, themes, and variations in the data across cases. Ethical issues such as informed consent, anonymity, and confidentiality are strictly adhered to, following established qualitative research standards.

# 2 Digital Transformation in the Wine Sector: Literature Review and Theoretical Framework

## 2.1 The Digital Transformation in Traditional Sectors

### *2.1.1 Overview and Definitions*

Digital transformation (DT) reshapes the way traditional industries conduct business, compete, and create value in the 21st-century economy. Unlike mere digitization, which (often) involves replacing analogue processes with digital ones, digital transformation disrupts how a business is structured and how it operates by embedding digital technologies at the very core of both the business models and operations (Johnson et al., 2024). Digital transformation stretches from reimagining and reengineering business models, strategies, and processes to technology-enablement.

Digital transformation is driven by a series of technological developments, including AI, big data analytics, IoT, and blockchain. Collectively, these technologies are re-imagining process efficiency, customer experience, and data for decision-making (Fu, 2025; Johnson et al., 2024). For instance, with the increasing use of AI-based predictive analytics and IoT-enabled sensors, businesses can predict the need for maintenance, streamline supply chains, and dynamically reallocate resources (Kamble & Gunasekaran, 2019; Wamba et al., 2015). However, numerous conventional sectors, including manufacturing and agriculture, continue to grapple with the repercussions of their legacy systems and a historical reliance on physical labor, consequently rendering them vulnerable to the competitive pressures exerted by the global market. In numerous conventional domains, organizational frameworks are characterized by rigidity, and the degree of digital maturity is constrained, thereby impeding transformative processes. However, it must be noted that each of these sectors is facing challenges in the form of global sustainability and changing customer expectations. These challenges are weakening the traditional fabric and forcing companies to transform digitally (Gandhi et al., 2016; Dressler & Paunović, 2021).

The digital economy is making this shift feasible. Specialized information systems, available information, and a variety of networked technologies are what tactically impel such a digital economy. Over time, it restructures some value lines and makes various

producers and consumers closely affiliated, and that response capacity and synchronicity capability are enhanced (Fu, 2025).

Empirical research also shows that the usage of digital platforms and cloud-based infrastructures within organizational processes not only leads to the enhancement of operational agility but also enables new revenue models like subscription services or platform-based commerce (Ghazawneh & Henfridsson, 2013; Gassmann et al., 2014). Furthermore, traditional companies, thanks to the digitization process, have the opportunity to go beyond territorial and sectoral borders and participate in innovative global eco-systems, hence extending their businesses (Yoo et al., 2010; Iansiti & Levien, 2004). This is evidence that digital transformation is not only about technology, but about redefining value creation and business models.

However, the road to such a transformation is not easy. The large upfront cost investment, organizational resistance to change, cybersecurity concerns, and the lack of digital skills are the key obstacles to traditional industries (Sosna et al., 2010; Dahlberg et al., 2015). These obstacles are compounded in the case of SMEs, which are typically characterized by smaller resource endowments. For SMEs in particular, because of their flexibility and crucial role in the economy, customized measures and public policies are necessary to pass this transition effectively (Ulas, 2019; Mefid & Ridhaningsih, 2024).

### *2.1.2 Key Global Trends*

The economy is undergoing a transition from the 4th to the 5th industrial revolution, which is characterized by the transition from a focus on mere efficiency and automation to an increasing focus on people and their centrality and social welfare, and on the sustainability of the world in which we live. This development results in human creativity being regarded as the basic one, hence the need for it to be connected with modern technologies, including AI, robotics, and big data. The data-driven Industry 4.0 is built on the advantages of efficacy and efficiency, ease of use, and emphasizes using cyber-physical systems, Internet of Things (IoT), and real-time data going forward. Instead, Industry 5.0 looks back and prods companies to make business performance part of wider social and environmentally sustainable goals, in other words, more ethical. (Festa et al., 2024; European Commission, 2021; Dressler & Paunović, 2021). There will also be a stronger focus on humans and machines, hoping for better results both in production labor

and in the health, happiness, and safety of laborers and communities (Balaji, 2025). In this view, innovation is not only an instrument of competition but also one of resilience, inclusiveness, and environmental stewardship (Balaji, 2025).

Probably the most important trend on the planet today is sustainability. Whether one turns to the global politics of the earth (climate change) or the problems of food security in the Global South, sustainability has rapidly become a central feature in dozens of global issues, including those which the science and technology studies community focuses upon, such as global innovation programs. Changing weather patterns, scarce resources, and a more demanding consumer base also are converging to force businesses to recalibrate operations in the face of new regulatory pressures and heightened social principles (Costa et al., 2023; Waye et al., 2023; Sabbagh et al., 2024). Digital technologies offer an attractive tool to reach sustainability goals, including reduced emissions, improved supply chain efficiencies, and the creation of circular economies (Galati et al., 2024; Waye et al., 2023). Consider, for instance, the disruptive potential of blockchain and Internet of Things in agri-food systems, which is instrumental for traceability of the origins of a product and of the footprint it leaves on the environment allowing companies to provide evidence-based information about the journey of a product from the point of its origin to the end consumer (Ibrahimli, 2024).

Another global trend that is driving digital transformation is the change in the expectations of customers and stakeholders. Consumers today are more and more looking for quality products of services, and also more transparency, responsibility, and company perspectives regarding ethical and social issues and environmental protection (Dressler & Paunović, 2021; Costa et al., 2023; Mola & Roffia, 2024). At the same time, stakeholders, whether investors, regulators, or civil society, are increasingly concerned about companies' environmental, social, and governance (ESG) performance. Leveraging on these changing views, blockchain technology is providing a mechanism for increasing transparency and trust in supply chain operations (Sabbagh et al., 2024; Galati et al., 2024;). It should be noted that one of the key tools for anti-counterfeiting and product traceability is the use of the blockchain approach (Ibrahimli, 2024). A secure and unalterable digital record is created and updated at every stage in the life of wine from production to sale, using blockchain technology. Every other participant along the supply chain inserts their piece of information in this system, where changes and erasures are

not allowed. Consumers can read this history, which encompasses where the wine comes from and the vintage year to production methods, by scanning a QR code or interacting with an electronic label that is attached to the bottle. Through this empowerment, customers gain more insight and have trust for the integrity of their data and against manipulation. The opportunities behind blockchain are endless; it aligns perfectly with sustainability objectives as it opens the entire wine supply chain, cuts waste, cuts fraud, and allows consumers to buy ethically produced wine (Giannini, Iacobucci, & Orci, 2025).

Sustainability aside, the aftermath of the COVID-19 pandemic further emphasized the necessity of innovation and digitalization as a firm's trump card when it comes to resilience. And the crises that had to be solved with digitalization also provided a sudden push for digital transformation in other, more traditional fields. Digital tools enabled governments and businesses to move swiftly to address health, logistical, and economic challenges. Developments in telemedicine, remote working, digital finance, and e-commerce not only facilitated the survival of businesses, but also fast-tracked the digitalization of traditional sectors (Ibrahimli, 2024). Alongside these shifts in what digital experience looks like, customers have evolved what they expect from brands since the time of COVID-19, so businesses have needed to adapt to respond to those new expectations. These new requirements are such as more security, personalization, or as has been said, to carry out sustainable activities for the environment. Needs that technology can help better meet. This has further reemphasized the importance for organizations to align organizational digital transformation strategies with broader, longer-term objectives relating to the environment and society (Sunjaya et al., 2022).

In this regard, governments also have an active role, as they create policy frameworks that stimulate innovation and, at the same time, support ethical and societal considerations (European Commission, 2021; Strilets et al., 2022).

In short, global tendencies for digitalization describe a multi-figured development—from the rationality of Industry 4.0, which is driven by productivity, to Industry 5.0 that tends to be humanity-centric. At the core of this paradigm shift is how the strategic orchestration of high technology, sustainability, transparency, and adaptability can tackle the complex issues of our day.

### *2.1.3 The Fundamental Technologies Driving Digital Transformation*

Digital revolution in agriculture and wine sectors rests largely on the adoption of key technologies: blockchain, IoT, AI, and data analytics. The technical implications may be complicated, but the technologies are fundamentally underpinning traceability, enabling operational efficiencies and predictive analysis, and establishing trust through value networks, increasing the visibility in the supply chain (Galati et al., 2021; Costa et al., 2023; Sabbagh et al., 2024).

A decentralized, secure ledger, such as blockchain, is especially useful for supply chains needing to prove traceability and origin, also considering that the wine industry is often plagued by counterfeiting and consequently by consumer skepticism. In the food and beverage industries, it provides end-to-end visibility, helping to validate origins, evaluate quality, and ensure regulatory compliance (Liu, 2025). Blockchain enhances consumer trust with the real-time access to immutable data on the process of wine production, certification, and logistics (Sermuksnyte-Alesiuniene et al., 2021).

Digitalization noticeably enhances financial efficiency. Technology adoption, such as cloud computing, automation, and sensor-based precision farming, reduces operating costs. This decrease in cost is a result of more efficient handling of resources, less waste, and automation of repetitive work (Dressler & Paunovic, 2021). IoT is comprised of connected devices and sensors that can collect and transmit information about physical phenomena. Furthermore, in what concerns food systems, IoT implementations range from maintaining soil conditions and crop status to controlling environmental aspects during transport and storage (Sermuksnyte-Alesiuniene et al., 2021). Adoption of IoT in the wine industry ensures better farming strategies and real-time logistics handling, leading to economies of scale in spoilage minimization and quality improvement (Liu, 2025).

On the other hand, AI and machine learning play vital roles in going further than prediction as a part of predictive analytics, ensuring better quality control and foresight on demand in the future. Drawing upon massive data sets, these technologies excel at detecting patterns and anomalies, with the result that producers and distributors can make informed decisions rapidly (Chatterjee et al., 2024). In winemaking, artificial-intelligence algorithms are increasingly being applied to optimize fermentation processes, predict shifting consumer tastes, and automate important business decisions (Liu 2025).

These revolutions are driven by data analytics. Through the process of aggregating and analyzing large internal and external datasets, both structured and unstructured, decision makers learn more about consumer behavior, market trends, and the most important internal performance indicators. Furthermore, sophisticated diagnostic tools have stimulated an enhancement of operative efficiency while consolidating the basis for strategic planning in numerous fields of industry (Tortorella et al., 2024).

Also, digital channels allow far greater access to markets. By using e-commerce, social media, and digital marketing tools, SMEs can circumvent conventional intermediaries and directly reach a global network of consumers (Marchiori, 2021). Especially for the family-led and regional-sized wineries, this digital presence supports internationalization and addresses niches that could not be reached until now via classical communication channels.

The degree of digitalization additionally stimulates new business model creation. SMEs are looking more and more to direct-to-consumer (D2C) strategies, such as wine club memberships, digital wine tourism experiences, and customized product offerings guided through data analytics (Dressler & Paunovic, 2021).

Although introducing new technologies can be difficult, such opportunities demonstrate the extent to which digitalization benefits small and medium-sized businesses. These technologies are significantly disrupting traditional ways of working in wine production and delivery and are a growth-oriented structure with data at its core. Their reach encompasses more than just technological advances and includes important strategic value as companies seek to align proven practices with new innovations in an increasingly competitive and transparent world.

### *2.1.4 Role of Public Policy and Funding Support*

Digital transformation has increasingly been recognized as a cornerstone of competitiveness and sustainability across all sectors of the economy. Governments and supranational institutions, particularly within the European Union, have placed digitalization at the center of industrial and innovation policies, framing it not only as a driver of productivity but also as a prerequisite for social inclusion and environmental sustainability (European Commission, 2021). Public policy support in this area typically combines regulatory initiatives, direct financial measures, and capacity-building

programs. These include grants, tax incentives, subsidized loans, and targeted training schemes that aim to address barriers such as limited access to finance, lack of digital skills, and resistance to change (Rupeika-Apoga, Bule, & Petrovska, 2022).

Small and medium-sized enterprises (SMEs), which constitute the backbone of the European economy, have been identified as particularly vulnerable in this transition. While large firms often have the resources to develop in-house digital competencies, SMEs face significant structural constraints and therefore require tailored public support to avoid widening the digital divide (OECD, 2021). Evidence shows that SMEs often struggle to cope with digital transformation without assistance, making public measures crucial to ensure both competitiveness and resilience (Rupeika-Apoga et al., 2022).

In this sense, public interventions play a dual role: on the one hand, they reduce the economic and organizational risks of adopting new technologies, and on the other hand, they shape the broader innovation ecosystem by providing infrastructure (such as broadband networks), fostering trust in digital environments, and promoting collaboration across industries and regions (Strilets et al., 2022). Initiatives such as the EU's Digital Europe Programme, the Digital Decade policy framework, and national digital strategies exemplify this integrated approach, which combines financial incentives with the creation of digital innovation hubs and data spaces to stimulate cross-sectoral cooperation (European Commission, 2021; European Investment Bank, 2021).

Seen from this broader perspective, public policy is not merely a facilitator of technological adoption but an active shaper of digital transformation pathways. The extent to which these measures are designed inclusively and implemented effectively determines whether SMEs can harness the opportunities of digital innovation or remain marginalized in increasingly digitalized markets (Strilets et al., 2022; European Commission, 2021).

Now the EU acknowledges more and more digitalization as a crucial leverage for the agricultural sector`s capacity to break path and remain sustainable and competitive, not the least with a view to climate change, globalization and the aftermath of the pandemic (Kondratieva, 2021; Alabrese & Saba, 2022). A number of major policy initiatives have been implemented to promote and finance digitalization in agri-food and wine and target SMEs in particular. Digital innovation forms a core component of the Common Agricultural Policy (CAP) to make agriculture more sustainable and more resilient. The

new CAP reforms focus not on introducing digital technologies for business efficiency purposes but mandating compliance with the climate neutrality and inclusiveness principles (Kondratieva, 2021). Digitalization is not anymore addressed only as an instrumental, but as a regulatory requirement to pursue environmental goals.

The 'From Farm to Fork Strategy' within the European Green Deal takes the CAP framework to the next level and highlights the need for the (re)building of sustainable food systems. It stimulates the application of enabling technologies like blockchain, IoT, AI in order to deliver traceability, less waste, and efficient production and distribution processes (Alabrese & Saba, 2022).

Digitalization of the agriculture is considered to be important for the fulfillment of climate goals by the year 2050 including reduction of pesticides by 50% till the year 2050 and increasing the organic farm to cover 25% of the agricultural area (Kondratieva, 2021). NextGenerationEU, the EU's recovery instrument post-COVID-19 also dedicates much funding to the green and digital transitions. It is to complement the CAP by granting Member States with sufficient funds to improve rural broadband and build innovation hubs, and to provide digital upskilling training for farmers and SMEs in rural areas (Alabrese & Saba, 2022). These initiatives are further complemented by Horzion Europe, EU's flagship research and innovation program (2021–2027) that places a the emphasis on the advancement of agricultural digitalization through targeted research actions.

Horizon Europe (€95.5 billion), such supports directly measures which are in line with the digitalisation of agriculture. The projects funded under Horizon Europe focus on precision farming, artificial intelligence in agriculture, blockchain applications at food traceability and sustainable farm practices (ACI Missione Europa, 2023).

The guidelines of Horizon Europe also focus on establishing the European Data Space for agriculture, which provides for a secure sharing of data among agricultural sector players in order to promote innovation and sustainability (Alabrese & Saba, 2022).

It is this mix of policies that generates a strong public "push" effect targeting structural obstacles in the traditional sectors, such as wine making, to favour digital technology adoption. In combination, these policy measures form a strong public push system aiming not only to improve competitiveness, but also to mainstream the principles of social inclusion, environmental sustainability and rural development throughout the agri-food industry.

## 2.2 Digital Transformation in the Wine Industry

### *2.2.1 The Wine Industry in the Digital Era*

The Food & Beverage (F&B) sector has a unique position in the digital environment on account of a combination of complex and often global supply chains, the perishable and highly valuable nature of the product, and the tough regulatory environment combined with the higher consumer expectations of transparency, quality, and sustainability (Kamble et al., 2019). But unlike other manufacturing industries, the F&B and wine industries, above all others, labor at the intersection of agricultural variability, craftsmanship of production, and consumer-facing branding (Kamble et al., 2020). The wine sector is a case in point, given its strong cultural heritage, artisanal production techniques, and regional character. It is a highly regulated structure of place-based industry: *terroir*, denomination of origin, and heritage are key factors in the brand identity of the product (Meloni et al., 2019). Wine is also an internationally traded commodity with significant export dynamics and, as such, is susceptible to regulatory fragmentation, logistical difficulty, and counterfeit threats. The combination of all this makes the wine market an attractive playground for digital transformation projects that focus on traceability, quality control, and consumer confidence (Galati et al., 2021; Sabbagh et al., 2024).

The world wine industry is distinguished from other agri-food sectors, thus establishing a unique niche in which economic value, cultural significance, and traditional artisan methods can be found. With a global market size of over $340 billion, wine is a core agricultural product but also a symbol closely related to cultural heritage, rural development, and social practices (OIV, 2023; Dudic et al., 2024). Its impact resonates locally and globally, greatly influencing territories, financial frameworks, and consumer patterns in established and emerging markets.

European countries continue to hold top spots in the world wine market. Italy, France and Spain are at the top of the list of leading wine-producing countries in the world. Together, these three countries are responsible for more than half of the total world wine production, and they control more than 60% of the global wine exports (Dudic et al., 2024; Galati et al., 2024). World competition has increased outside Europe with the development of the "New World" wines from the United States, Australia, Chile and South Africa. This change has realigned world trade patterns and consumer attitudes

about quality, as well as producing innovative developments (Galati et al., 2021; Dudic et al., 2024).

The cultural significance of wine eclipses its financial value. Across Europe, the art of viticulture is deeply ingrained within local identities, reflecting a rich past and safeguarding cultural heritage across generations. Recognitions, such as those awarded by UNESCO, of sites including Italy's Langhe-Roero and Monferrato hills, Portugal's Douro Valley, and France's Champagne region, are some examples (Aimar, 2024; UNESCO, 2014). Those awards acknowledge their fundamental contribution to the preservation of historical winemaking methods and the maintenance of a unique cultural environment (Aimar, 2024). Wine transcends mere commerce; it acts as a cultural symbol, representative of specific locations, a facilitator of social relationships, and an embodiment of craftsmanship. The wine sector is highly fragmentated, primarily composed of SMEs, which are particularly diffuse in Europe. At the basis of it, the sector is commonly made up of family-owned firms that combine time-honored techniques with familial managerial approaches (Galati et al., 2024). They have a significant dependence on cultural capital and brand heritage as sources of competitive advantages, which solidifies their place in regional economies and communities (Galati et al., 2024). Finally, compliance with regulations like PDO (Protected Designation of Origin) and DOCG (Denominazione di Origine Controllata e Garantita) emphasizes how important standards are to upholding geographic integrity and product quality (Meloni et al., 2019). But the wine industry continues to be confronted with several complicated problems that affect its viability. The issue of climate change has become a particularly urgent one, with consequences for grape yield, harvesting times and wine quality. This has led to the implementation of adaptive management tools, such as precision viticulture and sustainable growing, being imperative (Ferro & Catania, 2023; Sabbagh et al., 2024). The increasing pace of globalization has amplified competitive dynamics, forcing organizations to operate in complex global markets and in demand environments which more and more are increasingly focused on sustainability, transparency, and ethical sourcing (Galati et al., 2024). Regulatory burden, particularly concerning certifications, traceability, and environmental compliance, further contributes to the operational constraints, which is exacerbated for SMEs in the sector (Costa et al., 2023; Galati et al., 2021; Heizer et al., 2024).

Furthermore, altered consumer behaviors, encompassing the growth of wine-focused tourism, consumption centered on experiences, and direct-to-customer approaches, are modifying the strategies for wine marketing and sales (Dudic et al., 2024). Today's consumers are demanding not just great products but compelling experiences that connect them to the cultural sixth that surrounds the product, the people making the product, and the place where it comes from. This transformation has opened new doors to business development whilst also increasing the need for higher-level marketing methods, digital communication, and transparency in the supply chain (Dudic et al., 2024; Mola & Roffia, 2024; Dressler & Paunović, 2021).

In summary, the wine sector has a strategic place at the crossroads between economy, culture and the environment. With its long history, economic significance and craft based approach, it is an interesting field for a case study of the transformative advances that reach into traditional industries in a modern age (Galati et al., 2021; Costa et al., 2023).

### *2.2.2 Economic and Social Importance of Wine*

The profound impact of wine extends globally, touching economics and culture, but Europe, with Italy taking the lead, presents a remarkable case study. In Italy, the business of making wine isn't just an enterprise, but is entwined with national identity, history and tradition, and it has bolstered rural areas, too. Italy consistently ranks among the top wine producers worldwide, assessed by both the volume of wine produced and its financial value. The Italian exports represent a higher proportion than 19% of the world wine in value, while about the half (49%) of Italian wine is directly exported abroad (Dudic et al., 2024; OIV, 2023). At an international level this trade clearly demonstrates the vital economic importance for the nation's industrial life, affecting in a considerable way territories as Piedmont, Tuscany and Veneto (Galati et al., 2024).

The importance of Italian winemaking on a cultural level is deep and far greater than its businesses value. Piedmont's Langhe-Roero and Monferrato vineyards, for example, are UNESCO World Heritage sites. This status is a recognition of their character as a "living cultural landscape" or a space in which human and environmental forces have progressed together over the centuries (Aimar 2024). Such places embody the development of wine beyond a basic commercial offering, expanding into a vehicle for transmitting cultural narratives as well as for creating pride of place and preserving intangible cultural heritage.

Local distinctiveness is particularly ensured by the know-how of winemaking, which is thoroughly handed down in the family (Aimar, 2024), often leading to small family businesses. In the market of Italian wine, the small and medium-sized companies, very often with family management, are the most widespread form of organization (Galati et al., 2024). A key point in these companies is the strong identity between the brand image and family history of many of them; many use their name and legacy as a strategic asset to gain a competitive edge. This multi-generational structure also helps to keep traditional methods alive. It is also reinforcing the economic and social fabric in local communities, through consolidating a sense of place and the involvement in protecting regional environments (Aimar, 2024).

Wine tourism provides an important incentive for economies in the region and reinforces the cultural tapestry woven around wine production. Visitors are drawn by more than the flavor. The overall experience, a 'total experience' incorporating the beauty of the vineyard, the cellars, the flavors of local cuisine and storytelling, it captures the customer and creates loyalty and satisfaction with the brand (Dudic et al., 2024). The development of products such as wine trails for wine lovers and heritage-based experiences has effectively used wine as a catalyst for cultural exchange and the reinvigoration of rural regions (Dudic et al., 2024; Aimar, 2024).

In synthesis, for Italy wine transcends its perception as a high-value agricultural product. It represents a cultural heritage, an essential part of the economy and tool for the modification of the natural and social context. This has a tangible effect on scenery, livelihoods, and identity (Aimar, 2024; Galati et al., 2024).

### *2.2.3 The Structure of the Wine Industry*

The wine market is characterized by a peculiar structure linking back to ancient roots and very deep legacies in habits and traditions, particularly in old producing countries such as Italy. A defining feature of the sector is its fragmentation: the industry comprises a multitude of small to medium-sized enterprises (SMEs), many of which operate independently across different stages of the value chain. In Italy alone, over 300,000 farms grow wine grapes, though only about 55,000 are engaged in winemaking and fewer still handle bottling—illustrating a widespread decentralization in production processes (Corsi et al., 2019). This fragmented structure has been blamed for inefficiencies in

scaling, challenges in becoming digital, and in securities global market susceptibility (Costa et al., 2023; Galati et al., 2021).

Most of these companies are family businesses, a trait that adds to the sector's complexity and richness. Not only are these businesses economic systems, but they are also the bearers of a cultural patrimony, as keepers of an inheritance that is made of knowledge, values, skills and identity passed down through generations (Moisello, 2025). This "familiness" that permits authenticity and long-range planning may also lead to conservative decision-making and slow adaptation to technological evolution as well (Costa et al., 2023).

A third feature concerns the strong regional aspects of wine production. Terroir, Protected Designation of Origin (PDO), and local customs significantly shape the branding, marketing, and regulatory status of wines, especially in Europe. Italian wineries tend to orient their corporate identity around their region-based origin, engaging storytelling and heritage branding models as a means to achieve market distinction at international level (Spielmann et al., 2021; Gallucci & D'Amato, 2013)

Finally, the sector is highly dependent on exports. For example, Italy, the world's largest wine producer by volume, exports more than half of its production, with major destinations including the United States, Germany, and the United Kingdom (Corsi et al., 2019). Such dependence leaves wineries — particularly small ones — vulnerable to the volatility of international markets, regulatory flare-ups, and logistical disruptions. Notwithstanding these risks, internationalization continues to be a dominant instrument which is also supported by the export model and driving the demand for digital tools that ensure traceability, compliance and cross-border agribusiness marketing (Galati et al., 2024).

### *2.2.4 Main Challenges in the Wine Sector*

To deeply explore how SMEs in the wine industry might make use of technological developments, an understanding of key industry barriers and their repercussions is essential. That would necessitate recognizing external forces. This includes issues like the degradation of the environment and the scarcity of resources, the need to abide by the severe regulations, the growth of fraud, or the transversal inefficiencies of the supply chain (Costa et al., 2023; Galati et al., 2021).

There is no question that the climate change is a fundamental issue for the future of the wine industry. It particularly challenges the counterpart for wineries is operational management and adaptation to climate change. It poses a significant threat to the long-term economic viability of wine production. This phenomenon is not exclusive to the production and marketing of wine; it is particularly evident in the context of regional wines. If productivity is pushed away from global warming, the unique identity of certain regions is threatened as well. The increasing of temperatures, changes in rainfall and extreme events such as hail storms and spring frosts are affecting negatively the grape quality, the hydrological vineyard timetable and the geographical distribution of the same vineyard. Such factors contribute to less predictable growing conditions. Producers are therefore forced to introduce drastic changes, that include: the introduction of alternative grape varieties, the implementation of alternative farming systems or relocating their vineyards in cooler areas (Alessandri et al., 2024; Sabbagh et al., 2024). Furthermore, this is not solely an environmental issue; the economic aspects must also be considered. Climate-sensitive Protected Designations of Origin (PDOs) face the complex challenge of maintaining their distinctive regional identity despite quickly changing environmental conditions (Candiago et al., 2024).

In the agro-food system, the wine industry operates under an exceptionally complex and highly regulated system. All over Europe, the legislation – primarily Regulation (EU) No. 1308/2013 and its various updates – controls virtually all aspects of winemaking, from how grapes are grown to the requirements for labeling and the traceability of the production line. For instance, among wines with protected designations, there is a requirement to show information about the vintage, grape variety, and origin on the label. Producers must also carefully track every detail of their production process, everything from the yield of vineyards to bottle volume. These EU legislations are supplemented by national guidelines, such as those implemented by the Italian Ministry of Agriculture or France's INAO, which are particularly relevant for wineries interested in prestigious certifications like DOP or IGP (Heizer et al., 2024; Meloni et al., 2019). Though the intentions of these regulations are to preserve product quality and create consumer trust, they come with significant costs, especially for small and medium-sized wineries. For many family vineyards, abiding by compliance requires more than just good intentions. This consists of having to accommodate significant expenses, complex paperwork and

an administrative burden which frequently obscures their raison d'être which is to grow, mature and bottle great wine (Parry et al., 2024). To maintain a DOP or DOCG status, wineries, for instance, need to follow yield restrictions, adhere to the prescribed pruning methods and jump through mandatory testing before the wine is even available to the public. Additionally, these needs continue outside the box of the winery. Full compliance involves every link in the supply chain, demanding meticulous record-keeping in vineyards, adhering to deadlines for harvest declarations, and delivering comprehensive production reports. Even minor slipups, like missing a form or submitting it late, could imperil hard-won certifications and restrict access to premium markets. While larger wineries frequently designate specialized staff to navigate the regulatory maze, smaller producers frequently find themselves simultaneously managing these obligations while also tending to their vineyards, overseeing the cellar, and engaging with customers (Meloni et al., 2019; Heizer et al., 2024; Costa et al., 2023).

Pre-existing strains are amplified by the increasing relevance of sustainability. The connected wine drinkers of the world are becoming more and more savvy, not only about what's in the bottle, but also how it got there. Under this regime, there has been an explosion in certifications: organic, biodynamic (which require meticulously kept records and compliance). These certifications range from organic fertilizer use, restriction on chemical intervention, to biodiversity preservation requirements (Waye et al., 2023; Costa et al., 2023). This is particularly obvious in Piedmont. The region is best known for the iconic wines Barolo and Barbaresco. In this region, hundreds of small, family-owned wineries confront a dual challenge: satisfying the notoriously strict DOCG requirements, among Italy's toughest, and addressing the requirements of local environmental protocols, mandated by hillside viticulture, that include practices like soil conservation and biodiversity protection (Aimar, 2024; Sabbagh et al., 2024). Consider Barolo, it's not just another red wine offering: it has to age for a minimum of 38 months, at least 18 in wood, and has production restrictions (8 tones of grapes per hectare) and restrictions on the types of grapes used, (Nebbiolo, according to the Consorzio di Tutela Barolo Barbaresco Alba Langhe e Dogliani, 2024). Although these regulations are designed to safeguard Piedmont's prestigious status and picturesque landscape, they often strain the capacity of smaller producers, who often have to perform multiple roles such as winemaker, marketing specialist and office manager. Despite these adversities, many

Piedmontese wineries remain steadfast in their commitment to their heritage, fully understanding that their wines are a testament to a history interwoven with their location and family legacy (Robinson, Harding, & Vouillamoz, 2012). For many wineries, in fact, regulatory compliance is far more than just a nuisance, it's an integral part of who they are. And, specially, for the family wineries on a specific territory, its terroir, tradition, and local life, with local customs and culture, is the core of the identity of the family winery. However, this deeply entrenched loyalty to tradition can also at times obstruct much needed flexibility to negotiate new regulations or changing market tides, leaving these wineries in an ongoing battle to reconcile the respect for their past with the exigencies of an ever-changing future (Costa et al., 2023).

One of the most destructive threats to the sector is wine fraud. This ongoing matter is eroding the industry's ethical barometer and financial standing. Types of wine fraud include misrepresenting a wine's origin or vintage, the addition of unwanted substances, and misleading consumers who buy fake bottles of wine that are passed off as being connected to a reputable wine region. For example, there have been a number of high profile scandals in the EU for mis-labelled Bordeaux or Brunello wines. There is evidence that up to 20% of world wine trade could somehow be tarnished by some form of fraudulent activity (Koljančić et al., 2024). The economic fallout is not insignificant. The European Union Intellectual Property Office (EUIPO, 2016) calculates that counterfeit and pirated wines lead to European producers losing more than €1.3 billion a year in sales revenue, which in turn impacts their home and export markets. In China, a significant importer of fine wines, estimates are that half the wine bottles purchased with names like Bordeaux or Burgundy, associated with high end wines, as to be counterfeit or mis-labelled, highlighting the worldwide nature of the issue (Koljančić et al., 2024). Perhaps more damaging than the losses themselves is the eroding of consumer confidence. Once consumers start to doubt the authenticity of what's in the bottle, they may not be as willing to pay premium prices or trust regional labels. This hits especially hard at legitimate producers; the ones that still rely on export markets to make their living, and where the trust in European appellations (like Bordeaux, or Barolo, or Brunello di Montalcino) is crucial to market position (Costa et al., 2023; Sabbagh et al., 2024). Recently, high profile scandals within the EU have gained a great deal of media attention. For example, in Italy the Brunello di Montalcino scandal took place when some of the

producers were caught adulterating the DOCG wine with non-permitted varieties, compromising the prestige of the appellation (Koljančić et al., 2024). France has also dealt with several major fraud cases, including the seizure of more than 300,000 counterfeit bottles of Bordeaux, leading to some high-profile arrests and increased police activity (EUIPO, 2016). Large corporations may often absorb the costs associated with heightened oversight, but small and medium-sized wineries, particularly those that are family-owned, face an additional hurdle: compliance is an investment of time and money that is made while battling for market share in a global arena where name recognition is everything (Costa et al., 2023; Dressler & Paunović, 2021).

The wine industry supply chain is marked by fragmentation and there is a distinct lack of transparency in the flowing processes. It is a complicated process that implicates many parties. This includes grape growers, co-ops and individual winemakers, bottlers, marketing and distribution, import and export companies, retail, and of course producers and other regulators. At the source of the process, independent growers and vineyard hands tend to deliver their harvested grapes to co-operative bodies or commercial wineries. Such cooperatives pool resources to perform tasks such as production, storage and promoting sales of wine. There could be independent bottling plants, which are very common in circumstances where there are significant volume bulk wine transactions between wine producers. Distributors and wholesalers are critical to getting wines into the market, both at home and around the globe. For sales overseas, they often partner with specialized import companies (Galati et al., 2021; Waye et al., 2023; Heizer et al., 2024). Finally you have the retailers, which range from specialist wine stores to big supermarkets and digital sales platforms, where the consumer connects to the system. In addition, certifying agencies (i.e., DOC/DOCG system in Italy, INAO in France) regulate standards and supervise the labeling of goods (Heizer et al, 2024).

This multilayered system does not work as one entity and is fragmented as each individual organization runs with their own systems, processes and priorities. Smaller producers might rely on handwritten ledgers or Excel spreadsheets; large ones use sophisticated enterprise software. This lack of standardization and alignment results in an operational black box when it comes to the tracking of an individual wine bottle throughout its supply chain. For instance, if grapes from various producers are combined into the product of a co-op, or if bulk wine is transported across borders for bottling, the origin and handling,

as well as production details, can become murky and documentation inadequate (Galati et al., 2021; Costa et al., 2023).

This complexity often results in differences in documentation, manual work and reduced data transfer. Harvest records, for example, may not match bottling reports; temperature logs for storage or transport could be incomplete or go missing; and sales data might not find its way back to producers for use in planning production. In the absence of fully integrated logistics and traceability systems, preserving the quality of storage becomes difficult, especially so for temperature-sensitive wines such as sparkling or top-end reds (Waye et al., 2023; Heizer et al., 2024; Sabbagh et al., 2024). Breaking the cold chain during transportation can lead to premature aging or wine spoilage, with significant loss of product. Compliance with both national and international law regarding geographic origin, labeling, health and safety, taxation among many others is made more difficult without centralized or automated systems (Heizer et al., 2024).

There are other dangers as well, based on logistical failures. An imperfect cold chain, for example, can compromise a wine, especially when it is transported to hot or tropical regions. Inaccurate or incomplete export documentation can lead to customs congestion, causing delivery delays, higher storage fees, and penalties. Manual paper-based processes also increase the possibility for human error, including things like mislabeling, filing documents incorrectly, or loss of compliance data. These inefficiencies not only adversely impact product quality, but also increase operating expenses up and down the supply chain (Galati et al., 2021; Waye et al., 2023; Heizer et al., 2024).

### *2.2.5 Digital Innovation and Smart Technologies in the Wine Sector*

The agri-food sector is undergoing a rapid transformation driven by digital technologies. Digital innovation can enhance the efficiency of operations and functionality of applications and serve as a radical change accelerator to completely reshape production, processing, and consumption (Vahdanjoo et al., 2025). The wine sector is starting to deploy advanced technologies for its operations in order to respond to the increasing requests from stakeholders in terms of sustainability, efficiency, and traceability. These technologies help producers maximize operations, increase transparency, and provide greater value to consumers. They are frequently applied across different stages of the value chain.

In viticulture and production, IoT sensors and AI models are increasingly used to monitor vineyard conditions, optimize irrigation, and improve grape quality, thereby enhancing efficiency and sustainability (Dressler & Paunović, 2021; Costa et al., 2023). In logistics and supply chain management, blockchain and ERP systems support traceability, fraud prevention, and regulatory compliance, reducing operational risks and increasing consumer trust (Galati et al., 2021; Sabbagh et al., 2024). At the marketing and sales stage, digital storytelling, e-commerce, and CRM systems allow wineries to reach new markets, connect directly with consumers, and personalize offerings, particularly in export-driven or wine tourism contexts (Mola & Roffia, 2024; Costa et al., 2023).

Blockchain is a distributed ledger technology that allows secure recording of transactions across participants in a network in a manner that is independent of any central authority. Every validated transaction is recorded in such a block, which is linked with previous blocks in a time-series manner, hence creating an unhackable chain (Liu & Li, 2020; Nakamoto, 2008). The system is based on a consensus protocol; all network nodes, including observers, have to verify a new block added in the chain, which guarantees that all the participants agree about the transparency and trust among them (Giannini, Iacobucci, & Orci, 2025; Sabbagh et al., 2024). Apart from its origins in the crypto world, blockchain has been acknowledged as a game-changer in many sectors, agri-food and wine included, given its potential to improve traceability, enhance data security, and mitigate information asymmetry in complex supply chains (Sabbagh et al. 2024; Galati et al., 2024). In addition, the combination of blockchain with co-technologies like the Internet of Things (IoT), artificial intelligence and smart devices, broadens its scope of action to automated transactions and the real-time tracking of the product, in every phases of the supply chain (Giannini, Iacobucci, & Orci, 2025). As a result, blockchain has been touted as a potential solution to the challenges of authenticity, provenance, and transparency, especially in sectors most prone to fraud, such as the international wine business.

Sabbagh and his colleagues' (2024) work shows how blockchain-based applications enable wineries to keep unchangeable records regarding important information about the grape origin, wine-making techniques used, and product movements along the supply chain for rigorous product supervision. This is particularly important in premium wines,

where the origin plays a paramount role in the brand and consumers' willingness to pay. Consortia and certification entities are also utilizing blockchain solutions to ensure compliance with protected designation of origin (PDO) standards (Galati et al., 2024). Some case studies in Italy, and in Piedmont as well, show how both small and medium wineries have concretely used blockchain to distinguish themselves in the market, fight fraud as well, and access export opportunities. For instance, one study showcased three Italian wineries that had teamed up with technology partners to deploy blockchain labels that, augmented with QR codes, will enable end-users to track the entire production life cycle from grape to glass (Silvestri et al., 2023). This not only facilitates transparency but also offers a competitive edge in a global context and in areas where counterfeiting is a growing concern. In addition, blockchain implementation has been particularly successful in collaborative ecosystems. Having limited internal digital expertise, SMEs participate in strategic partnerships with technology providers, consortia, or regional certification entities for the possible deployment of blockchain solutions at a reduced cost level (Galati et al., 2024). These partnerships contribute to overcoming resource limitations and reinforce trust and legitimacy with consumers and stakeholders. But overall, the blockchain maturity is still very uneven across the industry. The adoption is generally stronger in the wineries of markets having a high level of institutional support or being part of innovation-driven clusters (Sabbagh et al., 2024). As suggested by digital maturity models (Kane et al., 2017), organizations in the "developing" or "emerging" stages of digital maturity often require external facilitation, training, and gradual onboarding to fully benefit from blockchain technologies. This is particularly relevant for wine SMEs, which frequently lack the absorptive capacity to manage end-to-end digital infrastructure independently.

The use of Internet of Things (IoT) devices such as sensors, drones, and automatic monitoring tools is a must for smart viticulture. Such tools allow real-time monitoring of critical crop environmental variables, such as humidity, temperature, soil types, vine health, and consequently better agricultural and sustainability practices (Dressler & Paunovic, 2021). IoT systems facilitate predictive interventions, such as adjusting irrigation or anticipating pest outbreaks, which help wineries reduce resource usage while improving grape quality (Dressler & Paunović, 2021; Costa et al., 2023). Along with environmental monitoring, the IoT can also enable tracking the goods as they are moved

along the supply chain. For instance, the new generation of radio frequency ID (RFID) tags and GPS-enabled transport management systems provide up-to-the-minute, real-world information on the status of wine in distribution. These characteristics are useful in logistics management and help prevent spoilage and possible mishandling of the products, especially when being exported to other markets (Galati et al., 2021; Sabbagh et al., 2024). Moreover, the incorporation of smart sensors help in monitoring phenological stages, harvest timing, or in identifying plant growth or pest anomalies (Galati et al., 2024). For instance, the association of drones and infrared sensors is more and more deployed in the canopy analysis in order to apply specific treatments and in order to assure the low environmental impact (Silvestri et al., 2023). However, the adoption of IoT by SMEs is still low because of high initial costs, low technological capabilities, and hardware and software integration complexities (Costa et al., 2023). Small wineries typically do not have the IT assets to process real-time data streams nor the analytics to turn sensor data into decision-ready information. This digital gap highlights the importance of partnerships with external service providers, precision agriculture platforms, or cooperatives that offer shared IoT solutions to reduce the technological and financial burden. On a digital maturity scale, the implementation of IoT tends to start at the lowest operational level, where we may observe simple weather monitoring, but becomes more strategic by use cases such as AI-powered vineyard management and blockchain-based environmental compliance (Festa et al., 2024). For most SMEs, this advancement is slow and is rooted in aspects such as availability of funding, farmer perceptions, and institutional encouragement (Costa et al., 2023; Waye et al., 2023). In the end, IoT not only helps wineries become more sustainable and produce a better product, but increasingly becomes an essential component in realizing transparency in products' data and in consumer trust. And with environmental credentials increasingly being provided via certification or carbon labeling, there's a strong chance that IoT data could be an essential element in helping companies respond to regulatory and market pressures for accountability (Sabbagh et al., 2024; Galati et al., 2021).

AI and big data analytics are also starting to be incorporated more and more into winery activity. AI is applied in many aspects: From the prediction of harvest yields based on weather data, through the analysis of customer preferences for targeted marketing, to the optimization of pricing strategy across channels. Big data systems are able to gather data

from many disparate sources, social media, e-commerce platforms, weather systems, and ERP systems, and they transform this data into actionable information for winery managers (Festa et al., 2024; Dressler & Paunović, 2021; Costa et al., 2023). In viticulture, AI-powered forecasting models are used to simulate optimal harvest windows and predict disease outbreaks by correlating historical climate data with real-time vineyard conditions (Dressler & Paunovic, 2021). These models inform agronomic management and enable wineries to make proactive decisions, reduce risks, and improve final grape quality (Dressler & Paunović, 2021; Festa et al., 2024). In winemaking, AI-powered systems help to monitor fermentation, controlling temperature and time to achieve greater consistency while reducing waste, an important feature for SMEs with limited lab resources (Costa et al., 2023). On the market side, wineries use AI to analyze customer data from digital channels, so that they can make more targeted marketing efforts and have better customer segmentation. For instance, machine learning can find patterns in internet behavior, like which types of wine appeal to which demographics, allowing for better ad targeting and a stronger D2C (Direct-to-Consumer) strategy (Mola & Roffia, 2024; Galati et al., 2021). AI contributes to dynamic pricing models as well, aiding wineries with altering online pricing through demand, inventory, and competitor benchmarks in real-time (Festa et al., 2024). However, the acceptance of AI and big data analytics in the wine industry is not homogeneous yet, specifically in small and medium wine businesses. Many small wineries do not have the internal data infrastructure and expertise needed to undertake advanced analytics (Costa et al., 2023). Wineries often rely on third-party providers, or in some cases, digital marketing agencies, to access AI, reflecting a broader pattern of outsourced digital specialization common in SME ecosystems. AI adoption typically corresponds with the advanced stages of digital maturity, where firms are no longer simply digitizing operations but are actively using data to drive strategy and innovation (Kane et al., 2017). For SMEs, such evolution is typically an incremental adoption process beginning with rudimentary monitoring tools located in CRM and ERP systems, and leading to more independent systems that deliver prescriptive insights. Critically, AI and big data are not just tools to be more efficient, they are strategic assets to be a source of competitive advantage. Wineries that leverage these technologies are more adapt at being able to predict consumer trends, better manage production volumes to reflect real-time demand, and be readily able to adapt to changing

marketplace conditions. Such strategic flexibility is ever more important in a global wine market filled with saturated competition, changing consumption patterns, and the rise of digital markets (Festa et al., 2024; Galati et al., 2024). For example, product customization based on data and dynamic management of the portfolio of wines can mean the difference for small wineries trying to survive next to large, well-funded producers. Plus, data and AI capabilities are transforming into a must-have for regulatory compliance, environmental certifications, and transparency in sustainability reporting, elements that are increasingly important in both local and international wine markets. As ESG (Environmental, Social and Governance) standards become more stringent, particularly in European markets, wineries will be expected to provide traceable, verifiable data regarding the input of resources, emissions, and ethical supply chain (Waye et al., 2023). AI-powered reporting tools are doing so. Such tools help to automate and facilitate these processes, reducing the paperwork and data entry burden on SMEs, whilst improving the quality and credibility of the data (Festa et al., 2024; Costa et al., 2023). In this light, AI-fueled decision-making becomes a central capability for digitally resilient wineries, which is to say, wineries that can withstand market, regulatory, and environmental whiplash through data-driven strategies (Waye et al., 2023; Dressler & Paunović, 2021). These capabilities also enable greater involvement in digital innovation ecosystems in which wineries partner with tech and research firms and export agencies to co-innovate new products, channels, and services (Galati et al., 2021; Sabbagh et al., 2024).

CRM systems manage the relationship with the digital clients. Wineries are trying to manage on a daily basis an increasing number of consumers who are digital consumers. Such tools facilitate customer segmentation, automated communications, individualized campaigns, and the setup of loyalty programs targeted at different customer types. In the context of post-COVID-19 world, when physical channels (like on-site tastings, visits to the cellar doors and the horeca distribution) experienced a substantial disruption, CRM tools become essential in maintaining the same level of intimacy with customers and of engagement with the brand when there was no direct interaction (Mola & Roffia, 2024). For SMEs, CRM solutions provide an affordable, scalable means to compete with larger manufacturers by providing a high level of customization, something which today's consumers increasingly demand. Customer purchase records, website browsing

behavior, interaction through email, and social media can be leveraged across CRM platforms to develop accurate profiles of consumers that can aid in informing targeted communications and product recommendations (Galati et al., 2024). It enables the expansion of D2C channels that have become critical to many wineries' business models due to the prevalence of e-commerce and the weakening of tourism-based sales. Additionally, by using a CRM platform, small teams can automate workflows that will alleviate the workload of day-to-day operations. Wineries, for instance, can send out promotional emails timed with seasonal releases or automatically remind customers to renew their wine club memberships. These small efficiencies are part of the digital capability, leading to better engagement with customers, and SMEs can now craft customer engagement strategies that are sustainable without the need for a large marketing department and huge technology infrastructure (Mola & Roffia, 2024; Dressler & Paunović, 2021). Further out on the CRM spectrum, CRM systems also enable wineries to log and store essential customer data that can inform demand predictions, new product development, and brand building (Galati et al., 2021; Festa et al., 2024). With data protection regulations (like GDPR) becoming more convoluted, professionally managed CRM solutions are also in accordance with data protection requirements that are essential for fostering trust in online transactions (Costa et al., 2023; Waye et al., 2023). In the end, CRM platforms are more than a mere marketing tool, they are a digital asset that empowers wineries to establish ongoing, data-rich relationships with consumers. When integrated with e-commerce platforms and ERP systems, CRM becomes a cornerstone of customer-centric digital transformation, particularly for SMEs aiming to grow their direct sales while maintaining brand authenticity and intimacy (Galati et al., 2021; Mola & Roffia, 2024).

Enterprise Resource Planning (ERP) and cloud-based platforms support internal integration across different functions such as inventory management, procurement, and production planning. These applications essentially allow wineries to minimize redundancy, simplify their business operation, and gain a clear, up-to-date overview of the gains and losses, while they can streamline their own workflow management and assign the right resources. ERP systems, for instance, can connect vineyard output predictions to bottling and procurement schedules, providing for better coordination between the agricultural and manufacturing parts of the business (Festa et al., 2024;

Galati et al., 2021). Cloud-based ERP solutions are particularly attractive for SMEs, as they provide scalability and cost-effective access to resources without the need for high upfront investment, while also enabling remote collaboration and integration with other digital tools such as CRM and IoT systems (Costa et al., 2023; Dressler & Paunović, 2021). Smaller and mid-sized wineries benefit from ERP systems, where data consistency, tight control over inventories or traceability, ability to meet safety standards and traceability (especially in managing several product lines of export markets) are particularly important. The current advantages presented by cloud-based ERP solutions (scalability, elasticity, cost-effective access to resources without requiring the initial high investment in IT) render such solutions more and more attractive for SMEs (Galati et al., 2024). They are the platform for remote access and teamwork, essential during the COVID-19 pandemic when much of business and administrative tasks were done remotely. Additionally, the integration of cloud-based ERP systems with other digital tools, such as CRM, e-commerce platforms, and IoT sensors, enables a more holistic digital architecture, where data flows seamlessly across different business units. This interconnectedness supports real-time decision-making, reduces manual entry errors, and enables wineries to react more swiftly to fluctuations in demand, raw material availability, or logistics disruptions (Costa et al., 2023). But implementation of an ERP system could be a complex process for SMEs in the wine industry, which may find difficulty in achieving process standardization and meeting the change management requirements. Most firms in the wine industry are indeed used to work on legacy platforms and informal processes, at the same time referring to the adoption of a fully integrated ERP kind of model, help from external sources, training and a re-thinking on the internal activities were required by our participants (Mola & Roffia, 2024). In this case, strategic collaborations with ERP suppliers or involvement in local digitalization projects can be a timely relief (Waye et al., 2023; Galati et al., 2021). At the end of the day, ERP and cloud systems provide one of the fundamental building blocks for operational digital transformation, providing wineries with the structure required to professionalize internal management, automate tasks and processes, bring as much transparency as possible into daily operations, and facilitate scaling in the long run (Costa et al., 2023; Festa et al., 2024). Their deployment represents a crucial step along the road to full digital maturity,

particularly when combined with outward-facing tools such as CRM and e-commerce platforms (Mola & Roffia, 2024; Dressler & Paunović, 2021).

Taken together, these technologies are reconfiguring how winemaking is linked to nature, to markets and to consumers. Their uptake depends on winery size, digital maturity and resource base, yet there is evidence that even small wineries can make substantial gains when digital technology is adopted strategically and in conjunction with other partners (Costa et al., 2023; Galati et al., 2021).

### *2.2.6 Barriers to Digital Adoption for Wine SMEs*

Although digital technologies and their disruption potential in the wine business are becoming an issue of interest, SMEs encounter various barriers that hinder their extensive engagement with and uptake of digital tools. These barriers can be classified as internal (organizational) and external (contextual and institutional) barriers.

One of the greatest barriers to their success is their decades-old technological infrastructure. These SMEs frequently suffer from having to use the older systems, which stand for operational rigidity and restrain the fluid assimilation of the new digital tools. Processing that legacy, and generally outdated systems, must often be renewed to effectively shape digital innovation, and this often causes technological resistance, which delays efforts for change (Costa et al., 2023).

Among the most cited internal barriers is a lack of financial resources. SMEs generally work on small margins with a very low budget to spend on digital infrastructure and hiring specialized resources (Galati et al., 2024). Although some enablers, such as CRM solutions or cloud-based tools, are becoming cheaper, costs and other barriers remain high, especially for blockchain systems, IoT devices, or data analysis tools (Silvestri et al., 2023). A 2023 study by Galati et al. showed that only 27% of wine SMEs in Italy adopted a cloud-based ERP, and only 11% used blockchain for traceability. The financial structure of many wine SMEs exacerbates this challenge. Given the long production cycles (e.g., one to three years from vineyard to market), cash flow in wineries is often seasonal and delayed, making it harder to absorb large capital expenditures (Festa et al., 2024). In addition, ROI for digital technologies tends to be more intangible in the short term, specifically for solutions that cater to traceability, compliance, or outward brand building. This, in turn, tends to discourage decision-makers from diverting revenue

from core operations, especially in uncertain times, such as dealing with the aftermath of COVID or dealing with climate-related disruptions. In others, wineries have certainly raised alarm bells regarding 'hidden' costs such as the costs to integrate, to train staff, to upgrade systems, and to introduce cybersecurity measures (Costa et al., 2023). These extra expenses are rarely considered when calculating the initial investments, yet they are prone to have significant implications for implementation success and sustainability. Even where public funding instruments and EU-level instruments (EPNE, NextGenEU) seek to lower financial barriers, access to them may be uneven. Several SMEs are not aware of these and do not have the administrative capacity to navigate application bureaucracy or match projects to eligibility criteria (Waye et al., 2023). This contributes to a digital divide within countries such as Italy, where bigger cooperatives and consortia have the knowledge to exploit public support while smaller, family-run factories do not. Consequently, many SMEs opt for cheaper entry-level tools and tend to defer larger investments until greater digital capacity and clarity are achieved (Galati et al., 2024). For example, the European Court of Auditors (2022) reported that only 13% of agri-food SMEs managed to access digital innovation funding from the Horizon 2020, referring to cumbersome procedures and mismatching eligibility criteria.

A low absorptive capacity represents another barrier. This capability refers to an organization's ability to identify, to comprehend and to utilize external knowledge. Regarding the latter, it is well-known that SMEs have to cope with the absence of both internal systems (system and personal skills) that would permit them to extract the most from tech developments (Omowole et al., 2024; Sabbagh et al., 2024). By failing to have a competent digital workforce, companies are forced to scale back their capability to use, adapt, and innovate with new technologies. In addition, less external interaction with sources of new knowledge - e.g., cooperating with academia or technology suppliers – deceases the opportunities for learning which are essential to build an agile capability and sustain innovation (Costa et al., 2023; Sabbagh et al., 2024).

Another important obstacle to the uptake of digital in wine SMEs is the absence of digital skills and internal capabilities. The lack of technical skills required to evaluate, deploy, and operate new digital systems, especially by small winery employers and employees, can be overwhelming (Costa et al., 2023). This is further exacerbated by the fact that wine SMEs are typically found in rural communities where access to proficient IT skills and

digital training facilities is limited (Waye et al., 2023). The digital literacy divide in the wine industry is not limited to core ICT skills. These include the absence of strategic digital thinking, the inability to adequately interpret data, the lack of awareness of cybersecurity, and the lack of successful system integration; all essentials for achieving success in digital transformation. According to Festa et al. (2024), the problem is not one of learning how to use a particular platform, but of developing firm-wide fluency in how digital tools can enable business models, customer relationships, and operational robustness. At a majority of family-owned wineries, decision-making is concentrated, and management might be insulated from digital technology and new business developments. This can create reluctance or doubt in investing in the digital transition, particularly when results are not a priori evident or when legacy analog systems are still "working well enough" (Dressler & Paunovic, 2021). The result is that digital projects often go on the back burner or are rolled out without a cohesive long-term vision. This is also compounded by a dearth of internal expertise, which usually pairs poorly with assessing the quality and appropriateness of digital service providers, exposing wineries to the risk of spending badly or failing when implementing digital solutions (Silvestri et al., 2023). This results in disappointed users and an even stronger aversion against new technology. Some SMEs seek to address this deficit by engaging consultants or outsourcing essential functions, such as digital marketing and CRM management. However, this approach renders them vulnerable to the influence of external entities and hinders the development of internal expertise. There are some wineries that are participating in regional innovation hubs or are members of a wine cooperative within a wine cluster where they have access to digital skills workshops, demo labs, and a hub where members can connect with experts (Waye et al., 2023). However, the kind of ecosystems that exist are not evenly distributed, and the establishment of those is successful depending on the local institutions' support (Galati et al., 2024). The digital skills gap is fundamentally not a technology challenge, it's a strategic and cultural one that demands sustained investment in human capital, leadership capability, and digital mindset. Unless purposeful interventions are applied both within firms and in terms of policy setting, this barrier is likely to remain as a drag on and perpetuate further the pre-existing digital maturity gap in the wine sector.

Cultural resistance to change is also a barrier to digital adoption in wine SMEs, especially for wine SMEs with deep craft traditions and ownership structures in the hands of long-established families. Traditional practices are generally considered to be authentic and offer a competitive advantage, and they may create a conservative firm culture where innovation is met with either skepticism or resistance (Waye et al., 2023). That clash between maintaining heritage and adapting to change is even stronger in places like Piedmont, Bordeaux and Tuscany, where cultural identity is so bound up with production methods and regional storytelling. UNESCO recognition of the Langhe-Roero and Monferrato winegrowing areas in Piedmont as a cultural landscape reflects this region's commitment to traditional viticulture techniques as being representations not only of production technologies, but also of local territorial identity (UNESCO, 2014; Galati et al., 2024). The transformation of the Chianti Classico region in Tuscany provides an example of how traditional "mezzadria" (sharecropping) farming and artisanal winemaking have created a long-lived absorbent structure that is not open to external technological changes. In Bordeaux, meanwhile, the long-standing concept of terroir, centered on the relationship between soil, climate, and human intervention, has frequently created an atmosphere where new technologies that could threaten traditional understanding can also struggle to find acceptance (Trubek, 2008). Such places make more than wine, they make tales and identities and national totems. Hence, digital transformation might be experienced not only as a technical process but as the danger of losing cultural continuity. Such resistance is often generational, with older owners and senior managers (some of whom have overseen decades of stability) less likely to embrace digital strategies particularly if they do not see the value or the payback is longer term (Costa et al., 2023). In these instances, innovation is occasionally seen as risk to the tradition of product, a threat to the 'handmadeness' or 'craft' narrative that forms the basis of brand value within the specialist wine category (Festa et al., 2024). And cultural resistance doesn't even stop at the top. Sometimes long-tenured employees resist learning new systems if they'll require changes in workflow, new skills or shifts in organizational responsibilities. This results in technological advancement outpacing organizational preparedness, a background referred to as "organizational inertia" in literature on digital transformation (Hess et al., 2016). A second source of resistance concerns the fear of depersonalization. Customer relationships are very personal and

community-oriented to many wineries. The thought of substituting in-person interaction for an automated CRM journey or virtual tastings can seem antithetical to the values of hospitality, connection, and artisanal craft. Consequently, while some SME owners may resist digital options because they do not have access to or understanding of these tools, others may decline to embrace them, fearing a distraction from the nature of the firm. Nevertheless, the literature reported that cultural resistance can be lessened when younger generations, who have not been socialized to external attitudes and considerations, are involved in the family and when exposed to examples of peer success from their region or network (Galati et al., 2024).

In addition to the more aggregated form of support previously mentioned, collective platforms, innovation centers, and training programs taking into account the cultural profile of wineries (and not only the technological gap) are more successful in promoting digital technology transfer. In that sense, cultural resistance is not something that should be approached as lack of openness, but a longing for a narrative alignment: a desire to frame digital transformation not as a break away from tradition but rather as a mean to protect, promote and scale artisanal value in the global market.

For wine SMEs, the barriers are amplified by the absence of a digital strategy or roadmap. In many small wineries, digital transformation is approached not as a structured, long-term initiative but as a reactive or ad hoc process, often triggered by specific crises (such as the COVID-19 pandemic) or external pressures like new compliance requirements (Costa et al., 2023; Galati et al., 2024). This lack of strategic planning cedes coherence, consistency of approach, cut-and-paste directives disguised as policy in ad hoc efforts that rarely scale or get integrated. Indeed, many SMEs find themselves unable to articulate what the strategic rationale for their digital adoption is going to be: is it going to enhance customer engagement, improve visibility of a company's supply chain, make a business more efficient, or all of the above – or are they mere goals on a checklist to meet the requirement for sustainability? Without such clarity, the decision about which tools to adopt, where to invest resources, or what competencies to develop becomes tactical and reactive as opposed to intentional and attendant to the broader business objectives (Festa et al., 2024). This results in what we might call "pilot project fatigue," where wineries test a digital tool only to then leave it unused because it's not integrated with internal workflows, wasn't adopted by staff, or cannot be shown to have an impact.

Adding to the problem is the lack of digital measurements of performance. Unlike corporations with their analytics dashboards and KPIs, SMEs generally lack mechanisms to assess the degree to which digital efforts are adding value or improving operational results (Waye et al., 2023). The lack of digital KPIs (eg, time-to-market reductions, digital-channel conversion rates, predictive maintenance savings) is making it difficult to argue for investments and leaves it open to interpretation what constitutes success (Kane et al, 2017; Dressler, Paunovic, 2021). And so, projects can become ineffective not so much in terms of the technology failing to deliver, but because there is no systematic process in place to measure their impact or to adjust to feedback. This absence of strategy also impairs organizational commitment. When the end is not clear to staff and leadership, resistance to change goes up, and implementation becomes a matter of who is enthusiastic rather than what we do as an institution. Without leadership endorsement and digital literacy at the strategic level, there is the risk that the deployment of well-designed tools does not percolate through the organization (Hess et al., 2016). Furthermore, concerns around cybersecurity: data breaches, system hacking, and GDPR non-compliance deter some SMEs from utilizing cloud or blockchain-based platforms (Sabbagh et al., 2024; Waye et al., 2023). Several studies highlight the significance of the road mapping and staged implementation models in the small and medium-sized enterprises (SMEs) context for digital transformation. These might be determining what 'digital ready' means, establishing stages of digital enablement, and matching tools to actual business needs (Kane et al., 2017). This gap is partially filled by some of the SMEs, which work in association with digital consortia or wine tech associations, who offer digital transformation guides, peer-to-peer case studies, and tools to plan projects (Galati et al., 2024).

Externally, the lack of digital infrastructure (especially in rural and semi-rural wine-making regions) is one of the main obstacles in the digital transformation of the wine industry. The insufficient broadband availability, poor quality of existing connectivity, and lack of local support networks hamper the introduction and efficient functioning of numerous data-heavy technologies (e.g., IoT, AI, cloud-based ERP systems) into these territories (Dressler & Paunovic, 2021). These limitations are especially problematic for real-time applications like smart viticulture, where sensor networks and drones depend on stable, high-speed internet for data transmission and remote monitoring. This rural-

urban digital divide is not only a technology gap, but it is also a structural barrier to the economic competitiveness and innovation. Wineries located in peripheral or mountainous areas often find themselves excluded from digital transformation initiatives simply because the physical infrastructure to support connectivity is either weak or nonexistent. As of 2022, in Italy, only 58% of rural areas were covered by broadband speeds higher than 100 Mbps (far from the target of 100% set by the EU), hampering the deployment of advanced digital services (ISTAT, 2022). As Waye et al. (2023) observe, this infrastructural gap leads to a two speed economy in the wine sector, with the companies in areas that are better connected (e.g., near urban innovation hubs) being able to adopt and scale-up digital tools, while others are increasingly digitally excluded. Network connections, though found in some villages and towns, are often unreliable or too slow to support cloud computing services, access to ERP systems from remote locations, or live data streams from IoT devices (Costa et al., 2023). This leaves some SMEs to use older, siloed systems that reduce the overall levels of interoperability and real-time coordination that digital tools are expected to support. Additionally, the unavailability of local tech support ecosystems in rural areas results in longer times and higher costs for SMEs to troubleshoot digital systems, train staff, or adapt software for their individual contexts. This risk can result in low government adoption of digital tools or filtration of digital efforts due to the presence of continued technical barriers (Festa et al., 2024).

Several EU and national policies, such as Italy's *"Piano Nazionale di Ripresa e Resilienza (PNRR)"* and broader initiatives under *NextGenerationEU*, aim to address this issue by expanding broadband coverage and promoting digital inclusion. However, implementation is uneven across regions, and many SMEs are still unaware of or unable to access these programs (European Commission, 2021b). Ultimately, the lack of robust digital infrastructure limits the scalability and effectiveness of digital transformation, reinforcing geographic inequalities within the wine sector. Addressing this barrier is essential not only for improving operational performance at the firm level but also for ensuring equitable access to innovation across rural economies.

Regulations are also another key driving force for digital transformation in the wine industry. Wine SMEs have to face a complex and often fragmented kaleidoscope of local, national, and international rules concerning food safety, traceability, labelling of products, environmental requirements, and, with an increasing insistence, privacy and data

protection. Increasing EU-wide sustainability requirements, like those related to the Farm to Fork Strategy, also push wineries to track and submit accurate environmental information. This has led to growing interest in digital tools related to recording carbon (conventional or multiple); tracking carbon, sustainable sourcing, or smart use of resources, but these types of systems may be rigid and costly to implement (European Commission, 2020;Festa et al., 2024). The associated legal complexity, for those firms trying to digitalize, is a serious impediment, where new technologies may raise legal uncertainties, or burdens of compliance (Sabbagh et al., 2024). This is especially true when it comes to the use of blockchain and the cloud, which, in turn, give rise to concerns around data sovereignty, interoperability and certification standards. For instance, service companies' tech firms that maintain and process data as part of blockchain platforms that are employed to trace wine, may see that their data is stored/processed in another country and become concerned about funds and/or compliance with their equivalent law to the General Data Protection Regulation (GDPR) in the EU or equivalent in export markets (Galati et al., 2024). Due to the resource implications of small businesses who lack in-house IT and legal expertise in assessing and mitigating risk, this risk may deter adoption of promising technologies completely. In addition, if manufacturers operate a cloud-based ERP or CRM platform, this could also raise questions about data residency, i.e. where in the world customer and production data is physically stored, and whether these systems comply with industry-specific audit and traceability requirements. For wineries governed by Protected Designation of Origin (PDO) or Protected Geographical Indication (PGI) schemes, if any digital system is implemented it needs to be compliant with the tight certification process that differs between regions but frequently includes legacy document protocols that still do not support digitalized formats (Waye et al., 2023). Another layer of complexity arises from export regulations. Wineries seeking to expand into non-EU markets must comply with foreign digital and labeling standards, which can differ significantly from those in their home country. Inconsistent regulations across jurisdictions create uncertainty, increase administrative burden, and limit the scalability of integrated traceability systems (Silvestri et al., 2023). Institutionally, programs and funding mechanisms to support digital innovation are often inaccessible or opaque. The processes are often too bureaucratic for many SMEs, and there may be a lack of legal or administrative capacity to adapt their activities to government program criteria (Costa et

al., 2023). This can create a gap between policy objectives and actual SME involvement, especially in more traditional sectors such as wine, where knowledge of digital tools is generally low, and day-to-day businesses are closely managed by small staff. Finally, regulatory impediments don't just postpone the embrace of digital's growing strategic value, they add to the perceived risk and complexity of innovation, particularly for small and midsize entities lacking in-house teams dedicated to compliance or legal functions. These barriers can be counteracted by improved policy coherence and more widely available advisory services, and a less complex regulatory environment that is better attuned to the capacity and needs of small wine producers.

Fragmentation in the wine supply chain and the lack of interoperability among digital systems represent significant barriers to effective digital transformation for SMEs. In contrast with those big vertically integrated corporations, the majority of wine SMEs are related to independent actors such as producers, cooperatives, logistics operators, distributors, and certification bodies whose digital maturity level and IT systems may vary and be non-interoperable (Galati et al., 2024; Festa et al., 2024). This fragmentation results in data silos and can make it challenging to facilitate end-to-end data flow across the value chain. Many SMEs lack standardized digital interfaces or application programming interfaces (APIs) that can communicate with external stakeholders' platforms. As a result, even when individual firms adopt ERP systems or traceability tools, they often face integration challenges that require manual data entry, reconciliation across platforms, or duplicate recordkeeping (Costa et al., 2023). This, of course, undermines the value of automation, is inefficient, and is error-prone, especially when dealing with complex processes such as certification office, inventory tracking, or export documentation. Moreover, these interoperability concerns undermine the utility of collaborative digital platforms, for instance, commercial blockchain consortia or digital export portals (Sabbagh et al., 2024), where seamless interfacing is a prerequisite to achieve efficiency and trust. For instance, a winery with a homegrown traceability system may not be able to interface with regional PDO certification systems and may hinder the exposure of their product data to institutional verifiers or downstream supply chain actors. Furthermore, lack of interoperability often forces SMEs to rely on workarounds, such as spreadsheets, email, or paper-based documents to bridge digital gaps. These practices not only increase transaction costs but also limit the winery's ability to scale operations or

participate in advanced digital ecosystems, such as predictive logistics or real-time market analytics, where interconnectivity is a prerequisite (Waye et al., 2023). Several studies underline the role of interoperable standards and shared infrastructure in facilitating SMEs engagement in digital innovation. For instance, Galati et al. (2021) point out that for regions where there is interoperability of solutions at a sectoral level (e.g. blockchain consortia or digital-certification hubs), SME digital participation and cross-actor collaboration are higher. However, such infrastructures are less developed in many of the traditional wine territories which are characterized by weak institutional coordination and where SMEs are typically left to get on with adopting ICT alone.

As previously discussed, even when financial support is available, navigating complex funding frameworks remains a challenge for wine SMEs. This constraint is compounded by limited public support and financing for digital transformation in the agri-food sector, reducing the ability of SMEs to innovate. Despite a handful of EU programs (e.g., NextGenerationEU, Horizon Europe, Common Agricultural Policy, CAP) meant to boost digital innovation and sustainability, in practice, small winegrowing businesses' accessibility to these resources is rather limited (Festa et al., 2024). Grant processes, technical requirements, and administrative hurdles are time-consuming and difficult for a small, family-run business to manage without the managerial bandwidth or legal knowledge to get through it all. According to Waye et al. (2023), most small wine growers do not know such funding opportunities, and those who know do not have enough capabilities to create competitive project proposals. For others, the complexity of post-grant reporting, technical documentation, or co-financing rules is a turn-off. As a result, available funding is often disproportionately captured by larger cooperatives, wine clusters, or technologically advanced firms that have dedicated staff for grant applications and digital project management. Furthermore, digital at the national level has often not been customized enough for the specific constraints associated with older industries, such as wine, where cultural components, craft processes, and levels of regional governance make a "single size fits all" approach less appealing. This disjunction between policy craft and street-level experiences continues to alienate the SMEs from playing any active role as users of public innovation programs (Costa et al., 2023). Wineries are often widely distributed across geography, and even if concentrated, may be in remote or mountainous areas where local advisory services or regional innovation hubs that assist with digital

transformation planning, partner matching, and funding application processes are not easily accessible. In such settings, SMEs have a double-edged disadvantage – the absence of digital infrastructure and a lack of resources to overcome it (Dressler & Paunovic, 2021). Although it is becoming more and more acknowledged at the EU policy level, the practical application is still inconsistent. End-point solutions such as Smart Villages, Digital Innovation Hubs, or EIP-AGRI provide promising templates for inclusion, yet the implementation of these across wine regions is uneven.

It is worth noting that barriers are significant, but the literature reflects different opinions. According to some studies, the democratization of digital tools, and especially the diffusion of Software-as-a-Service (SaaS) and mobile-friendly solutions, is progressively decreasing costs and entry barriers for SMEs (Mola & Roffia, 2024; Galati et al., 2024). Others argue that in the absence of systemic support, investment in human capital and long-term capability-building, digital innovation is likely to be restricted to larger, networked wineries that have access to infrastructure and institutions (Costa et al., 2023; Dressler & Paunovic, 2021). There are multifaceted obstacles to wine industry digital transformation deeply ingrained in organizational culture and environmental context. Although internal matters involve budget and technical limitations, external conditions are established to be considered by infrastructural, regulatory, and policy matters (Festa et al., 2024; Waye et al., 2023). And, fragmented broadband access, institutional coordination, and policy execution also render the sector's digital transition very uneven. High technology readiness in urbanized or technology-driven areas is contrasted by lower digital readiness often faced by SMEs in rural or heritage-driven areas, due to poor infrastructure, restricted local assistance, and the absence of national strategies adopted to their needs (European Commission, 2020; ISTAT, 2022). This fragmentation underscores the importance of cross-sectoral collaboration and strategic partnerships—both to combine the financial and technical resources needed and to foster shared learning, interoperable solutions, and access to digital ecosystems (Galati et al., 2024; Festa et al., 2024).

### *2.2.7 Strategic Partnerships and SME Resilience in the Wine Sector*

In response to the multifaceted barriers outlined in the previous section, strategic partnerships have emerged as a vital mechanism for SME wineries to access digital

capabilities, share resources, and foster innovation. These collaborations allow SMEs to overcome internal limitations, such as a lack of expertise, digital skills, or capital, while simultaneously building resilience against market disruptions and technological uncertainty (Galati et al., 2024; Festa et al., 2024).

Wineries are increasingly entering into "vertical" cooperation with tech start-ups, IT suppliers, and software developers to co-design digital tools that are specifically adapted to the sector's needs. Such partnerships are typically centered around precision agriculture, traceability systems, and real-time vineyard monitoring. Through collaborating with third parties, SMEs can make use of tailored digital solutions, like blockchain labels, IoT devices, or mobile dashboards, without the necessity to develop them as individual companies by themselves (Costa et al., 2023). These collaborations not only speed up the tech fuss of technology adoption, but also stimulate absorption and reduce technological risks of experimentation and system integration (Galati et al., 2024). For example, blockchain's provision of traceability typically entails multilateral collaboration between wineries, certification consortia, regional authorities, and tech companies. Sabbagh et al. (2024) discuss how Italian PDO-focused consortia have provided collective access to blockchain tools, which enable small actors to also comply with traceability standards and provide better brand protection. These multiple joint activities testify to the dependence on harmonized governance mechanisms to underpin transparency, trust, and fair access between participants; already important when combining SMEs with different resources and different degrees of digital readiness. It enables access to shared infrastructure and common digital frameworks, improving interoperability and lowering cost obstacles.

Apart from technological alliances, SME are participating in horizontal agreements of cooperation with other wineries, especially through wine clusters, cooperatives and export associations. These platforms facilitate digitally wrapped propositions such as, coordinated bargaining for digital services, co-investment in platforms, e.g. e-commerce or CRM systems, and use joint participation in public funds acquisitions. In territories such as Piedmont or Emilia-Romagna, they have been instrumental to lead small wineries in digitalization pathways and to develop shared competencies (Waye et al., 2023). Such associations assist SMEs to overcome the digital transformation by providing access to shared infrastructure, supporting training programs and organizing pilot projects

of tools such as ERPs, traceability systems, and e-commerce platforms (Waye et al., 2023; Galati et al., 2024). For example, PDO verification via blockchain has been piloted by Piedmont's Consorzio Barbera d'Asti e Vini del Monferrato, whereas Emilia-Romagna's cooperatives have also developed a range of vineyard-monitoring systems based on IoT, in cooperation with IT companies and spread throughout members' estates (Silvestri et al., 2023; Festa et al., 2024). Besides technical support, such cooperatives also serve as social and institutional anchors that can cultivate a sense of common identity and cultural continuity that can limit resistance to change, especially in the more traditional family-run businesses (Dressler & Paunovic, 2021). This is because, given their proximity to producers and understanding of local production dynamics, they are more effective in building trust and addressing adoption constraints when compared with external consultants. In addition, the cooperatives are also intermediaries for specific projects seeking public funding, supporting wineries to formulate and prepare project proposals in connection to EU programs (Costa et al., 2023). They allow to anchor digital transformation into existing governance systems, working through the translation of overarching strategies of digitalization into local, operational and culturally aware programmes in sectors where innovation needs to be intertwined with artisanal values and geographical originality (Galati et al., 2024). Intersectoral coopetition, such as that between wineries and logistics firms, tourism platforms or universities, can generate more generalized digital ecosystems of innovation that do not stop at sectoral boundaries. A few wineries have collaborated with academic research institutions and universities to trial innovative digital tools designed for use in the vineyard, for marketing , and to interact with customers. For example, joint efforts between wineries and institutions such as the University of Turin and Università Cattolica del Sacro Cuore have experimentally tested AI-based disease predictive weather forecast models and optimized irrigation management strategies (Galati et al., 2024; Festa et al., 2024). These models integrate vineyard-level IoT data with real-time meteorological inputs to anticipate mildew outbreaks or drought stress—reducing resource use and improving grape quality. Beyond agronomic innovation, academic partnerships are increasingly used to explore immersive and experiential technologies, such as virtual reality (VR) and augmented reality (AR), for wine tourism and branding. Several wineries in Tuscany and Trentino-Alto Adige have co-developed digital tasting experiences with regional tourism boards and design schools,

enabling consumers to participate in virtual cellar tours, immersive vineyard walks, and narrated tasting sessions via mobile apps or online platforms (Dressler & Paunovic, 2021; Mola & Roffia, 2024). These new technologies meet the demands of changing consumer behavior, particularly post-COVID, where remote experiences and digital storytelling both drive perceived realism and create stronger brand attachment. These networks help SMEs move beyond operational upgrades toward new digital business models and customer experiences.

Strategic alliances are also used as a governing instrument to ensure a coordinated deployment of digital innovation in fragmented supply chains. This is even more important in the case of SMEs developing in certification-intensive environments (PDO or PGI schemes), as standardization, legislation, and tracking validation can only be based on a shared effort of several players (Silvestri et al., 2023). Strong collaborations inspire trust, decrease information asymmetries, and drive incentive alignment throughout the value chain (Galati et al., 2024).

Lastly, collaboration may help to reduce the attendant risks of digital dependency by integrating wineries into regional or sectoral innovation systems, providing a supply of ongoing support, troubleshooting, and upskilling via collective mechanisms. Small and medium enterprises partnering in such collaboration, instead of overly depending on outside consultants and commercial vendors, tend to have higher ability and a strong focus on internal capability and long-term strategy addressing nature of technology management of transitioning (Festa et al., 2024).

Strategic partnerships are also evident in the growing use of digital wine marketplaces such as *Vivino, Tannico*, and *Wine Searcher*, which act not only as online sales platforms but as data-rich ecosystems that enhance wineries' visibility and consumer intelligence. These exchanges pool together thousands of wines, thus, the customer has the opportunity to directly purchase a variety of wines from producers, and notably small and medium-sized producers, without the high investment and the management of selling direct-to-customer (D2C) (Mola & Roffia, 2024). Digital marketplaces directly offer SMEs with limited resources instant access to features that include the e-commerce platform, the customer review process, and focused marketing tools. Most services also include real-time analytics that allow wineries to understand what consumers are doing, pricing trends, where demand lies geographically, and

compare where they rank competitively (Festa et al., 2024). Wineries can thus customize the products they offer, optimize promotions, and also benchmark performance, even in markets where they they lack a physical presence. In Italy, collaborations with platforms such as *Tannico* have been particularly useful for wineries left reeling after the collapse of the COVID-19-hit horeca and tourism channels. *Tannico*'s business model includes the distribution of the products and B2C sales but is enriched by the strong logistic support and by its possibilities to support the storytelling of the wineries and at the same time to propose video content, ratings, sommelier notes on the labels, and so forth— one of the main added values of on-line retail if compared to traditional one (Mola & Roffia, 2024). In contrast, *Vivino* is a global operator that connects winemakers with consumers through algorithmic exposure (in terms of consumer reviews) and tailored consumer recommendations, resulting in increased reach (scale) and relevance in competitive markets (Galati et al., 2024). But these alliances don't come without any risks. This is the platform-dependent, loss of direct customer touch point, digital noise for truly small businesses. Apart from risks associated with the platform, some partnerships in the wine sector have struggled due to lack of sustained alignment, trust breakdowns, or unclear benefit-sharing mechanisms.

Dressler & Paunovic (2021) observe that in several cases, cooperatives and digital consortia have not been taken to scale, or have collapsed after pilot phases, owing to changes in leadership, without performance measures, and with disputes over data ownership. Similarly, Galati et al. (2021) identified examples of poor integration planning and of financial and impact expectations between SMEs and tech providers that led to digital collaborations failing to materialize. These examples illustrate that digital partnerships are about far more than funding or infrastructure; they're about long-term investment, adaptive governance, and cultural fit. Without this, promising efforts can be isolated experiments, or worse still, spawn resistance to future innovation attempts. It may be hard for producers (Dressler & Paunovic 2021) to distinguish their products, to keep the price level high on a platform with its algorithm ranking and discount showrooming, oriented visibility. But for wineries without the means to build out entirely owned, full-fledged e-commerce capabilities, or implement advanced CRM, they're also a more scalable onramp into D2C commerce and a rich stream of consumer data. Together with brand positioning and a selective use of platforms, they provide an opportunity to

strengthen the resilience, marketing agility, and internationalization for SMEs in the wine industry. Export-facilitating alliances also increase the strategic and operational resilience of wine SMEs responding to increasingly complex global markets. Small and medium wineries, which usually do not possess export departments or the logistical expertise, frequently contract with freight forwarders, customs brokers, and import agents providing not just transportation, but the use of digitally enabled compliance and monitoring tools (Galati et al., 2024; Silvestri et al., 2023). Such collaborations can cover off digital tracking systems, cold chain validation, and automated customs clearance portals that will facilitate on-time delivery of the wine, the integrity of the wine in transit, and eliminate much of the headache traditionally faced by those in cross-border trade. Such as partnerships with companies like DHL Wine & Spirits or Italian wine exporters Prolog or Italwine Logistics provide SMEs with IoT-powered shipment tracking, blockchain-enabled exporting documents, and connected interfaces with destination market customs (Festa et al., 2024). These kinds of consortia are especially useful for SMEs looking to break or penetrate non-EU markets, where differences in regulation, documentation requirements, and traceability demands may be as intimidating as overcoming schist. Through working with organisations that own 'global networks and compliance systems', wineries can help 'to mitigate the risk of customs hold ups, creates a more efficient and quicker supply chain, reduce risk from rejected shipments and even costly fines' particularly in susceptible markets such as China as well as U.S. and Japan (Dressler & Paunovic, 2021).

Beyond the aspect of traceability and product integrity, such collaborations generally also offer market intelligence dashboards that help SMEs to better understand demand patterns abroad, pricing benchmarks, and consumer trends, which are key information for planning internationalization strategies (Mola & Roffia, 2024). Export middlemen, for instance, might be delivering quarterly analytics on SKU performance, competitor placement, and market entry points, resources typically out of reach for resource-constrained SMEs. These export-related partnerships are becoming more digitally enabled, using cloud-based logistics platforms, automated compliance applications (e.g., the EU's GI regulations and FDA wine imports), and shared dashboards that provide greater visibility, efficiency, and coordination along the supply chain (Galati et al., 2024). They allow small wineries to engage more quickly and less riskily in international markets

and so support both short-term agility and long-term strategic expansion ability. Export-promoting partnerships are not risk-free, despite the indirect approach. In some of the wineries, there is a concern raised about the high level of involvement that large logistics partners might have had in regard to the brand image, pricing, and standards of service outside of the country of origin (Costa et al., 2023). Trust issues can arise when third-party providers prioritize scale over product specificity, particularly for boutique wineries whose value proposition hinges on authenticity and quality perception. Moreover, fluctuations in international trade regulations or customs digitization standards can expose SMEs to unanticipated compliance costs, especially when partnerships are not regularly updated to reflect regulatory shifts (Silvestri et al., 2023). These challenges illustrate the importance of active coordination, legal clarity, and joint contingency planning in export-oriented digital collaborations.

An additional valuable relation is cooperation in intersectoral innovation networks, including actors related to academic, agricultural, touristic, creative industries, and digital technology sectors. These locally rooted ecosystems represent arenas in which cross-disciplinary experimentation is played out, such as traditional knowledge interfacing with the new possibilities offered by digital technologies (Dressler & Paunovic, 2021; Galati et al., 2024). Not using only in-house R&D (often scarce in SMEs), wineries are more and more supported by the co-development of novel services, experiences, and business models with external stakeholders that correspond both to the technological and the local dimension. These networks can be, in the case of the wine sector, digital innovation hubs, food-tech accelerators, tourism consortia, and rural development agencies. For instance, in Northern Italy, a number of wine-producing areas (e.g., the Langhe, Trentino, Collio) have set up multi-stakeholder initiatives that include entities as universities, agritech start-ups, cultural entities, and local authorities to foster digitally-enabled tourism, sustainable agriculture, and wine-tech pilot projects (Festa et al., 2024). These networks enable not only knowledge sharing but also the co-creation of business model innovations grounded in the region (for instance, interactive D2C winery platforms, immersive tasting trails, or AI-supported vineyard tourism logistics). These networks allow SMEs to test the waters in a low-risk environment, to engage in co-funded shared pilot projects, and to take part in joint learning exercises that enhance digital readiness and strategic thinking. Furthermore, they are often in synergy with EU regional

development policies (e.g., Smart Specialisation or the Digital Europe Programme), which promote inter-sectoral collaboration as a lever of innovations for rural digitalization and sustainable transitions (European Commission, 2020). For SMEs rooted in closely-knit local communities, these networks decrease the social and institutional distance to innovation by making it materialize into collective goals and indirectly into economic competitiveness and territorial cohesion (Costa et al., 2023; Waye et al., 2023). Finally, intersectoral innovation eco-systems offer SMEs in the wine industry a more inclusive and sustainable way of approaching the digital transformation, one based on a model of local co-operation rather than of central disruption. These networks enable wineries to better navigate the daunting issues presented today, from climate change to sustainability requirements to digital integration. SMEs can test new technology in turn through workshops, pilot projects, and public-private interventions, and share risk through investment (Dressler & Paunović, 2021; Galati et al., 2021).

While strategic partnerships offer clear advantages, their success is far from automatic. There are a number of key relational and organizational distinction factors that exert influence on whether such collaborations help deliver substantive digital transformation, especially in those family owned SMEs common to the wine sector. These include trust, cultural similarity and a long-term strategic orientation (Galati, et al. 2021; Festa, et al. 2024). In several small wineries decision-making is highly centralized, and ownership of the business is likely to be in the hands of a single owner or family member whose attitude towards risk, tradition and innovation strongly influences partnership choices (Costa et al., 2023). In these kind of situations, trust formation is not only about contractual clarification but is equally about shared values, informal alignment and social embeddedness, all traits that require time to develop and that are often related to personal relationships and reputation (Waye et al., 2023). Cultural fit between partners is especially crucial when external collaborators are introduced into a world built upon artisanal craft and intergenerational knowledge. When values or communication styles clash this can result in reticence, poor engagement and even early endings to the relationship.

Another important variable is the absorptive capacity of the winery, that is, the ability of the business to identify the value of external knowledge, to assimilate it into its own processes, and to put it to use either for commercial or operational purposes (Cohen & Levinthal, 1990). Absorptive capability is related not only to technical capabilities but

also depends on organizational openness, strategic vision, and learning mechanisms. In many wine SMEs--especially in rural environments-- the problem of low absorptive capacity can hinder the partnerships that are promising but not transformed into organizational change. For example, when wineries play a part in developing AI and CRM tools with external partners, they may not always implement these tools in daily routines or adjust business models accordingly (Festa et al., 2024; Galati et al., 2024). Some wineries invest in training employees, succession planning, and joining regional knowledge networks to develop absorptive capacity in an effort to help them assess partners' contributions and maintain innovation over time (Silvestri et al., 2023).

In the absence of this internal grounding, collaborations may be shallow or overly reliant on outside actors, thereby constraining long-term resilience and digital maturity.

The mechanisms for governance are also fundamental to the effectiveness and equity of strategic partnerships, particularly when coordinating multiple players. It is important to have clear contractual frameworks, well- defined roles and transparent communication mechanisms among partners in order to align expectation, reduce ambiguity and risk of opportunistic behavior, a typical fear in the asymmetric relationships between S MEs and bigger partners (Galati et al., 2024; Costa et al., 2023). Good governance allows partners to organize their affairs, manage interdependencies, and police transgressions in ways that do not erode trust and continued cooperation. This is especially relevant in family-owned wineries, where informal decisions may be encouraged by guiding indicators without destroying self-determination (Festa et al., 2024). For example, joint steering committees, performance trackers, feedback loops, and partner alignment have all been demonstrated to lead to better collaboration effectiveness and higher levels of partner commitment (Waye et al., 2023). Particularly in the dynamics of multi-SME consortia, like in regional wine clusters, or PDO associations or the blockchain traceability environments, governance becomes even more complicated. These networks sometimes need intermediaries such as institutions to act as the coordinators for digital projects, to manage shared infrastructures such as cloud server or certification portals and mitigate imbalances in accessibility of resources between heterogeneous firms and between firms of different size and digital maturity (Silvestri et al., 2023). However, without formal rules or explicit benefit-sharing arrangements, larger players could secure an over-proportional percentage of rent and smaller ones drop-out or are kept away. Widespread citizen support

through the encouragement of local or regional governmental bodies, sectors of commerce, or industry associations can significantly influence how best to govern. In digital innovation partnerships, these 'actors' frequently offer technical support, templates for standardization, and even mediation of conflict. For instance, some wine producing regions in Italy have devised a public–private governance model which situates local SMEs inside funding consortia, thereby enabling the attainment of EU digitalization objectives without renouncing to local values and to the artisanal production system (European Commission; 2020; Festa et al., 2024). Finally, effective governance mechanisms enhance the quality of project implementation, which benefits the sustainability of projects, organisational learning, and the embedding of digital practices over the long haul. But that's not how all governance models work in reality. Some of the consortia or regional collaborations have collapsed because of lack of ownership, role confusion, and change in leadership priorities (Waye et al., 20231). Fragmented areas have been found to experience weak institutional coordination, which may involve duplication of efforts, waste of resources or disengagement by the smaller countries that consider themselves left out of strategic decision-making. In the words of Dressler & Paunovic (2021), without on-going facilitation, clear governance processes, and incentives for continued engagement, consortia may wind up being symbolic rather than substantive – delivering "innovation on paper" instead of transforming anything. It also underscores the importance of resilient forms of governance that are inclusive and have the backing of both public and private actors.

Strategic alliances are a strong driver of the digital transformation of the wine sector, and of SMEs, in particular, confronted with internal and external barriers. Wineries can access capabilities they could not build on their own by working with technology providers, digital markets, logistics companies, and cross-sector networks. This articulation serves to strengthen resilience, facilitate innovation and to ensure the future of regional wine ecosystems. As these partnerships deepen, they increasingly embody the overarching principles saturated within the Industry 5.0 paradigm, notably human-centricity, sustainability, and ethical digitalization. Rather than instrumentalizing digital tools to foster efficiency, wine sector collaborations affirm today a sense of social embeddedness, care for cultural heritage and long-term resilience (Festa et al., 2024; European Commission, 2021). This transition is being demonstrated through actor-assemblages

which contribute to environmentally friendly viticulture, collaborative innovation processes, and regional knowledge exchange systems. Strategic partnerships here do not just provide pathways of technological diffusion; they're also interfaces for involving digital transformation into larger societal pursuits.

### *2.2.8 Conceptual Framework for the Empirical Investigation*

A review of the existing literature revealed several recurring constructs that are particularly important for understanding how small and medium-sized wineries approach digital transformation. Understanding these constructs is key to grasping the opportunities and challenges of digitalization, as well as the strategies and contextual dynamics that influence adoption.

To consolidate the insights from the literature review and to establish a clear link between theory and empirical investigation, I developed the following framework *(Table 2.1)*. It synthesizes the main constructs and themes that recur across the reviewed studies and that are most relevant to the digital transformation of wine SMEs. These constructs encompass both internal and external dimensions, ranging from perceived benefits and barriers to enabling strategies, global trends, and the tension between tradition and innovation.

The framework is designed to serve two purposes: first, to provide a structured overview of the theoretical aspects identified in the literature; and second, to guide the empirical phase of the thesis. Accordingly, the interview guide is aligned with these dimensions, ensuring that data collection directly addresses the issues highlighted in prior research while also allowing space for new, context-specific insights to emerge.

***Table 2.1 Conceptual framework: main constructs guiding the empirical investigation***

| Construct / Aspect | Derived from Literature | Relevance for Data Collection |
|---|---|---|
| **Perceived benefits of digital transformation** | Transparency, efficiency, innovation (Kamble et al., 2019; Dressler & Paunovic, 2021) | How do wineries perceive the added value of digital tools for their operations and competitiveness? |

| | | |
|---|---|---|
| **Barriers to digital adoption** | Financial, skills gap, cultural resistance, regulatory burdens (Costa et al., 2023; Galati et al., 2024) | Which challenges prevent wineries from adopting digital technologies, and how do they experience them? |
| **Adopted technologies and value chain stages** | Adoption of blockchain, IoT, AI, big data analytics, and e-commerce across viticulture, production, logistics, marketing, and sales (Galati et al., 2024; Mola & Roffia, 2024; Sabbagh et al., 2024). | Which are the types of the most frequently adopted technologies, and which is their position in the value chain? |
| **Tradition vs. innovation tension** | Cultural heritage, family legacy, authenticity vs. digital change (Aimar, 2024) | How do family-owned wineries reconcile heritage with technological innovation? |
| **Enabling strategies & support (skills, partnerships, policy)** | Public policy, funding, strategic partnerships, cooperatives (European Commission, 2021; Waye et al., 2023) | What strategies (alliances, funding, policy support) have wineries used to overcome barriers? |
| **Global/sectoral trends** | Sustainability, consumer expectations, Industry 5.0 (Balaji, 2025; Ibrahimli, 2024) | How do global sustainability demands and new consumer preferences influence digital adoption decisions? |

This framework thus operates as a bridge between the literature review and the empirical chapters. It ensures that the findings are not only grounded in existing theoretical debates

but also capable of extending them by examining the lived experiences of wineries in the Piedmont context.

# 3 Methodology

## *3.1 Research Approach*

This thesis adopts a qualitative approach, as the objective is not to generate statistically generalizable findings but to develop an in-depth understanding of the processes, perceptions, experiences, and attitudes of winery owners' perspectives on digital innovation, elements that are embedded in personal meaning, context, and culture, and therefore cannot fully be described by quantitative means. Schreier (2018) argues that qualitative research is particularly relevant when the goal is to learn about diversity, the role of context, and process rather than generalizing from cases to large samples statistically. Since the wineries included are mostly small and family-run, where cultural values and personal relations figure prominently and in context-specific ways, it is necessary to use a methodology that can paint the nuances of this contestation.

Within this qualitative framework, the thesis follows a multiple case study design. Case study research is especially appropriate when investigating contemporary phenomena in their real-life settings, where the boundaries between the phenomenon and the context are blurred (Yin, 2014). The choice of a case study design is also consistent with the exploratory aim of this research: to identify barriers, opportunities, and strategies linked to digital innovation in small and medium-sized wineries. The study takes an inductive orientation, seeking to build insights and categories from empirical evidence rather than testing predefined hypotheses.

The case selection focuses on small, family-led wineries located in Italy, with a particular emphasis on the Piedmont region. Piedmont was chosen because it represents one of the most historically significant and internationally recognized wine territories, where tradition and heritage play a central role in shaping firms' strategic behavior. At the same time, it is home to a multitude of SMEs, which form the backbone of the Italian wine sector and embody the cultural tensions between preserving artisanal values and embracing digital change. This combination makes Piedmont particularly relevant to address the research questions. In addition, my residence in Piedmont has facilitated direct contact with winery owners and managers, improving access to participants and enabling the establishment of trust-based relationships that are essential for qualitative inquiry. Sampling is purposive, as participants are selected precisely because they are

owners or managers of wineries who directly influence strategic decisions regarding digital transformation (Etikan et al., 2016).

Data collection is primarily based on semi-structured interviews with winery owners. According to Roulston and Choi (2018), qualitative interviews are well-positioned to access participants' subjectivity, to comprehend their experiences and practices, and understand the meanings that are given by participants. I chose semi-structured interviews because, in the interview process, they grant more freedom of questioning while also keeping the central themes (e.g., ones about perceptions of digitalization, barriers, opportunities, and the tension between keeping to tradition and being innovative) asked in parallel across cases. Semi-structured interviews ensure that follow-up can take place depending on the specific responses given by participants, hence allowing to "dig" further in areas that are most important (or salient) for them to discuss, while still keeping the discussion of topics such as perceptions of digitalization, constraints and opportunities, traditional or innovative balance, also in a consistent way across cases. This strategy also reflects Orlikowski and Baroudi (1991) and their interpretation of the interpretive perspective, which states that reality is socially constructed and can be best captured with the meanings that members of the society attach to reality. Regarding digital transformation in wineries, the visions, traditions, and subjective valuations of owners are important factors in determining adoption behaviors and the acceptance of novelties.

Finally, triangulation is fundamental to this work. Triangulation, drawing upon various data sources and viewpoints, is important to increase the credibility and richness of the qualitative study by obtaining a fuller picture of the phenomenon (Flick, 2018). The interviews are complemented in this analysis with secondary data, e.g., company files or public documents.

### *3.2 Data Collection Method*

The interviews were either face-to-face, online (video call & conferencing), or telephone, according to the participants' wishes and convenience. The interviews were in Italian and lasted approximately 30-60 minutes. The decision to conduct interviews in Italian was deliberate and critical. Speaking in their native language allows participants to express themselves more freely and authentically, reduces misunderstandings, and creates a more relaxed and natural interview atmosphere (Temple & Young, 2004). This linguistic

correspondence provided depth and nuances in collecting data, especially for culturally related issues such as balancing traditional and modern perceptions or overcoming digitalization obstructions.

The amount of time was selected for the interviews to ensure that the participants' time was respected and to delve deeply into the most important areas.

The interviews were audiotaped and transcribed to provide accurate data capture and to facilitate later theme analysis. Interview insights were supplemented with secondary data (e.g., company websites, public records) for purposes of triangulation and enhancing construct validity (Flick, 2018).

Sampling was based on a combination of purposive and convenience sampling strategies; the participants were chosen for their relevance to the research questions (i.e., small family-owned wineries with current/potential digital transformation initiatives), and contacts were predominantly made via LinkedIn, reflecting pragmatic access (Purdam & Elliot, 2015). While this approach was effective in identifying relevant cases, it also introduces a potential selection bias, since wineries with a stronger digital orientation may be more active on platforms like LinkedIn. To mitigate this, the sample included both wineries with high and low levels of digital maturity, ensuring variation along key dimensions such as size, market orientation, and generational composition (Etikan et al., 2016).

To enrich the qualitative insights from interviews, the study also integrated secondary data where available, including winery websites, social media pages, and relevant public records. This triangulation helped in building a more comprehensive understanding of each case and provided context for interpreting interview findings.

Finally, I kept a fieldwork journal to document observations, reflections, and emerging themes throughout the data collection phase. This self-reflective practice not only helps capture context and nuances that may not be evident in transcripts but also provides valuable material for later analysis and discussion (Ortlipp, 2008).

The design of the study also respected the quality aspects: construct validity, internal validity, external validity, and reliability.

### *3.3 Data Analysis*

I analyzed the data gathered via semi-structured interviews using thematic analysis, a method of qualitative inquiry that involves identifying, analyzing, and reporting patterns (themes) within data. This method has a particular relevance to the study of the perceptions and experiences of winery owners with digital innovation, enabling the researcher to go beyond descriptive or surface observations to reveal underlying themes, rationale, and influences (Braun & Clarke, 2006). The semi-structured interview guide was developed on the basis of the conceptual framework (Table 2.1), ensuring alignment between the research questions and the empirical investigation. It covered six key themes: perceived benefits of digital transformation, barriers to adoption, adopted technologies across the value chain, the balance between tradition and innovation, enabling strategies, and global/sectoral trends. The full interview guide is provided in Appendix B.

Key stages were applied during the analysis process as proposed by Braun and Clarke (2006):

- Familiarization with the data: The researcher will read and re-read the transcripts (and listen to the audio recordings, if deemed necessary) until the data and the initial insights are familiar.
- Initial coding: Initial coding can be carried out manually or with qualitative software (e.g., NVivo, where available). Relevant data will be categorized into segments. The initial codes will represent both theoretically grounded categories (e.g., barriers, opportunities, tradition vs. innovation) and emerging ideas that emerge inductively from the data.
- Theme identification: Similar codes will be categorized into themes, such as cultural resistance, perceived benefits of digital tools, external assistance, or skill deficit.
- Reviewing themes: The themes will be reviewed by examining how well they cohere and are consistent across the data set , and concerning the research questions.
- Theme identification and naming: The theme/s' scope and definition will be established, and the researcher will give them clear names.

- Report writing: The final stage involves selecting vivid, representative quotes and integrating the themes into the thesis narrative to address the research questions.

The coding approach was both deductive, driven by the research questions and previous literature (e.g., Lindgren, 2018), and inductive, permitting new themes to be generated from the participant data (Schreier, 2018). Taken together, these two strategies ensure that the analysis is both theoretically grounded and open to serendipitous discoveries. In practical terms, I conducted and recorded each interview, then transcribed the audio and anonymized the transcripts to ensure confidentiality. I uploaded the anonymized transcripts into NVivo software, which I used to support the coding process. I created nodes corresponding to the main constructs of the research questions (e.g., perceived benefits, barriers, adopted technologies, tradition vs. innovation, enabling strategies, global trends). As I read through each transcript, I highlighted relevant segments and assigned them to the appropriate nodes. When new ideas emerged, I created additional child-nodes (for instance, under "barriers" → financial constraints, skill gaps, regulatory burdens). Using NVivo in this way helped me to systematically organize the material, compare cases, and refine codes across the dataset, while ensuring that the thematic analysis remained consistent with the research objectives. Data collection proceeded until thematic saturation was reached, meaning that additional interviews did not generate substantially new insights (Guest, Bunce, & Johnson, 2006). Saturation was observed after 14 interviews, with two additional cases confirming recurring themes and ensuring robustness of the findings.

For transparency and credibility of the findings (Ortlipp, 2008), I conducted the analysis with a reflexive journal running throughout the analysis, documenting analytic decisions, reflections on the findings, and potential biases.

The interviews were in Italian, and the analysis remained in Italian in order to capture the subtleties of the respondents' language. Selected quotes will be translated carefully into English for the thesis, with consideration given to preserving their meaning (Temple & Young, 2004) when presenting the results.

To ensure consistency between the conceptual framework (Table 2.1) and the empirical analysis, I developed a coding framework in NVivo that mirrored the theoretical constructs identified in the literature and research questions. Each main

node corresponded to one of the six constructs (perceived benefits, barriers, adopted technologies, tradition vs. innovation, enabling strategies, and global trends). These nodes reflect categories that were theoretically grounded in the literature review and operationalized through the interview guide. Within each node, I created child-nodes to capture more fine-grained themes as they emerged inductively from the data. For example, under "Barriers," codes were further subdivided into financial constraints, skills gaps, cultural resistance, and regulatory burdens; under "Benefits," sub-codes included transparency, operational efficiency, and market access.

This hierarchical coding structure allowed me to align deductive expectations from the literature with inductive findings from the field, ensuring that the analysis was both theoretically guided and empirically open. By organizing the material in this way, I was able to systematically compare cases, identify convergences and divergences, and refine the categories across the dataset. The resulting coding framework thus serves as a bridge between theory and data, improving the traceability of how insights moved from raw interview transcripts to the thematic findings.

***Table 3.1 Coding Framework***

| Theoretical Construct | Example Child-Nodes (Sub-Codes) | Description of Coding Decision |
|---|---|---|
| **Perceived benefits of digital transformation** | Transparency; Operational efficiency; Cost savings; Market access; Innovation/New business models | Sub-codes created to capture interviewees' recurring references to efficiency gains, supply chain transparency, international competitiveness, and the creation of hybrid offerings (e.g., wine tourism + digital storytelling). |
| **Barriers to digital adoption** | Financial constraints; Skills gap; Cultural resistance; Regulatory burdens; Infrastructure gaps | Sub-codes reflect both internal barriers (e.g., legacy systems, intergenerational resistance, lack of absorptive capacity) and external barriers (e.g., |

| | | |
|---|---|---|
| | | broadband access, fragmented certification). These were strongly grounded in literature and repeatedly mentioned in interviews. |
| **Adopted technologies and value chain stages** | IoT (viticulture); AI/Big Data (production); Blockchain (logistics/traceability); ERP (operations); CRM (marketing & customer management); E-commerce & Social media (sales, communication) | Sub-codes linked directly to different stages of the wine value chain, following both interview evidence and secondary data from websites/social media. Coding captured whether technologies were used for internal processes or consumer-facing activities. |
| **Tradition vs. innovation tension** | Heritage and authenticity; Generational divide; Fear of depersonalization; Craftsmanship vs. efficiency | Sub-codes created inductively as interviewees described ambivalence toward digital tools, e.g., older owners fearing erosion of personal relationships vs. younger successors advocating modernization. |
| **Enabling strategies & support** | Cooperatives; Strategic partnerships; Public policy & funding; Training & skill development; Digital Innovation Hubs (DIHs) | Sub-codes linked to different types of enablers. Some (e.g., cooperatives) were already anticipated from the literature, others (e.g., DIHs) emerged inductively from interview narratives about local support networks. |

| | | |
|---|---|---|
| **Global/sectoral trends** | Sustainability & ESG; Industry 5.0 (human-centric digitalization); Changing consumer expectations; International competition | Sub-codes created to capture external dynamics shaping wineries' digital strategies. Coding here was strongly informed by references to EU policies, consumer behavior shifts, and the pressure of "New World" competition. |

### 3.3.1 Overview of the Sample

I conducted 16 semi-structured interviews across 9 small and medium-sized wineries located in Piedmont. The sample was selected by purposive sampling, a widely used methodology in qualitative research when the participants are purposefully selected due to the perceived relevance of their contributions to the research problem (Etikan, Musa, & Alkassim, 2016). Purposive sampling, in contrast to probability samp, which is a statistical representation, will enable the investigation of information-rich cases that can offer the deepest look at a particular phenomenon. The 9 wineries were chosen based on significant scale:

Size (small to mid-sized wineries, small vs medium wineries between 10 and 50 ha),
Market orientation (local/regional vs international/export oriented),
Generational composition (traditional family leadership vs generational transition or younger-to-adult ownership),
Digital maturity (from rudimentary IT utilization to sophisticated blockchain and Internet of Things).

This diversity allowed us to take cases not just from digitally sophisticated wine wineries but also from resistant ones, providing a much fuller picture of how small and medium-sized enterprises (SMEs) in the wine industry view and participate in digital transformation. Information on these criteria was collected from publicly available sources, such as company websites, producers' associations, and wine guides, and through initial contact with the wineries to validate fundamental characteristics. Interviewees comprised winery owners, family successors, and managers directly related to strategic (or digital) operations. This variety of roles enabled the study of views within one, such

as differences that could be seen in the same winery (Intergenerational differences). Interviews were undertaken between March and July 2025, each lasting approximately 30–60 minutes. Most interviews took place through face-to-face interviews, and some were performed through videoconference (Zoom). Finally, in order to verify this authenticity, the core interview data were triangulated by secondary sources, including websites, cooperative reports, social media pages (e.g., Facebook, Instagram, TikTok), relevant policy documents (e.g., CAP, Horizon Europe, NextGenerationEU), etc., with the main data gathered from interviews. Drawing upon and integrating sources like these helped in creating a complete and more accurate portrait of the phenomenon that was under investigation. Table 3.1 summarizes the main characteristics of the 9 wineries in the study to give a good overview of the study sample. This table shows the main dimensions used for case selection (size, market orientation, generational composition, and digital maturity).

***Table 3.2 Characteristics of the wineries included in the sample***

| ***Winery (Pseudonym)*** | ***Size (ha)*** | ***Market Orientation*** | ***Generational composition*** | ***Digital Maturity*** |
|---|---|---|---|---|
| ***A*** | 10 | Local/regional | Family-owned, 3rd generation | Low (basic IT, no advanced tools) |
| ***B*** | 40 | International (EU, US) | Family, international outlook | High (blockchain, e-commerce, CRM) |
| ***C*** | 15 | Regional sales | Traditional single-owner, aging leadership | Low (Excel, simple website) |
| ***D*** | 30 | Regional + online | Mixed-generation | Moderate (website, e- |

| | | | | |
|---|---|---|---|---|
| | | | (father + daughter) | commerce, IoT pilot) |
| ***E*** | 25 | Export + wine tourism | Young innovative owner | Moderate-high (IoT sensors, digital storytelling) |
| ***F*** | 50 | National retail chains | Multi-family cooperative | Moderate (ERP, shared e-commerce) |
| ***G*** | 12 | Local niche markets | Heritage-focused, single generation | Low (manual processes, occasional posts) |
| ***H*** | 35 | EU + Asia | Family-owned, active successor | High (blockchain for PDO, B2B e-commerce) |
| ***I*** | 20 | Regional + tourism | Generational transition (successor taking lead) | Moderate (CRM, digital payments) |

### 3.3.2 Cases Profiles

Although all wineries chosen for this study have a comparable background found in Table 3.1, this section specifically defines each case. This brief profiles' section sets out the size and distribution of wineries in its current market orientation status. Also, the age range and other factors such as technological or market maturity attained. They also bring together a blend of these two insights, conveying how each one of the wineries is thinking and positioning themselves for digitalization. Narrative rendering of these cases provides a fuller understanding of their histories, strategies and inner dynamics, particularly intergenerational tensions and attitudes to innovation.

***Winery A***

Winery A is a small, heritage-driven winery cultivated over three generations. Its attention is primarily drawn to the region and local markets, with emphasis placed on artisanal production. Digitalization is minimal, ranging from the use of spreadsheets for administration (Microsoft Excel) to social media for visibility. Interviews with the current owner and his son revealed intergenerational contrasts: although the father holds traditional views and is wary of digital change, the younger generation views digital tools as vital for marketing to, and drawing in, younger consumers.

***Winery B***

Winery B is the most digitally advanced case in the sample. With 40 hectares and export-oriented, it is also fully embraced by internationalization. In line with our strategy which includes premium markets in both the euro area and America, the winery has implemented blockchain for PDO certification, operates an e-commerce platform and relies on CRM systems to manage customer relationships. Interviews with the owner, export manager, and an IT consultant demonstrate how a proactive attitude towards technology underpins both competitiveness abroad and transparency toward consumers.

***Winery C***

Winery C is a small family business with very little digital support. An elder owner maintains the establishment and prefers traditional forms of operation to technology-based innovations. The winery has a minimal digital footprint consisting of a minimal website and infrequent posts for Facebook. The interview confirmed that digitalization is often ignored, as seen not as the strategy, but as an extra burden on the resource system.

***Winery D***

Winery D highlights the role of generational dynamics in digital transformation. A father and his daughter run the winery together. The father is a conservative manager who has a

bit of a reluctance to invest in new technologies. While her daughter has driven an uptake of an ecommerce channel and the introduction of IoT sensors in the vineyard as a pilot. The duality of these leadership structures encapsulates this ongoing negotiation of what is old versus new.

***Winery E***

Winery E is run by a young, innovative entrepreneur who combines wine production with wine tourism. With 25 hectares of land, the digital maturity of the site is medium- to high, with sensors for monitoring vineyard performance, digital storytelling for brand promotion, and multiple social media platforms (Instagram, TikTok, YouTube) to reach younger customers and tourists. Interviews showed there was a clear strategic intent to connect digital innovation to sustainability and experiential marketing.

***Winery F***

Winery F operates as a cooperative involving five families. Its larger production scale allows for resource sharing and collective investment in technologies such as ERP systems and shared e-commerce platforms. The cooperative's manager and agronomist emphasized the importance of collaboration for overcoming SME limitations in digitalization. The cooperative model not only facilitates efficiency but also provides a structured framework for experimenting with innovations at a lower cost and risk.

***Winery G***

Winery G is a small, heritage-focused winery producing for local niche markets. Authenticity, craftsmanship, and personal relationships with consumers was held up as essential tenets, presented, in many speeches, as conflicting with digitalization. The winery is virtually invisible online, having just one page on Facebook. Interviews confirmed that digital tools are being used more as a marketing 'something' than as a strategic asset.

***Winery H***

Winery H has been working actively to become digitally savvy as a means to facilitate export opportunities, notably in Europe and Asia. The owner and export manager explained how blockchain is used for PDO certification, and how B2B e-commerce platforms are key to accessing distant markets. The winery's investment in digital tools is closely linked to its international strategy and the need to ensure transparency and trust for foreign buyers.

***Winery I***

Winery I is undergoing a generational transition, with the younger successor gradually assuming leadership. The older generation was still conservative but the successor was able to upgrade sales to CRM systems and use digital payments—thus trying new technology tools; all to modernize marketing processes and improve relations with its customers. Another wine-tourism focus for the winery's strategy is to promote experiences within wine tourism, using digital channels and visitor attraction.

### *3.3.3 Cross-Case Characteristics*

Despite the nine wineries varying markedly in terms of scale, market orientation, and digital maturity, there are several recurring narratives that emerge in these cases. First, most of the wineries are family-owned and multigenerational. This structure promotes authenticity and tradition—so central to a brand's identity—it also creates internal conflicts when new technologies are brought into play. "Senior members of the family will not be ready to embrace digital tools, and that comes with its own set of problems," he said. As illustrated by recent studies, familiness has the effect of enhancing and inhibiting digital transformation in winery SMEs (Paunović et al., 2022; Dressler & Paunovic, 2021). Younger successors at wineries like A, D, and I pushed for digitalization, while older members of the family questioned or resisted it. This intergenerational dynamic underpins the digital transformation process within the sector, as also highlighted in the most recent literature investigating family-owned wineries, and the extent to which next generations may serve as agents of change against a backdrop of

conservative traditions (Costa et al., 2023; Dressler & Paunovic, 2021; Paunović et al., 2022). A second common thread relates to the level of digital maturity, which varied greatly according to wineries' market orientation and was not consistent. Those aimed at the international market, e.g., Wineries B and H, could be more experienced and have introduced blockchain, computerized CRM, e-commerce, and other technologies to further increase transparency and to compete internationally. Meanwhile, local/rural (including A, C & G) wineries appeared to be mostly non-digital (minimal e-communication or only using basic IT mechanisms or a few of the social media for visibility). This trend mirrors a general trend that export-oriented wineries have a higher preference to deploy sophisticated digital technologies due to their international competitiveness, while region-specific, smaller-sized SMEs tend to confine their own adoption to lower-cost, introductory apps (Galati et al., 2024; Costa et al., 2023; Dressler & Paunovic, 2021). Another driver for digital adoption was the integration of wine tourism. Wineries E and I, like other operators in that sector, mixed their working processes with hospitality, leveraging digital storytelling and digital platforms to drive engagement. In these cases, diversification into tourism was an incentive behind digital tools that could promote visibility and consumer engagement. This finding aligns with larger findings, such as how experiential consumption and wine tourism increasingly drive SMEs to adopt aspects of digital channels and storytelling strategies that serve the needs of younger, experience-oriented consumers (Dressler & Paunovic, 2021; Mola & Roffia, 2024). The cooperative Winery F displayed how group structures can deal with the lack of resources common to SMEs. To make this happen, the cooperative pooled investments to access ERP systems and shared platforms that could not have been viable or affordable for individual family wineries. Cooperatives are highlighted as an enabler of digital transformation in the literature, with shared infrastructures and collective governance found to be effective practices enabling the uptake of digital platforms by resource-constrained SMEs (Costa et al., 2023; Galati et al., 2024). For all of these differences, there was a common set of constraints faced by all wineries, typical of SMEs present in conventional sectors. The cases were identified as having financial problems, a lack of digital skills, or relying on external actors – including consultants, cooperatives, and policy frameworks – as the gatekeepers to innovation. These structural constraints are in line with previous research, in which the limited absorptive capacities and resource

endowments of SMEs have been emphasized as critical barriers to digital adoption (Costa et al., 2023; Dressler & Paunovic, 2021; Waye et al., 2023). It contributes to the understanding of why digital uptake is uneven, as well as the role that cultural and institutional settings play in shaping the trajectory of digital transformation in the wine industry (Galati et al., 2024). In their synthesis, the cross-case evidence brings out a duality. Digitalization, on the one hand, provides a great opportunity to gain the advantages of efficiency, increasing transparency, and expanding the market. On the other hand, resources and cultural investment in the past made transformation a negotiated and not linear process. These findings match the constructs of the conceptual framework (Table 2.1 Conceptual framework: main constructs driving the empirical research), especially the interaction between the perceived benefits, barriers, and the cultural conflict of tradition and innovation, confirming the relevance of the framework in directly directing the empirical study.

### *3.4 Reliability and Validity*

The rigor, reliability and validity of qualitative research are essential for credible and trustworthy findings. Although reliability and validity are quantitative terminology, they are also essential in qualitative research with certain adjustments to suit the nature of the study (Lincoln & Guba, 1985; Yin, 2014). Reliability in qualitative research is the extent to which the research process is repeated, transparent enough for another researcher to conduct the same process and identify similar findings. In this thesis to allow the reliability of such comparisons a case study protocol will be developed to standardize data collection procedures across interviews (Yin, 2014). Moreover, a detailed audit trail will be maintained, documenting all research decisions, coding procedures, and analysis steps. Finally, interview transcripts, codes, and thematic summaries will be systematically organized in a research database to enhance transparency and replicability.

Validity in qualitative research encompasses several key dimensions. Construct validity will be addressed by using multiple sources of evidence, including interviews and secondary data such as company websites and public documents (Yin, 2014). Internal validity, often referred to as credibility in qualitative research, will be enhanced through pattern matching and triangulation, comparing data across sources to identify consistent

themes and relationships. Reflexive notes will also play a critical role in monitoring potential biases during interpretation (Lincoln & Guba, 1985).

To further support the dependability and confirmability of the research, the researcher will engage in peer debriefing, discussing emerging interpretations with the supervisor to ensure that the results are grounded in the data rather than shaped solely by the researcher's own assumptions (Lincoln & Guba, 1985).

By integrating these methodological strategies, the study aims to produce findings that are credible, meaningful, and analytically transferable, offering valuable insights into how small family wineries approach digital transformation.

### *3.5 Ethical Considerations*

Ethical considerations are central to the design and implementation of this research, especially given the personal and context-specific nature of qualitative data collection. Following the principles outlined by Lincoln and Guba (1985) and Mertens (2018), this study adheres to a framework of respect, transparency, and care toward all participants involved. Before each interview, participants will be fully informed about the purpose of the research, the voluntary nature of their participation, the approximate duration of the interview, and their right to withdraw at any time without consequence. Verbal informed consent was obtained, as this is often more culturally appropriate and comfortable in the context of informal, semi-structured interviews with small business owners (Mertens, 2018).

In order to protect participants' privacy and confidentiality, no names or identifying details will be included in the thesis or any related outputs. All interview data will be anonymized, and any potentially identifying information, such as the name of the winery, geographic specifics beyond the regional level, or personal details, will be carefully removed or generalized in the reporting. This decision aligns with the principle of confidentiality, ensuring that participants' views, experiences, and opinions can be shared freely without risk of recognition or harm (Mertens, 2018; Lincoln & Guba, 1985). Participants will be informed of this approach during the consent process and will be assured that their data will be used only in aggregate or anonymized form.

Audio recordings and transcriptions will be securely stored on password-protected devices, and access to the raw data will be limited to the researcher. In line with best

practices, participants will also be offered the opportunity to review summaries or excerpts from their interviews (Lincoln & Guba, 1985).

Special attention will be paid to cultural sensitivity, especially given that many of the participants come from family-owned businesses where tradition and reputation hold significant weight. Conducting interviews in Italian is another ethical choice, as it allows participants to express themselves freely in their native language, reducing the risk of misinterpretation and creating a more respectful and relaxed environment (Temple & Young, 2004).

By integrating these ethical principles, the research aims to foster trust, minimize harm, and ensure that participants' voices are represented accurately, responsibly, and respectfully.

# 4 Findings

## *4.1 Introduction*

This represents the empirical findings under this study and addresses digital transformation in small and medium-sized wineries in the Piedmont region. Building on the conceptual framework elaborated within Chapter 2 *(Table 2.1 Conceptual framework: primary constructs shaping the empirical investigation)*, the analysis is driven by the research questions elaborated within the first section *(Section 1.3 Research Questions)*, with 16 semi-structured interviews carried out across nine wineries, along with secondary data including company websites, social media pages, cooperative reports, and relevant policy documents.

This chapter presents the empirical findings of the study. Thematic analysis is structured *(Sections 4.2–4.7)* based on the six research questions: perceived advantages of digitalization, the barriers that hamper digitalization adoption, the nature of technologies adopted throughout various value chain stages, the competing interests between the traditional and the innovative, enabling and sustaining strategies, and the significance of global and sectoral changes. The chapter ends with an overview of the findings that are summarized in Section 4.8, which makes the groundwork for Chapter 5. In this arrangement, the chapter intends to offer an in-depth and multifarious understanding of how wine SMEs strike a balance of risk and potential within their digital transformation journeys, focusing on the ambivalence of digitalization as a disruption in and perhaps facilitator of heritage continuity and competition. Illustrative quotations for each construct and research question are provided in Appendix A, which summarizes the most representative excerpts from the interviews.

## *4.2 Perceived Benefits of Digital Transformation (RQ1)*

What emerges among the interviews that I take as a common thread here is the awareness that digital transformation can indeed be an actual benefit to wineries, despite the uneven rate of implementation. Despite the hesitancy and constraints on resources faced by the more reluctant, less supportive companies, it was acknowledged that digital tools could indeed raise efficiency, boost transparency, and even open up new avenues of market. Transparency and traceability in the supply chain became, for some wineries at least, the

primary perceived benefits. Wineries B and H, for example, focused on the fact that blockchain-based applications are not only used to prevent fraud, they also represent marketing vehicles when facing off with foreign buyers. This result is corroborated by the published literature that blockchain enriches the sense of trust in the wine supply chain by logging immutable data as to the vineyard origin, production process, and logistics movements (Galati et al., 2024; Sabbagh et al., 2024). Interviewees indicated that monitoring systems could distinguish premium wines and reassure buyers in industries where faking the grape is an issue. Cost savings and operational efficiency were another category of benefits, particularly perceived. Winery F, a cooperative, stressed how inventory management of its resources was facilitated through ERP systems, and how this helped to avoid redundancies, whereas Winery E highlighted how monitoring through IoT allowed them to operate their vineyard more effectively due to usage management of resources. These perceptions align with other research indicating that digital tools including IoT sensors and ERP tools help prevent wastage, improve quality of work, and reduce operating costs in the field of precision viticulture (Dressler & Paunovic, 2021; Costa et al., 2023). Even in lower-end wineries with limited adoption, there was an acknowledgement that simple digitalization (e.g., swapping old records to cloud-based storage) might save time and help cut down on administrative complexity. Third is that a company can tap into the market and internationalize. Export-oriented wineries (B, H, and E) had defined digital platforms and e-commerce as the gateways to the consumer (outside the original country) and reduced reliance on intermediaries. And A, C, and G: local market-based wineries tend to view digital marketing and social media as a means of maintaining customer loyalty and engaging with young consumers. The literature is also in line: digital applications and e-commerce both increase reach and the opportunity for SMEs to engage directly with international consumers, bypassing established distributors (Festa et al., 2024; Mola & Roffia, 2024). Interviewees also pointed to the innovation of digital transformation that could lead to new business models. Winery I, which is in a generational transition, mentioned the application of CRM as part of developing customer relationships that are long term and data-centric. Equally, the coupling of wine tourism with digital storytelling at Winery E highlights how digital solutions can help form hybrid offerings that integrate cultural legacy with experiential marketing. These examples are also consistent with global evidence that digitalization

enables SMEs to re-imagine their business models, towards direct-to-consumer, subscription-based services, or experientially branded products (Costa et al., 2023; Galati et al., 2024). On balance, however, the evidence indicates that SMEs in the wine industry view digital transformation less as an individual innovation and more as a set of benefits that augment efficiency, foster transparency, open new market outlets, and encourage innovation. While the level of interest differs from case to case, all point to the idea that digitalization, when effectively managed, can increase both competitiveness and resiliency. This realization forms the background to ask why wineries take digital initiatives in addition to the obstacles, which will be addressed in the second part (4.4).

### *4.3 Barriers to Digital Adoption (RQ2)*

Although the wineries included in this study recognized the potential benefits of digital transformation, they also recognized a lot of barriers that limit its adoption. Such obstacles are reflected in the literature, and broadly fall into financial and technological constraints, lack of skills and capabilities, cultural resistance, and external institutional challenges. Financial and technological constraints were the most frequently cited obstacles. Several wineries (e.g., A, C, G) stressed that advanced digital tools like blockchain or IoT devices are prohibitive for wineries with limited margins and seasonal cash flows. As one owner put it, “We cannot afford to invest in systems that will only pay off after years, when we have to survive harvest by harvest.” These issues also correspond to studies indicating that SMEs tend to delay or desert digital projects, attributed to substantial initial costs, hidden costs (including training, integration, and cybersecurity), and delayed ROI (Costa et al., 2023; Galati et al., 2024; Festa et al., 2024). Even when funding programs exist, wineries reported difficulties accessing them due to complex application processes and limited administrative capacity, a problem emphasized by Waye et al. (2023). Another primary challenge has to do with digital skills and absorptive capacity. Owners of smaller wineries (C, G) confessed to having trouble understanding and evaluating digital solutions, while younger successors (A, I) often described themselves as “teaching” parents or colleagues about technology. It is well documented in the literature that many wine SMEs, in addition to lacking the necessary digital ICT skills, don't even have a widespread digital literacy, such as strategic digital thinking, data interpretation, and systems integration (Costa et al., 2023; Festa et al., 2024; Waye et al., 2023). This

deficiency has caused firms to rely relatively heavily on external consultants, a situation that can be exploitative to them and hinder the development of internal expertise (Silvestri et al., 2023). There was also strong cultural resistance to change in the context of multigenerational wineries (A, D, I). Older owners viewed digital-driven tools as a danger to craftsmanship and authenticity, younger owners as something that they could only adopt if they had to for better competitiveness. Related trends are widely documented: traditional winemaking behavior and regional identities (e.g., terroir, *mezzadria*, or heritage branding) contribute to conservative organizational cultures, which oppose technology diffusion (Dressler & Paunovic, 2021; Costa et al., 2023; Galati et al., 2024). A few wineries perceived the threat of depersonalization of service with digital touch-points as just as serious as financial and technical obstacles, by preventing that face-to-face interaction. Overcoming challenges beyond internal problems creates a hindrance in digital uptake, both external and institutional. Several wineries cited inadequate broadband infrastructure in rural areas, making it hard for them to implement cloud-based ERP systems, real-time Internet of Things (IoT) monitoring, or e-commerce platforms. Dressler & Paunovic (2021); Waye et al. (2023); Festa et al. (2024) recognized this rural–urban digital divide as a structural barrier to transformation. They were also frustrated with regulations on wineries. In the export-oriented cases (B, H), different international standards for labeling and digital compliance lead to higher administrative costs, while other members of the profession were concerned over data privacy regulations when implementing blockchain or cloud solutions. Such perceptions mirror evidence in that fragmented regulations and certification systems frequently delay or discourage adoption of promising technologies (Silvestri et al., 2023; Sabbagh et al., 2024; Costa et al., 2023). To sum up, from these results, it is clear that barriers to digital adoption in wine SMEs are complex and linked. Financial restrictions and skills gap are essential barriers; however, these features are exacerbated by cultural and institutional resistance within family businesses and by external factors (inadequate infrastructure or regulatory constraints). Not only do these factors explain the different degrees of digital maturity in the cases, but they also reflect the danger of digital gap growth in the industry. Then (4.5) explains how wineries counter these issues by adopting certain technologies across the value chain.

### *4.4 Adopted Technologies and Value Chain Stages (RQ3)*

The wineries exhibited a patchwork acceptance of digital technologies, differing across the value chain. This trend mirrors what has been reported in terms of the incremental and irregular nature of use of digital tools, which is not only influenced by resources and capabilities, but also by strategic imperatives (Costa et al., 2023; Galati et al., 2024). Viticulture and vineyard management were the first contexts incorporated, particularly in wineries E and D. IoT-based sensors, drones, and weather monitoring systems were employed to acquire up-to-date data on soil condition and vine health, as well as climatic variation. These applications empowered more sustainable practices and improved resource utilization. The evidence of the case supports a general claim that IoT supports precision viticulture improvement, resource-saving, and quality outcomes (Dressler & Paunovic, 2021; Festa et al., 2024). But adoption is limited to the smaller wineries (A, C, and G) who are still using traditional observational techniques. In production (or winemaking), adoption of the electronic medium was more modest. Winery I, in a process of inter-generational transition, started to use a CRM system with fermentation monitoring and production matching to customer demand. Similarly, Winery E reported experimenting with artificial intelligence predictive analytics in order to optimize harvest timing and fermentation. These practices are in line with research showing that AI and big-data analytics have applications in product quality control, disease prediction, or demand forecasting, although this adoption is generally reserved for wineries with higher digital maturities (Festa et al., 2024; Costa et al., 2023). Logistics and supply chain management represent another important phase of the digital process. Wineries B and H, both exporting, have invested in promoting blockchain solutions for traceability and PDO compliance. In those systems were viewed in the context of regulatory compliance, and as competitive assets in foreign markets, which are highly reliant on consumer trust and fraud prevention. Italy's case study highlights the importance of blockchain for transparency, fraud reduction, and informing consumer access to provenance in real time (Sabbagh et al., 2024; Silvestri et al., 2023). ERP systems are even adopted by cooperative structures like Winery F in order to ensure coordination of inventory and distribution, illustrating how collective approaches allow SMEs to counter resource constraints (Galati et al., 2024). Digitalization during the market and sales phase. Almost all wineries had internet exposure, primarily through social networks like Instagram, Facebook, and, more

recently, TikTok. Younger owners (Winery E, Winery I) used these tools in a narrative and as interactive resources for consumers. Export wineries supplemented this with e-commerce platforms and B2B portals—extending reach while decreasing reliance on intermediary partners. The literature also stresses the growing importance of e-commerce and D2C models, especially after the COVID-19 pandemic that disrupted (Mola & Roffia, 2024; Festa et al., 2024). In post-sale engagement and customer relationship management, CRM systems were referred to as emerging tools for maintaining loyalty in the consumer. CRM was utilized by Wineries I and B to gather purchasing information, automate communication, and keep their wine club membership structure. CRM, as suggested in literature, enables SMEs to provide personalized marketing and maintain long-term customer service relationships without the overhead of an external marketing department (Galati et al., 2024; Mola & Roffia, 2024). In conclusion, digital transformation among wine micro-enterprises appears stagewise, piecemeal, and fragmented. Technologies like blockchain and ERP are related to internationalization and compliance; IoT and AI are tied to viticulture and production efficiency; and CRM/ e-commerce and social media are at the consumer-facing end of the value chain. Despite uneven uptake, even slight implementation of digital tools illustrates the ways in which technology in business can be introduced to make small and medium-sized entrepreneurs realize value from new features in an effective, transparent, and attractive manner to the market.

### *4.5 Tradition vs. Innovation Tension (RQ4)*

An issue that can only be made possible through digital culture. Especially in multigenerational wineries (A, D, I) where tradition was central and younger wineries wanted digital integration, tension was evident between the traditional and technological communities. For the father-owner of Winery A, digital technologies were “distracting from what makes our wine unique,” whereas his son saw platforms like Instagram as vital to connect with new consumers. Winery D also displayed a dual strategy where the father preferred to focus on traditional cultivation practices, whereas the daughter adopted e-commerce and IoT experiments. These results agree with the literature regarding cultural resistance in family wineries. Traditional winemaking practices, often viewed as defining authenticity and differentiation, can engender conservative organizational cultures where innovation is met with skepticism (Waye et al., 2023). In places like Piedmont, Tuscany,

and Bordeaux, where wine is intimately linked to terroir and heritage, technological change is not only a business decision but a possible encroachment on cultural continuity (UNESCO, 2014; Trubek, 2008). In such a context, digital transformation is experienced as a threat to the "handmade" or "craft" narrative on which premium market positioning is based (Festa et al., 2024). The resistance wasn't just generational but organizational. And old-timers at wineries C and G are loath to use digital at all, especially when the use of new systems is linked to changes in work styles or skills. The attitudes are indicative of what the literature characterizes as 'organizational inertia,' where the technological potential differs profoundly from organizational preparedness (Hess et al., 2016; Costa et al., 2023). Some are concerned about the impersonal nature of digital CRM systems or virtual tastings, which they believe are eroding the personal, face-to-face relationships that underpin winery hospitality. At the same time, those cases also show us that tradition and innovation are not mutually exclusive. Winery E, managed by a young entrepreneur, shows how digital storytelling and IoT monitoring can go hand in hand with a strong emphasis on heritage and terroir. For PDO certification, Winery H similarly adopted blockchain while framing it not as a disruption but rather as a tool with which to safeguard authenticity and strengthen consumer trust in traditional appellations. The literature also demonstrates ways in which resistance to digitalization could be managed, especially when the discussion of digital transformation is framed less as the replacement and more as a means of preserving and expanding artisanal values (Galati et al., 2024; Costa et al., 2023). The dichotomy between tradition and innovation, as a structural feature of wine SMEs, was revealed to be underpinned by generational practices, organizational culture, and regional heritage. Although reluctance to adopt it usually results in slower adoption, such resistance does speak to a cultural value of trust and authenticity—one that can be deliberately tapped when digital becomes invested into a story of craft and origin, and identity with cultural communities. This ambivalence is what makes the wine sector a rich case to understand digital transformation in traditional industries.

### *4.6 Enabling Strategies & Support (RQ5)*

Three families of enablers emerged through the nine wineries: (1) policy- and ecosystem-level scaffolding that mitigates risk and unifies actors, (2) capability-building mechanisms to develop digital competences and managerial readiness, and (3) financial

instruments and partnering models that reduce the upfront costs of adoption. These levers together translate abstract "readiness" into implementable roadmaps for SMEs. A recurrent theme in interviews was the importance of regional innovation intermediaries (for example, digital innovation hubs [DIHs], chambers of commerce, cluster organizations), which serve as first ports of call to explore technologies, meet vetted suppliers, and co-design pilot projects. In line with EU guidance, DIHs are one-stop shops that provide test-before-invest facilities, training, matchmaking, and help to find finance to support the Smart Specialization (RIS3) agenda, a model with an institutional configuration that our own Piedmont examples leveraged in order to develop proofs of concept with low sunk costs. DIH playbooks explicitly reference the existence of such service and archive agrifood-oriented hubs (e.g., AgriFood Lithuania DIH) as precedents on cross-sectoral cooperation AI/IoT/blockchain that matches the collaborative model we have noticed at the local level. In small, family-run wineries, human capital is the hinge between pilots and scale. Owners and next-generation successors focused on brief, practical training (e.g., data basics, CRM use, cybersecurity hygiene) and on-the-job mentoring from technology partners. Similar to our own comparative evidence that divides SME support into human, technological, and financial streams, where upskilling, mentoring, and scaling up skilled workforce have been identified as the key to success in overcoming adoption barriers, such as skills gaps and resistance to change. Those who graduated beyond pilots frequently did so by merging internal finances with public co-financing (regional vouchers, advisory grants, or project-based subsidies). The cross-country practice catalogues demonstrate similar toolbox—digital vouchers for the micro–SMEs, advisory grants in e-commerce and process digitization, targeted projects for cloud/AI/IoT, tax relief—aimed at lowering entry costs and external resource expenditure. For example, in the wake of the pandemic, Italian regional schemes provided support to employ remote work tools and training; Slovenia's "digital vouchers" supported strategy, competences, and cybersecurity; and Irish trading-online vouchers targeted online sales of micro-firms—evident types of instruments which wineries in our sample found or could realistically use together. Where individuals' capability is low, targeted partnerships—DIHs, universities, accredited consultants, logistics providers, consortia—provide the foundation for adopter growth. Policy handbooks identify DIHs at a key coordination point that stitches EU, national, and regional programmes together

(but avoids duplication) and directs SMEs to common labs and demonstrators that support regional aspirations – exactly the picture at the center of many of our vineyard-IoT and traceability pilots. The case-to-case picture corresponds with wider evidence from SMEs: digitalization payoffs exist, but smaller firms adopt second on account of finance, skills, uncertainty, and organizational inertia—hence the need for integrated packages enabling funding to go hand in hand with training and trusted intermediation. Public-support syntheses discover four recurring levers that most closely align with what we used in our cases: (i) enhance financing capacity for tech adoption; (ii) promote hard/soft digital skills through focused training and advisory; (iii) enhance the business environment (infrastructure, standards, platforms); and (iv) popularize digital strategies so that firms connect tools to goals rather than to stand-alone pilots.

For wineries at early maturity, the following is the minimum level of risk that we can identify in our cases: (1) diagnostic with a neutral intermediary (DIH/cluster); (2) test-before-invest prototype on a bounded use case (e.g., vineyard monitoring or D2C CRM); (3) pair funding (voucher/grant) with training/mentoring; (4) scale through a partnership contract clarifying data ownership, support, and KPIs. This chain captures the human-technology-finance triad advocated in SME-policy studies and witnessed in the best cases in this paper. Although these enabling levers are an integral part of the adoption of digital technology, there is evidence that there remain enduring differences between policy intentions and real-world performances. Small and small-scale, traditional wineries [A and G] often reported challenges accessing public funding, which could be attributed to a lack of administrative capacity and awareness of existing tools. Meanwhile, engagement with Digital Innovation Hubs or cooperative networks varied, benefiting some wineries significantly, while others languished. This observation also mirrors the literature definition of the “last-mile problem” with SME digitalization policies: in spite of a broader set of support mechanisms, the firms requiring it the most are often the firms least able to leverage the systems (Costa et al., 2023; Waye et al., 2023). This is why filling these gaps is critically important to ensure that public interventions are translated into inclusive, effective pathways of digital transformation through the fragmented wine sector.

### *4.7 Global and Sectoral Trends Shaping Digitalization (RQ6)*

The wineries in the sample are not only affected by internal and local influences but also by broader global and sectoral forces driving a digital transformation agenda. These external pressures presented themselves in interviews as opportunities to be seized and risks to be managed. There is a first trend of increasing focus on sustainability and ESG compliance. Many interviewees reported that consumers are more demanding of production details, environmental footprint, and authenticity. Winery E, for example, stressed that "younger visitors want to know how sustainable we are before they even taste the wine," while Winery B stated that blockchain-based traceability was now a must to satisfy such expectations in export markets. These considerations correspond with wider evidence that digital technologies (e.g., blockchain, IoT) are indispensable for assessing carbon footprints for transparency and adherence to the EU sustainability vision (Sabbagh et al., 2024; Galati et al., 2024; Waye et al., 2023). A similar development was described by Efficient and C (2022) regarding the potential for digital transformation in the wine industry in Australia. The other major trend is from Industry 4.0 to Industry 5.0. For wineries like H and I, digitalization was presented as not just about efficiency but also about how human workflows could be integrated with technology. From a modern perspective of digitalization, which refrains from defining digitization as a repudiation of tradition, instead conceptualizes it as a means through which values can be preserved and presented. Influences on consumer behavior are another contributor. In all those cases, wineries saw a move to experience-based consumption spurred by digital technologies. Winery E fused wine tourism with digital storytelling on TikTok and YouTube to reach younger consumers, while Winery D tried online tastings during the COVID-19 pandemic. This is complemented by literature showing positive trends toward "experiential wine consumption," wherein digital tools (e.g., D2C, personalized marketing, hybrid experiences) allow for these (Dressler & Paunovic, 2021; Mola & Roffia, 2024). Wineries also cited the effects of global competition and regulatory pressures. Interviewees from B and H, both producers of exports, underscored the importance of using digital tools to compete with "New World" producers and to meet more sophisticated traceability and certification requirements abroad. "Without digital proof of origin and compliance, we risk losing credibility in foreign markets," one export manager said. Such concerns stem from evidence that global markets value transparency

and digital readiness, and punish SMEs lacking the ability to meet developing international standards (Costa et al., 2023; Waye et al., 2023). Some wineries see these dynamic shifts as outside forces, but other wineries strategically reposition them as tools to further their level of authenticity and growth in the marketplace. In this sense, then, digitalization is not just a technology; it is also a cultural and strategic response to the systemwide shift to an agri-food and wine economy.

### *4.8 Summary of Findings*

This chapter introduced the empirical findings of 16 interviews in nine wineries located in Piedmont and the secondary data collected from company websites, social media, cooperative reports, and policy documents. The analysis was framed using the six research questions based on the key constructs defined within a conceptual framework. The results disclose a multifaceted and heterogeneous scenario on the digital transformation in the wine sector. Wineries see digital tools as strategic and offer efficiency, transparency, and market access while on the flip side they also have their own strategic outlook. While at the same time there are variations in adoption, the situation has been complex by financial constraints, skill scarcity, cultural resistance, and infrastructure deficit. Tech is usually adopted slowly and in limited places only at the stages of the value chain that are most directly linked with the winery strategy (e.g., blockchain for exports, IoT for sustainable viticulture, social media for local visibility). Family background is of dual importance at both the cultural (and sometimes economic) resistive stage and at the enabling stage, where digital is presented as a means to preserve authenticity. Finally, the cases also demonstrate the value of enablers like these in the country of employment, such as policy, financial incentives, training, and cooperative networks, which will lower costs, give SMEs an ability that they were less than able to gain by themselves. Last but not least, the greater global context (environment of sustainability imperatives, changing consumer preferences, and global competition) serves as catalysts that induce wineries to use digital technology despite the bad conditions inside them. Overall, the results reveal a dual aspect of digital transformation in wine, that is to say that it is a disruptive force against traditional practices and a strategic enabler, in which wineries keep their heritage but are able to compete in rapidly changing

markets. This duality sets the context for the comparative discourse with the existing literature in the next chapter.

*Table 4.1 Summary of findings across research questions*

| Research Question | Main Findings from Case Evidence | Interpretation |
|---|---|---|
| **RQ1. Perceived benefits of digital transformation** | Wineries identified transparency, efficiency, cost reduction, market expansion, and new business models (e.g., wine tourism, CRM-driven personalization) as key benefits. Export-oriented firms emphasized blockchain for consumer trust; smaller wineries focused on social media visibility. | Benefits are widely acknowledged but unevenly realized. Perceptions align with literature that digitalization enhances competitiveness and resilience. |
| **RQ2. Barriers and challenges** | Financial constraints, legacy systems, lack of digital skills, cultural resistance, weak infrastructure, and regulatory complexity were cited as major obstacles. Generational tensions amplified | Barriers are multidimensional: internal (skills, finance, culture) and external (infrastructure, regulation). These reinforce the digital divide in the sector. |

| | | |
|---|---|---|
| | resistance in traditional family firms. | |
| **RQ3. Adopted technologies and value chain stages** | Adoption is fragmented. IoT applied in vineyards (E, D); AI/CRM in production and customer management (I, B); blockchain in traceability and PDO compliance (B, H); ERP in cooperatives (F); social media and e-commerce widespread at marketing/sales stages. | Technologies are strategically adopted at specific value chain points, confirming incremental and context-dependent digitalization patterns in SMEs. |
| **RQ4. Tradition vs innovation tension** | Older generations often resist digitalization, viewing it as a threat to craftsmanship and authenticity. Younger successors act as digital champions. Some wineries (E, H) frame digital tools as protecting rather than undermining heritage. | Tradition and innovation coexist in tension. Resistance is cultural but can be reframed if digitalization is aligned with heritage narratives. |
| **RQ5. Enabling strategies and support** | Wineries leveraged policy programs (e.g., DIHs, vouchers, EU funding), capability-building initiatives (training, | Support mechanisms reduce adoption barriers when combining funding, skills, and partnerships. Access remains uneven, |

| | | |
|---|---|---|
| | mentoring), and partnerships (universities, consortia, cooperatives). Cooperative models (F) facilitated shared digital infrastructures. | favoring networked or export-oriented firms. |
| **RQ6. Global and sectoral trends** | Sustainability and ESG demands, shifting consumer expectations, Industry 5.0 discourse, and global competition drive digital adoption. Export wineries emphasized compliance and trust; tourism-oriented wineries emphasized digital storytelling and experience-based marketing. | Wineries interpret global trends both as external pressures and as opportunities to reinforce authenticity and expand market reach. |

# 5 Discussion

## *5.1 Introduction*

This thesis has explored the experience of small and medium wineries as they embark on a journey of digital transformation, focusing specifically on the effects of technology on the context where they operate, their organizational culture, and the support or resistance to digitalization from institutions. This chapter interprets the findings in relation to the literature and theoretical debates on digital innovation in traditional sectors, building on the conceptual framework developed in Chapter 2 and the empirical findings presented in Chapter 4. The discussion takes place in four phases. First, the findings are re-examined regarding each of the six research questions, alongside case evidence, literature insights, and areas of agreement and divergence. Second, the chapter describes the theoretical key contributions of the study and demonstrates how the findings contribute to the existing literature on digital transformation in SMEs and family businesses. Third, we highlight managerial and policy implications, showing how wineries, cooperatives, and institutions can use the findings to design more effective strategies to engage in digital transformation, inclusive and sustainable. Finally, limitations are discussed, and future work is proposed. By providing this framework, the conversation both contextualizes the results within the context of literature and outlines pragmatic advice available for practitioners and policymakers. In so doing, it reinforces the double role of digital transformation in the wine industry: as a disruptive driver pushing back against old-fashioned ways of doing things, as well as an enabling force that underpins heritage, competitiveness, and resilience in a fast-evolving world.

## *5.2 Revisiting the Research Questions*

### *RQ1 – How do SMEs, such as those operating in the wine sector, perceive the strategic benefits of digital technologies in terms of value chain transparency, cost reduction, market access, and innovation in the business model?*

The sample of wineries across five different markets confirmed that digital transformation is perceived as a package of positive effects rather than as a single innovation. Interviewees mentioned transparency and traceability (e.g., blockchain for PDO certification), operational efficiency (ERP in cooperatives, IoT in vineyards), market

expansion (i.e., e-commerce for exports), and new business models (CRM-based personalization, digital wine tourism). These results mirror earlier studies, which have highlighted transparency, efficiency, and innovation as primary advantages of digital adoption within agri-food SMEs (Dressler & Paunovic, 2021; Costa et al., 2023; Galati et al., 2024). This research contributes to the literature by highlighting diversification into wine tourism as a digital driver. Whereas previous studies were about supply chain transparency and efficiency specifically, the cases indicate that tourism-related wineries (E and I) strategically utilized digital storytelling and social media as a tool to enrich customer experience. This suggests that digital transformation in wine SMEs is extending far beyond end-to-end procedures and is now linked to the creation of experiential value.

***RQ2 – Which are the most frequent barriers and challenges that hinder the digital transformation of wine SMEs (e.g., financial constraints, legacy systems, resistance to change, low digital skills, regulatory complexity)?***

As expected from the literature (Costa et al., 2023; Waye et al., 2023; Dressler & Paunovic, 2021), the most common barriers and constraints are legacy systems, poor absorptive capacity, low digital skills, and cultural resistance. Furthermore, external hurdles like poor broadband service availability in the rural areas or regulatory complexity (particularly for export-oriented wineries) had a common emphasis that corroborated previous reports of structural and institutional barriers (Silvestri et al., 2023; Sabbagh et al., 2024). This study adds valuable insights to the issue by revealing how and where these barriers interlink and reinforce each other. For example, poor financial resources restrict investments in training, which furthers the absorptive capacity deficit. In addition, the analysis underscores the "hidden" costs of implementation (e.g., training, cybersecurity, system integration) that are regularly ignored in policy design but were found in strong evidence in interviews. This offers a more subtle appreciation of why digital transformation is still far from uniform in small wineries when policy supports are becoming more widespread.

***RQ3 – Which are the most frequent digital technologies used by wine SMEs, and what stages of the value chain do they cover?***

The uptake of the product is shown to be fractured and stage-based. IoT products were adopted in viticulture (vineyard supervision and precision irrigation), AI/CRM in the production-customer processes, blockchain technology for logistics and certification, and ERP in cooperatives for resource sharing, as well as social media/e-commerce in the marketing and sales stage. Such data also confirm previous studies indicating incremental and uneven digitalization in agri-food value chains (Costa et al., 2023; Festa et al., 2024; Galati et al., 2024). The novelty of the study lies in its detailed mapping of the technologies in the spectrum of the value chain, as well as in its findings showing that wineries adopt selectively in the course of their strategic priorities. For example, wineries in export settings leaned toward blockchain for compliance and transparency, while wineries at the local level emphasized core IT and social media. This also lends weight to the hypothesis that SMEs' digital maturity is not linear, but rather a function of market orientation and resource endowments.

***RQ4 – How do small, family-owned, and heritage-based wineries resolve the tension between tradition and innovation in the pursuit of digital transformation?***

The case evidence indicates that tradition and innovation live in a dynamic tension. In the case of multigenerational wineries (A, D, I), older owners had also resisted digitalization because they saw it as a dilapidation of craftsmanship, while younger successors were seen as "digital champions," promoting e-commerce, CRM, or IoT. This is consistent with existing literature that demonstrates the potential for family legacy to assist and hinder digital transformation (Costa et al., 2023; Dressler & Paunovic, 2021; Paunović et al., 2022). The research enriches the debate by demonstrating that resistance is not only generational; it is also organizational or cultural. In wineries C and G, experienced employees refused to adopt digitization for fear of the alteration in workflow, a de-personalization of customer relationships. Meanwhile, some wineries were redefining digital tools as custodians of heritage: For instance, Winery H employed blockchain to protect PDO certification, while for Winery E, digital storytelling celebrated terroir. This is that aligning culture and narrative helps to reconcile tradition versus innovation--a dimension hidden in the literature that can paint resistance simply as a linear block

movement.

***RQ5 – How is it possible for wineries to develop the skills that are necessary to adopt and incorporate digital tools (e.g., collaboration agreements, cooperative networks, public support)?***

SMEs rely heavily on mechanisms to support them: public policies on entrepreneurship and its environment (DIHs); programmes of capacitating capacity to develop in new areas or by taking advantage of opportunities (coaching); partnerships (universities, cooperatives, technology suppliers). Cooperatives like Winery F proved how collective structures can help with shared resources and accessing ERP and e-commerce platforms typically not applicable to individual SMEs. This is consistent with the literature, placing importance on networks, consortia, and public–private partnerships for the digitalization of SMEs (Galati et al., 2024; Waye et al., 2023). But the research also found a policy–practice gap. Much recent research has investigated this problem, since many small and traditional wineries simply did not have the administrative infrastructure or know-how to access funding opportunities. Adding to the digital divide in the space, this "last-mile problem" in SME policies (Costa et al., 2023). And, ultimately, the study shows how enabling strategies exist, but their effectiveness is a function of accessibility and local institutional mediation.

***RQ6 – Which tactics can be suggested to help the wine industry in its sustainable, inclusive, and culturally sensitive digital transition?***

Through the cases, we found that wineries are influenced heavily by global and specific sectoral trends such as sustainability objectives, ESG conformity, changes in consumer norms, and international competitiveness. Wineries with export emphasis (B, H) adopted the use of blockchain and electronic commerce to compete and meet global trade and traceability requirements, while those that are tourism-oriented (E, I) utilize digital storytelling and social media to enhance experiential marketing. These results align with the wider literature regarding the influence of sustainability and consumer-centric trends on the emergence of digital strategies (Sabbagh et al., 2024; Galati et al., 2024; Waye et al., 2023). The value of this study is to illustrate how these pressures are construed in wineries both in terms of external burdens (ex: compliance costs, regulatory complexity)

and as strategic opportunities for authenticity reinforcement, product differentiation, and market expansion. Through a focus on this ambivalence, the study expands from compliance-level analyses to demonstrate how digital transformation can simultaneously reinforce resilience and cultural continuity.

### *5.3 Theoretical Contributions*

There are several significant ways this thesis adds to the accumulating body of literature on digital transformation in SMEs and the traditional sector. Previous research has emphasized the prospects of utilizing digital technologies to improve transparency, efficiency, and competitiveness (Costa et al., 2023; Dressler & Paunovic, 2021; Galati et al., 2024), but this study advances the discussion by showing how digitalization plays out in deeply entrenched heritage-driven environments, such as family-owned wineries. Firstly, the research highlights intergenerational dynamics as pivotal to the digital transformation of wine SMEs. Whereas earlier research found cultural resistance and managerial conservatism as obstacles (Paunović et al., 2022; Waye et al., 2023), this study shows the role of younger successors in becoming the champions of the digital culture, not only delivering new tools but also re-presenting these tools in terms of congruency with tradition. This demonstrates how family ownership can act as an obstacle as well as an enabler, depending on how generational transitions are handled. Second, the results reveal wine tourism as the catalyst of digitalization, a dimension little discussed in previous literature. Wineries that merged production with hospitality services (E and I) put more resources into social-media promotion-driven social-communication, digital storytelling-led experience, marketing program, and so on. This indicates diversification into tourism offers further incentive for digitalization, with innovation tied to innovation not only in terms of efficiency but also in experience-based value creation. Third, the study highlights the crucial role of collective structures, i.e., cooperatives and consortia, as potential mediators of digital transformation. Although prior studies have addressed resource constraints for SMEs (Costa et al., 2023; Galati et al., 2024), the case of Winery F shows how a common ERP system and e-commerce platforms help small wineries surmount their individual limitations. This proves that the digitalization of fragmented industries is its ro,ot a networked and not firm-level phenomenon. Fourth, the research adds to discussions on the dichotomy of digital transformation, which demonstrates both

the emergence of digitalization as a disruptive force in the business process and digitalization's role in protecting authenticity. Blockchain and traceability systems, while sometimes viewed as costly compliance tools, were reframed as guarantees of heritage and terroir in other wineries. This ambivalence enables us to broaden the theoretical understanding of the relationship of digital tools to cultural and identity politics in traditional sectors. Finally, this study adds nuance to the policy debate by clarifying the gap between policy intentions and the practical implementation. Despite a range of EU and national interventions, the wineries that required support the most (smaller, traditional, heritage-based) were often not sufficiently supported technically or intellectually to access them. While underscoring an empirical case in support of the "last mile problem" in SME digitalization policies (Waye et al., 2023), the research shows that local institutional mediation must also be utilized in bridging the gap. Overall, the study contributes to the theoretical discussion by presenting digital transformation as cultural, generational, and institutional rather than merely a technological or economic process. This perspective can enhance understanding of digitalization in heritage-oriented SMEs and offer a contextualized view that can help to bolster the models of digital maturity and adoption.

While this thesis focused on the digital transformation of small and medium-sized wineries in Italy, findings have wider implications for other traditional, heritage-based industries that experience comparable tensions between cultural preservation and innovation. Cheese, olive oil, specialty coffee, and craft beer, in which traditional roots dominate, share many of the structural characteristics of wine SMEs: family ownership, strong attachment to place and tradition, fragmented value chains, and resource constraints. The concurrent role of digital transformation as a disruptor of the status quo and an enabler of heritage preservation is equally relevant in these contexts. The barriers that we identify in this study — financial limitations, low absorptive capacity, and cultural resistance — are not exclusive to the wine field, and present challenges across agri-food SMEs globally. Also, the building blocks presented here (collaborative relationships, cooperative systems, targeted policy interventions, etc.) can be the templates for other sectors that face the digital transformation and want to maintain authenticity. Last but not least, global forces driving the wine industry, such as the need for sustainability, evolving consumer attitudes, and regulatory pressures, are also altering established food and craft

industries, more broadly speaking. In this regard, the insights of this thesis can be used by policymakers, industry associations, and entrepreneurs in a range of fields where digital transformation should be balanced against the loss of cultural heritage and artisanal values.

### *5.4 Managerial Implications*

These implications offer several implications for small and medium-sized owners of small and medium-sized wineries concerned about digital transformation who need to still preserve the cultural and craft characteristics. First, digital transformation is a staged and selective transition, not a radical transformation. The cases suggest that wineries see the best performance when technologies are deployed that complement their current strategic aims, for example, blockchain for exporting, IoT for vineyard efficiency, or CRM for client-driven touchpoints. This staged strategy enables firms to address and minimize costs, decrease risks, and develop internal skills set in stages, resonating with wider findings regarding gradual rollout in SMEs (Costa et al., 2023; Galati et al., 2024). Second, generational transition is an opportunistic opportunity for digitalization. In all the cases (A, D, I), younger heirs were key in the push towards digital solutions and in maintaining the heritage story of the winery. Managers need to know these intergenerational dynamics and to actively promote knowledge sharing between senior members who protect tradition, and junior members who enter the world with digital skills and open minds. Third, wineries must invest in the process of developing internal digital capacity, even at a rudimentary stage. Whilst a dependency on consultants or collaborative assistance is productive, it reveals that SMEs that lack internal absorptive capacity have difficulty appraising technologies, bargaining with providers, and incorporating the utilities into their practices. Just less dependence and more capacity - something as simple as training staff in digital literacy, appointing a “digital contact person” or encouraging younger staff to mentor colleagues. Fourth, joint ventures and ties may help relieve limitations on resources and spread risks. The cooperative (Winery F) model demonstrates just how pooling resources provides smaller wineries with access to ERP systems, e-commerce solutions, and training opportunities that would be beyond their means. Likewise, collaborations with universities, consortia, and technology companies offer access to information, infrastructure, and capital. Therefore, managers

should strive to look beyond the borders of one firm and take part in regional or industry networks. Fifth, digital tools can be couched as a means of authenticity-enhancing rather than anti-authenticity strategic framing. Wineries like H and E showed how blockchain and digital storytelling can reinforce heritage narratives and terroir authenticity to consumers. Traditional winery managers need to preach about how digitalization preserves and transmits tradition, instead of making it obsolete. There are ways of refocusing that can help overcome internal resistance and build consumer trust in this effort. Lastly, in its final stages, managers should have a long-term strategic mindset for digital transformation. What we found was that ad hoc, reactive adoption was frequently hamstrung by inefficiency or misuse of existing tools. Managers should instead articulate digital goals — efficiency, internationalization, tourism, sustainability, to name a few — and tie those investments in technology to those objectives. Even small wineries benefit from road mapping and performance monitoring: this helps ensure that digital adoption helps a broader strategy instead of just some quick fixes in the short term.

### *5.5 Policy Implications*

The findings here can also have significant implications for policymakers and other organizations who are attempting to encourage digital innovation in legacy-based SMEs. Although there has been a plethora of other initiatives in place already at the EU and national governments (CAP, Horizon Europe, NextGenerationEU, Digital Europe), the results demonstrate the strengths and limitations of these initiatives in terms of implementation. First, make it easier to access digital money and less time-intensive to be an admin-heavy entity. Smaller wineries did not have the necessary knowledge, administrative experience, or time to apply for any of the grants or vouchers they could seek, and thus, support instruments by organizations like cooperatives and export-oriented companies were primarily available to larger ones. Public service delivery policies should therefore simplify application processes, reduce reporting requirements, and provide tailored advisory services suitable for small, family-owned businesses. In the absence of such simplification, policy tools risk widening instead of closing the digital gap (Costa et al., 2023; Waye et al., 2023). Second, reinforcing local mediation structures to tackle the “last-mile problem.” In our cases, digital innovation hubs, chambers of

commerce, and cooperative networks were valuable, but we saw uneven engagement. Policies should invest in enabling these intermediaries to actually "reach out" to smaller wineries, deliver "test-before-invest" facilities, and provide sector-specific digital road maps. This would ensure that policies made at the EU regional or national level can be effectively adapted to local situations. Third, invest more in upskilling people in digitalization and human capital development. Absorptive capacity and digital literacy were the key barriers in all cases. Beyond technology subsidies, policy should fund short, practice-oriented training programs on digital tools (CRM, e-commerce, blockchain dashboards) and encourage mentorship schemes pairing younger successors with senior managers. This addresses not only technical skills but also cultural resistance by framing digitalization as compatible with heritage. Fourth, match digitalization policies in the direction of sustainability and authenticity. Digital adoption was a compliance need for many wineries. How can technology help defend terroir, counter fakery, improve environmental reporting, and strengthen cultural identity, rather than undermine them, should be given explicit emphasis in policies? Especially in sectors where value creation is rooted in tradition and place authenticity, this alignment is key. Fifth, promote a cooperative networked solution. Winery F and other similar examples indicate that collective structures save money and minimize the odds of cost and adoption risk. Policymakers instead should implement incentives to encourage inter-firm collaboration, whether it is through cluster-based digital platforms, shared ERP solutions, or joint training schemes. These projects can draw upon existing PDO/PGI consortia and cooperatives as institutional pillars for the sector-level digitalization agenda. In summary, these results indicate that while a financial element is necessary, SME digitalization interventions in traditional sectors should be scaled up. Reach, Mediation, Human Capital, Culture Fit, and Collaborative Models. Policymakers can design interventions around the particular attributes of heritage-led SMEs in a way that digital transformation is not just a technological solution, but also inclusive and culturally sustainable.

### *5.6 Limitations and Directions for Future Research*

Just like all qualitative research, the results of this study should be viewed with certain limitations, which should be considered along with the possibility for further

investigations. This study drew empirical attention from wineries in the Piedmont region, a special area that features distinctive cultural, economic, and institutional aspects. Although this offers a rich understanding of the dynamics of heritage-driven SMEs, it also constrains the generalizability of the findings. As a way forward, studies in Italy, Europe, and the "New World" (e.g., Chile, Australia, USA) are needed to compare the outcomes in different wine regions by institutional frameworks/market conditions, and explore digital transformation trajectories.

Second, the sample size is suitable for in-depth analysis of cases, but it does not represent the diversity of the Italian wine sector. Larger analyses, specifically mixed-methods ones that mix surveys and statistical analysis, could validate the patterns suggested and generalize them, particularly pertaining to how market orientation, generational dynamics, and digital maturity interrelate.

Third, the qualitative nature of the study prioritized depth instead of breadth. Interviews gave nuanced perceptions, strategies, and experiences, but longitudinal analysis on digital adoption dynamics (regarding generational transitions or shocks such as climate change or market disruptions) could better complement the findings.

Fourth, the study demonstrates the role of cooperatives, networks, KS, and policy instruments, but cannot systematically measure the impact of these instruments. Additional research could facilitate the design of frameworks and indicators to help measure the effectiveness of these enabling strategies to bridge digital divides, enhance SME competitiveness, and cultivate inclusive innovation.

Finally, rapid technological change requires ongoing analysis. New tools such as AI for predictive analytics, immersive technologies for digital wine tourism, and carbon-tracking devices for ESG reporting will rewire the industry in the years to come. Future inquiries may consider how the SMEs actually utilize these new technologies and the ethical/cultural/economic considerations they generate. To conclude, although the research findings offer a sound basis for interpreting the impact of digital transformation on wine SMEs, the geographical range, sample diversity, mixed and longitudinal design, and new technologies should be broadened, and further studies should be conducted. Such research will contribute to knowledge enhancement, helping ensure that strategies are flexible and stay agile to respond to the digital transformation challenges and opportunities in traditional sectors as they change.

### *5.7 Conclusion of the Discussion Chapter*

This chapter placed the empirical results within the larger academic discussion on digital transformation for SME and traditional companies' context of technology. When reviewing 6 research questions, the analysis was able to confirm that research contributions found in research on barriers, benefits, and enabling strategies remain relevant, while building upon this base and adding contextual elements, especially on intergenerational dynamics, wine tourism, and local cooperative structures. Several theoretical contributions were identified, which positioned digital transformation as not only a technological or economic phenomenon, but also a cultural and institutional negotiation. It also described managerial implications, emphasizing gradual and strategic adoption and capability-building while reframing digital tools as protectors of authenticity. The study was also a good primer on how we have to manage the challenges in a digital age and the ways that we can change organizations for the better to tackle these. For policymakers, the findings highlight the need to make funding easier, create pathways for local mediation, prioritize the provision of skilled resources, and develop intercultural support frameworks. Limitations of the study were recognized, as were options for future research that might expand the empirical coverage, employ longitudinal and mixed methods, and analyze technology adoption. Ultimately, the conversation supports the main thesis of this thesis: that the transformation of the wine industry digitally is a two-way process, disruptive in its challenges but ultimately making it even more resilient and in a position to provide a valuable competitive advantage. This insight also paves the way for the final chapter, in which the effects of the study are discussed in its larger context.

# 6 Conclusion

## *6.1 Restating the Purpose*

This thesis sets out to explore how small and medium-sized wineries navigate digital transformation in a sector characterized by strong traditions, cultural heritage, and fragmented structures. The central research question asked how wine SMEs adopt digital tools and what strategies they develop to overcome adoption barriers. By combining semi-structured interviews with secondary sources, the study provided insights into the perceptions, challenges, and strategies of wineries in Piedmont, situating them within the broader European and global debates on digital innovation in agri-food industries.

## *6.2 Main Findings*

The empirical analysis revealed a dual reality. On one hand, wineries recognize the benefits of digital transformation in terms of transparency, efficiency, market access, and innovation. On the other hand, adoption remains uneven due to financial constraints, skill shortages, cultural resistance, and infrastructural gaps. Technologies are introduced selectively and incrementally, often guided by market orientation, with export-oriented firms adopting advanced tools such as blockchain and CRM, while locally oriented wineries rely primarily on basic IT and social media.

Intergenerational dynamics emerged as a defining factor, with younger successors acting as digital champions and reframing innovation as compatible with heritage values. Wine tourism was identified as a significant driver of digital adoption, as diversification into hospitality incentivized investment in storytelling, social media, and experiential platforms. Cooperative structures and partnerships proved to be essential enablers, mitigating resource limitations and facilitating access to shared infrastructures. At the same time, gaps between policy intentions and practical implementation highlighted the need for more accessible and inclusive support mechanisms. Finally, the findings underscored the influence of global trends, sustainability imperatives, changing consumer expectations, and international competition on wineries' digital strategies.

## *6.3 Contributions of the Study*

The study contributes to the literature by:

- Demonstrating how intergenerational dynamics shape the pace and framing of digital transformation in family-owned SMEs.
- Identifying wine tourism as an underexplored but powerful driver of digital adoption.
- Highlighting the role of cooperative structures as effective enablers in fragmented industries.
- Extending theoretical debates on digital transformation by showing its dual role as both a disruptive force and a protector of authenticity in heritage-driven sectors.
- Providing empirical evidence of the policy–practice gap that limits the inclusiveness of EU and national support measures for SMEs.

### *6.4 Practical and Policy Relevance*

For managers, the findings underline the importance of incremental, strategically aligned adoption, investment in digital skills, and partnerships that reduce risk. For policymakers, the study calls for simplifying funding access, empowering local intermediaries, and aligning digital tools with sustainability and authenticity goals. Together, these insights can inform more inclusive, culturally sensitive strategies to foster digital transformation in the wine sector and beyond.

### *6.5 Limitations and Future Outlook*

As a qualitative, context-specific study, the findings are not intended for statistical generalization. Instead, they offer rich, contextualized insights that future research can build on through comparative, quantitative, and longitudinal approaches. With technological innovation accelerating and consumer expectations evolving, continued investigation into how traditional SMEs adapt and how institutions can support them remains essential.

### *6.6 Closing Reflections*

This thesis has shown that digital transformation in the wine sector is not merely about technology but about negotiation—between tradition and innovation, between local heritage and global markets, and between institutional frameworks and entrepreneurial agency. By framing digitalization as both a challenge and an opportunity, wineries can

not only preserve their cultural identity but also enhance their resilience and competitiveness in a rapidly changing world.

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# Appendix

***Appendix A. Summary of Illustrative Quotations by Construct/Research Question***

| **Construct / RQ** | **Example Quotation** | **Winery / Interviewee** |
|---|---|---|
| **Perceived benefits (RQ1)** | *"Blockchain helps us prove the authenticity of our Barolo abroad. Customers trust us more when they can scan and see the full history."* | Winery B – Export Manager |
| **Perceived benefits (RQ1)** | *"Using IoT sensors in the vineyard reduced our water use and made us more efficient. Before, we just guessed."* | Winery E – Owner |
| **Barriers to adoption (RQ2)** | *"We cannot afford to invest in systems that will only pay off after years, when we have to survive harvest by harvest."* | Winery A – Owner |
| **Barriers to adoption (RQ2)** | *"My father doesn't see the point of digital tools. He thinks it undermines our artisanal work."* | Winery D – Daughter |
| **Adopted technologies & value chain (RQ3)** | *"We use CRM to follow our wine club members and personalize offers. It helps us keep relationships alive even online."* | Winery I – Successor |
| **Tradition vs. innovation (RQ4)** | *"Digital risks making our wine less personal. People come here for us, not for an app."* | Winery G – Owner |
| **Tradition vs. innovation (RQ4)** | *"Instagram is not just a tool, it's how we tell our story and keep our heritage alive for young people."* | Winery E – Owner |
| **Enabling strategies (RQ5)** | *"As a cooperative, we can invest together in ERP and e-commerce platforms. Alone, we would never manage."* | Winery F – Manager |

| | | |
|---|---|---|
| **Enabling strategies (RQ5)** | *"The regional digital voucher paid for half our e-commerce project. Without it, we wouldn't have tried."* | Winery H – Export Manager |
| **Global/sectoral trends (RQ6)** | *"Younger visitors want to know how sustainable we are before they even taste the wine."* | Winery E – Owner |
| **Global/sectoral trends (RQ6)** | *"Without digital proof of origin, we risk losing credibility in Asia. Buyers there demand it."* | Winery H – Export Manager |

***Appendix B. Interview Guide***

**Introduction to the interview**

- Thank the participant for their time.
- Explain the purpose of the study: to explore how small and medium-sized wineries are experiencing and approaching digital transformation.
- Reassure about confidentiality and anonymity.
- Ask for consent to record the interview.

**Section 1: Background Information**

1. Can you briefly describe your role in the winery?
2. Could you tell me a little about the history and organization of the winery (size, family structure, markets served)?

**Section 2: Perceived Benefits of Digital Transformation (RQ1)**

1. In your experience, what advantages can digital technologies bring to wineries like yours?
2. Do you think digital tools improve efficiency or reduce costs in your operations?
3. How important is transparency and traceability (e.g., showing wine origin or production process) for your customers or markets?
4. Have you seen digital tools open new market opportunities for your winery (e.g., exports, direct-to-consumer sales)?

**Section 3: Barriers to Digital Adoption (RQ2)**

1. What challenges or difficulties do you face when trying to introduce digital tools?
2. How do financial aspects influence your decisions about investing in digital technologies?
3. Do you feel there are enough digital skills within your winery to manage these tools?
4. How do traditions or generational perspectives within your family/business affect digital adoption?
5. Have regulations or infrastructure (e.g., internet connectivity) posed challenges?

**Section 4: Adopted Technologies and Value Chain Stages (RQ3)**

1. Which digital technologies are you currently using (e.g., social media, e-commerce, blockchain, IoT, CRM, ERP)?
2. At what stages of your value chain (vineyard, production, logistics, sales, after-sales) are these technologies applied?
3. Are there technologies you would like to adopt in the future but haven't yet? Why?

**Section 5: Tradition vs. Innovation (RQ4)**

1. How do you balance your winery's heritage and traditions with the need to innovate?
2. Do you see digital tools as a threat to authenticity, or as a way to strengthen it?
3. How do different generations in the winery (if applicable) view digital transformation?

**Section 6: Enabling Strategies & Support (RQ5)**

1. What kind of external support has been useful to you (e.g., public funding, regional programs, cooperatives, consultants)?
2. Have you collaborated with other wineries, cooperatives, or technology providers to adopt digital tools?
3. What type of training or knowledge do you think would help wineries like yours most in using digital technologies?

**Section 7: Global and Sectoral Trends (RQ6)**

1. Have changing consumer expectations (e.g., sustainability, transparency, experiences) influenced your winery's decisions about digital tools?
2. How do you perceive global competition (e.g., "New World" wines) and regulatory pressures in relation to digitalization?
3. Do you think digital technologies can help address challenges such as climate change, sustainability, and certification requirements?

**Closing Questions**

1. Looking ahead, what role do you see digital transformation playing in the future of your winery?
2. If you could change one thing (policy, support, training, funding) to make digital adoption easier, what would it be?

**Wrap-up**: Thank the participant, remind them about confidentiality, and ask if they would like to receive a summary of the findings once the thesis is completed.