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Risk management in wine supply chain: a state-of-the-art analysis

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Abstract

Although the wine market is experiencing significant growth, the Wine Supply Chain (WSC) remains remarkably fragile and susceptible to risky events that can impact vine health and wine quality. These factors, in turn, affect the performance of the entire chain. The distribution of vineyards is highly diverse, and in some cases, situated in extremely fragile territories. The evolution of climate change further exacerbates these vulnerabilities, exposing farms to several risks that, if not properly managed, can threaten production. To navigate the highly dynamic environment characterizing the Wine Supply Chain, there is an increasing need for proactive strategies through the introduction of tools that assist managers in avoiding and/or mitigating potential risks within the value chain. These strategies aim to preserve product quality and integrity, enhancing the resilience of the entire WSC. Despite the higher relevance of risk management in wine than in other agricultural industries and related supply chains, as the raw-material transformation constitutes high-level value-added processes, the scientific literature seems to lack an overall analysis related to the risk strategies and methods developed over the last years in the field of WSC. Therefore, the primary objective of this research is to provide a comprehensive analysis of the current state of Risk Management in the Wine Supply Chain. The study aims to: (i) identify the main processes and associated risks, (ii) establish the primary methods and tools developed by researchers to date, and (iii) highlight the key gaps that need to be addressed. The findings indicate a growing focus on agricultural risk events and reveal a lack of comprehensive methods that encompass the entire Wine Supply Chain—from farmers to end consumers—despite technological advancements in agriculture, logistics, and production. This gap underscores the need for integrated risk management approaches to prevent the degradation of business performance.

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Keywords: Wine Supply Chain; Risk Management; Resilience; Climate Change

1. Introduction

The wine industry, one of the oldest activities in the agri-food sector, is a key economic activity for many nations. World wine production is estimated at about 230 million hectoliters (2022) and has a market value of about 250 billion euros. Europe is the main producer with an annual growth rate of 6%. Overall, Italy, which has an estimated market value in 2021 of about 15 billion euros, produced about 44 million hectoliters in 2023 on a cultivated area of 6200 km^2 and has

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an estimated market value in 2025 of about 19 billion euros [1]. In Italy, the diversified distribution of vineyards, and the extremely fragile territories can expose vineyards to risks that, if not properly managed, can threaten production. To cope with the continuous process of change associated with both globalization and the highly dynamic environment [2], improving the effectiveness and efficiency of the Wine Supply Chain (WSC) is becoming crucial to the competitiveness of companies, which in recent years have begun to focus on improving product quality rather than quantity [3]. Achieving these objectives is not trivial, given the extreme fragility of the WSC, which is characterized by seasonality, periodicity, regionality of production, and the perishable nature of the products [4]. Climate change plays a key role in the vulnerability of the WSC, affecting yield, berry composition, vine health as well as wine quality, which in turn affects the businesses' performance [5]. The conservation of natural resources such as water and soil are also under threat. Indeed, water and soil are closely linked and climate change can threaten the amount of water reaching the soil and change land use and cover [6]. The wine production process itself also plays a key role in climate change. It is still far from being environmentally friendly [3].

In addition, the WSC is also highly complex due to the greater length, numerous actors and relationships between them, the needs of final customers, and the legal constraints [7, 8]. Given this complexity of the chain, the interrelationships between the actors and its extreme fragility, linked above all to the uncertainty that characterizes the various processes, the concept of resilience, i.e. the ability to anticipate negative disruptive events, respond adaptively and avoid extremely negative effects, becomes fundamental to establish a more profitable position after the event to obtain a competitive advantage. Specifically, the ability to control the complexity enables cost efficiency and risk reduction. The estimation of risk leads to better risk management, reduces the extent of losses, and improves supply chain resilience [9]. Contingency planning for disruptions makes companies resilient and provides a competitive advantage. Recent disruptions that have affected the overall performance of the entire Supply Chains (SCs) include the COVID-19 pandemic, or the war in Ukraine, resulting in increases in energy and raw material prices [2]. Especially in globally distributed supply chains where companies increasingly align key suppliers and buyers for competitive advantage, risk dependency, and risk propagation have become critical issues [10]. Anticipating risk propagation within and between firms can enable predictive or proactive risk management strategies [10]. To do this, given the complexity and the multi-layered supply chain environment [11], it is important to understand the interactions within and between firms because the implementation of some firm-specific risk mitigation strategies may not lead to the expected performance and may negatively affect the performance of the other actors of the SC itself.

This context highlights the importance of Supply Chain Risk Management (SCRM) defined as a systematic and phased approach for recognizing, evaluating, ranking, mitigating, and monitoring potential disruptions in supply chains [12, 13]. This requires several activities, such as risk identification, risk assessment, and risk treatment [2]. The first activity is useful for the identification of the main events that may occur to classify them and, subsequently, to manage them. Risk assessment involves the use of qualitative or quantitative methods to arrive at the treatment stage, where the risk can be accepted, mitigated, or transferred in accordance with the expected level of damage. SCRM is an important area due to an incident's cascading effects on logistics networks [2]. Although the topic of risk is fundamental nowadays, it is more relevant in the wine than in other agricultural industries, as the raw-material transformation and wine production constitute high-level value-added processes compared with many other agricultural products, and these processes are mainly generated along localised wine supply chains and within territorial clusters [2].However, until now researchers have never focused their attention of the overall risk management in the wine supply chain from a managerial point of view.

Over the next 10 years, as reported in the study by Lockshin et al. [14], risks related to climate change, water availability, labour issues, etc. will strongly affect the supply chain for all types of wine businesses and up to now the works have focused narrowly on the single issue and a single country or region. Scientific literature has drawn attention to the topic of Supply Chain Risk Management without a specific focus on the Wine Supply Chain [15–17], whereas only one general overview of risk management in the wine industry has been proposed by Seccia et al. focusing on economic literature analysis [18]. For this reason, a scoping literature review specifically based on Risk Management in the Wine Supply Chain has been carried out to investigate the main actors, processes, and risks involved in WSC, highlighting the method and model developed by researchers to identify, assess and manage risks over the supply chain and identifying the main research gaps and trends. This review will provide useful insights for academic practitioners detailing the actual state of the art and identifying the possible trajectories for future research.

The structure of this paper is organized as follows. In Section 2, the methodology used to investigate the literature is described, whereas Section 3 discusses the main findings of the review, and Section 4 presents the implications, limitations, and future research directions in this research topic and draws the main conclusions of this work.

2. Research Methodology

Due to the high complexity and heterogeneity of the topic of this study, it is based on a scoping literature review, instead of a precise systematic literature review of the evidence, to identify research gaps and set the scene for a future research agenda [19]. Based on the research aims, this study attempts to address the following Research Questions (RQs).

- *RQ1: What are the processes, actors, and risks involved in the Wine Supply Chain?*
- *RQ2: What are the tools/methods used for managing risks along the entire Wine Supply Chain?*
- *RQ3: What are the research trends and gaps in the Wine Supply Chain Risk Management?*

To answer these RQs, a research activity has been carried out in four consecutive steps: (i) the definition of keywords; the literature database search under constraint; (ii) paper selection according to screening criteria; (iii) analysis of selected papers, and (iv) data extraction. This research, carried out in May 2024, is based on the results of the Scopus database.

According to the aim of the study, the search string, which covered the titles, keywords, and abstracts of the papers, was constructed by combining the three main research themes: the wine sector ("Wine*", "Grape*", "Vine*", "Viti*"), the supply chain ("Supply chain*") and the risk management ("Risk*"). Each keyword was inserted as a disjunction combination of elements (operator "OR"), while each group was combined through a conjunction operation (boolean operator "AND"). Then, the search was limited to papers written in English in the last 20 years (2004-2024), and whose document type was conference proceedings, articles, or reviews. In the next step, papers were selected according to specific inclusion/exclusion criteria. In particular, papers were excluded if they (i) analyzed the presence of chemicals in the fruit (grape or otherwise), (ii) proposed methods only to increase the sustainability of the WSC, and (iii) addressed the Wine Supply Chain issue from a strictly economic perspective or (iv) were not related to the wine industry. On the other hand, all papers that involved Risk analysis, Risk assessment, Risk management, or that described the structure of the WSC, including processes, actors, events, and/or required resources, were included.

Firstly, by reading the title and abstract it was possible to delete all papers that were not related to the main topic of the research; secondly, by reading the full text, the most relevant papers that enabled to answer the above-mentioned RQs were identified. Lastly, relevant information on the papers resulting from the second screening was collected. The carried-out analysis was focused on the main bibliometric characteristics of the article (such as type of document, source, etc.), the supply chain processes investigated, and the "actors" involved, the main Business Continuity Objectives to be achieved, the main risks identified or analyzed, and the risk management method, approach or tool developed by the researchers.

3. Quantitative and qualitative analysis

Interestingly, despite the keywords set in the query, the topic of Risk Management in the Wine Supply Chain has been found among the goals of the articles in a limited number of cases. The number of articles that resulted from the search was 47. The first screening stage allowed us to exclude 29 papers not in line with the objectives of this research work. Finally, only 14 articles were selected according to the exclusion criteria described in Section 2. All the details of the screening process can be found in Fig. 1.

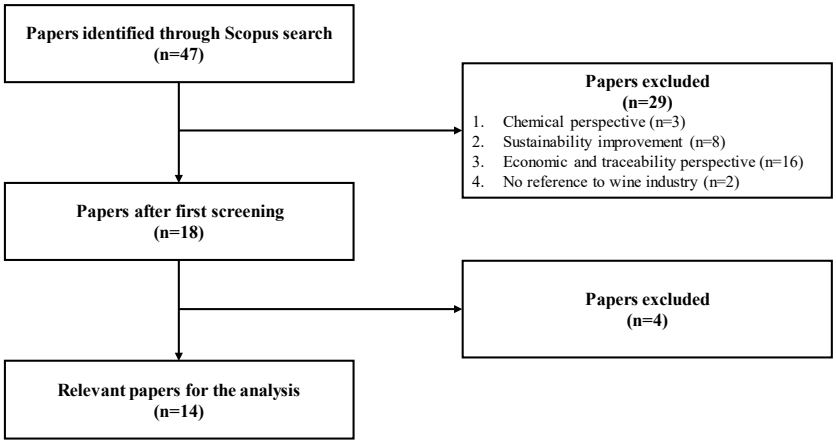


Fig. 1. Scoping Literature Review Process and Results.

In line with the growing interest in SCRM over the last 10 years [14], the chosen studies covered a time horizon ranging from 2014 to 2024 (only 1 paper was published in 2004) with a peak observed in 2022 (4 papers). Regarding the type of article, all of them were published in peer-reviewed journals (13 articles and 1 review).

3.1. RQ1: Processes, actors, and risks

For the continued growth of the wine market by increasing its market value and contributing to the development of the agri-food sector, the proper functioning of the WSC is essential. If any single node fails, the negative consequences affect both the business performance of all those involved in the supply chain and the quality of the finished product itself. Thus, given the main characteristics of the Wine Supply Chain described above, it is clear that is difficult for managers to complete the decision-making process to improve the overall performance while mitigating the negative effects of such disruptions and avoiding interruptions along the entire chain [7]. It is only through the mapping of the different actors of the WSC itself and their interrelationships that companies can identify bottlenecks in order to take useful actions to mitigate risks and ensure a continuous flow of goods and information.

Thus, the first step of this research is an in-depth analysis of the complex structure of the WSC, both in terms of physical and information flows, to identify the relationships between actors and processes, define the objectives that must be achieved and identify the main risk events that may occur during activities.

The results of the literature review carried out to define the main processes that constitute the WSC, and their relevant actors made it possible to identify 3 key macro-stages that allow the realization of the finished product: Supply, Production, and Distribution.

Supply stage

The Supply stage includes all activities related to the supply of raw materials, dry goods, and key services, each essential to enable activities of the entire supply chain from cultivation to end customer delivery. Raw materials are defined as everything needed in the early stages of vineyard cultivation and harvesting, such as fertilizers, pesticides, farm equipment, and also grapes or bulk wine when the amount cultivated is not sufficient to meet all needs [7]. Instead, dry goods refer to all materials used in the bottling and packaging stage, such as bottles, corks, labels, or boxes, and in the wine-making process, such as yeast or oak barrels used for fermentation and aging of wine [2, 20]. In addition, there is the provision of essential services such as water or electricity, without which activities would not be possible. The main players are precisely the "*suppliers*", who must be correctly located so as to always guarantee the continuity of the supply of essential materials and services: any type of supply problem, such as low materials availability, low suppliers' reliability, or transportation disruptions, can lead to production delays and low customer service levels.

Production stage

The Production stage includes all the steps involved in the production of wine, from the "cultivation" or "grapes growing" stage to the wine-making process, which produces the final product which is then bottled and stored. During the grapes growing stage, choosing the right planting environment is crucial: cooler climates produce wines with higher acidity and lower sugar and alcohol levels, while warmer climates accelerate ripening, producing wines that are sweeter, more alcoholic, and fuller-bodied [20]. The quality of wine production is influenced not only by natural factors but also by the way the producer manages the vines during pruning and harvesting: harvesting too early or too late can result in grapes that lack the perfect balance [4]. In addition, determining the optimum rate to harvest and process the crop is a challenging problem in balancing the risk of overinvestment in capital with the risk of not harvesting the entire crop [21].

During the wine production process it is also important to avoid contamination with chemicals or low-quality derivatives (must, spirits) [22]. Once the fermentation and maturation phase of the wine in the barrels has been completed, the next step of the Production process is the bottling plant, where the final product is bottled and packaged for shipment to the "*distribution centers*". The main actors in this phase are the "*farmers*", who cultivate the land and harvest the grapes, and the "*winemakers*", who are responsible for the entire wine production process, from the receipt of the grapes to the ageing in barrels and the bottling.

Distribution stage

Finally, during the Distribution stage, the final product awaits delivery to retailers who will take it to the end customer. Due to the long production process, the distance between cellars and suppliers/markets, and the importance of having the right quantity of products for orders, a lot of stock is held throughout the supply chain. Reduced stock levels can be financially beneficial in an industry where cash flow is already a challenge [23]. At this stage, it is important to select reliable warehouses that can guarantee the correct preservation and integrity of the products, both during storage and during handling for the subsequent shipping stages. Scraps due to product damage can have a significant impact on costs [24]. To connect all the nodes of this supply chain, transportation is needed. The transport of raw materials from suppliers to production processes and of final products to warehouses and customers is the responsibility of "*transporters*", whose job is to plan and organize the flow of information and goods through the supply network. Transporters are required to plan the delivery route to minimize the overall distance, delivery time, and environmental impact. Thus, the transport of

wine is a very delicate phase: the correct packaging and temperature conditions, the mode of transport, the possibility of damage caused by accidents during transport, etc. must all be taken into account. Other risks at this stage include delivery delays due to strikes, adverse weather conditions or road closures due to political tensions [12], or loss of cargo in transit.

Fig. 2 illustrates the overall structure of the Wine Supply Chain described above, highlighting the key stages involved and their individual processes. It reports the transformation stages of raw materials and details how the actors and phases are interrelated, the inputs and outputs of each process and the flow of both materials and information throughout the entire chain.

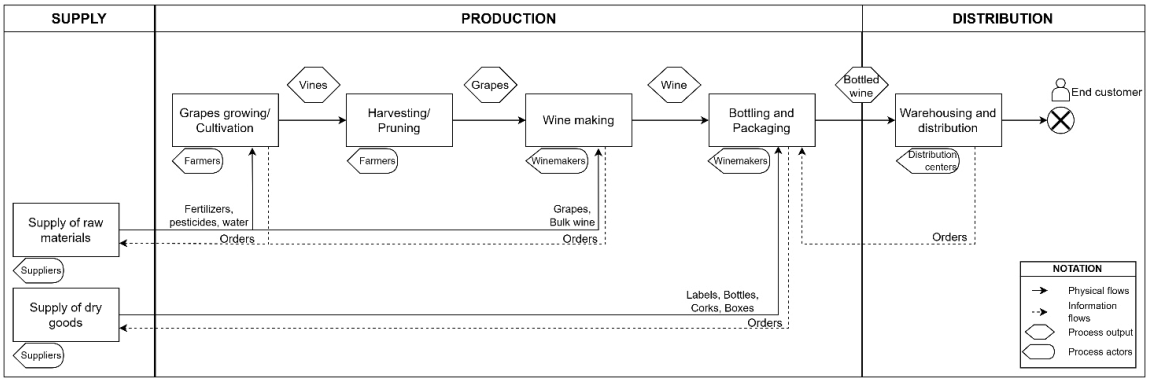


Fig. 2. Wine Supply Chain structure.

To obtain high-quality of finished product and to ensure the resilience of operations in the face of unforeseen events or disasters, companies define their key Business Continuity Objectives (BCOs), i.e. essential goals aimed at protecting key resources, minimizing financial losses, and upholding the organization's reputation. Key Business Continuity Objectives for the Wine Supply Chain identified from the literature review include [10]:

1. Quality, i.e. ensuring production continuity and product quality
2. Timeliness, i.e. maintaining the proper functioning of the distribution chain
3. Reliability, i.e. managing customer relationships and trust by ensuring continuous supply
4. Cost, i.e. minimizing the total SC costs

While BCOs set specific goals to ensure business continuity in case of disruptions, it is necessary to identify some quantifiable metrics, i.e., Key Performance Indicators (KPIs) to measure effectiveness and efficiency in achieving these objectives. The quantification of KPIs will allow the monitoring of progress towards the achievement of the BCOs, supporting firm-level decision-making and providing useful information for the improvement of the Business Continuity Plans, if necessary. Specifically, the main KPIs include supply chain profit [2], logistics performance index and resource utilization index [7] (Cost), total build cycle time and delivery cycle time [7] (Timeliness), and yield [12] and service level index (Quality/Reliability). These KPI values, each linked to one or many BCOs, will show the result of the efficiency of several activities performed along the chain and represent a high-level representation of results. When performing the above activities, different risk events of varying probability and magnitude may occur at each stage of the process, and their impact on the SC's business continuity must be properly measured to assess the system's response to the event occurring. This makes it possible to understand which are the best countermeasures to implement in order to reduce the overall damage and consequently keep the KPI values as close to the target values as possible.

For these reasons, through the analysis of scientific literature and of the processes themselves that characterize the WSC, the effects of the occurrence of risk events on the activities of the entire supply chain were investigated and detailed. A set of Key Risk Indicators (KRIs) that are measurable metrics that signal potential operational and strategic risks affecting businesses [25] have been identified and associated to each risk event. By tracking changes in risk exposure and measuring results along the supply chain, they offer early warnings to prevent deviations from expected performance. Each risk has been classified according to its nature, the stage/sub-stage in which it may occur, and the BCO that it may affect. In particular, the "Supply Chain" (SC) risk category refers to risks that may occur in a general supply chain, while the other one refers to risks that are specific to the Wine Supply Chain (WSC).

In conclusion, the results of the carried-out analysis useful to address the first RQ are reported in Table 1.

Table 1. Risk Events and Key Risk Indicators (KRIs) for WSC stages.

Process stage	*Sub-stage*	*Actor*	*BCO*	*Risk category*	*Risk event*	*KRI*	*Ref.*
Supply	**Raw materials**	Suppliers	Cost	SC	Price increase	Raw materials expense	[2]
			Reliability	SC/WSC	Low availability of raw materials	Raw materials availability	[26]
			Quality	SC	Poor quality of goods	Supplier reliability index	[12]
			Timeliness	SC	Late delivery of goods	Supplier accuracy index	[26]
Production	**Cultivation**	Farmers	Quality	WSC	Poor quality of cultivated grapes	Right quality grapes index	[22]
			Reliability	WSC	Disastrous weather (heat stress, water deficit, bushfires, waterlogging)	Yield	[4, 12]
	Harvesting		Cost	WSC	Improper harvesting time/Staff mishandling	Scrap expense	[4]
	Wine making	Winemakers	Cost	WSC	Errors during vinification	Scrap expense	[22]
	Bottling and packaging		Cost	SC	Price of picking and packaging activities	Picking and packaging activities expense	[4, 26]
			Cost	SC	Errors during picking and packaging activities	Scrap packaging expense	[22]
Distribution	**Storage/ Warehousing**	Distribution centers	Cost	SC	Damage during storage	Scrap expense	[12, 22]
			Cost	SC	Price of warehousing	Warehouse expense	[12]
	Purchasing		Reliability	SC	Available quantity of wine	Wine availability	[4]
			Quality	SC	Quality of purchasing wine	Purchaser reliability index	[4]
Transportation	**Transportation**	Transporters	Cost	SC	Transportation cost	Transportation expense	[2, 12]
			Cost	SC	Transportation delay	Customer service index	[12, 26]
			Cost	SC	Damage during transportation/Deterioration of goods or loss of quality	Customer service index	[4, 12]

3.2. RQ2: Methods and tools to manage/assess risks

The carried-out analysis has shown that, with particular reference to the logistical phase of the products' transport (grapes or finished products) on national and international markets, there are several studies aimed at researching and defining useful methods for improving traceability and visibility along the supply chain. This is useful for the real-time monitoring of transport conditions, to **avoid the risk of deterioration of goods or loss of quality**, always ensuring that

the values of the control parameters are within the set targets. Otherwise, non-negligible scrap expense would be incurred, preventing the supply chain from achieving the above Quality and Costs objectives.

The proposed systems, thanks to the introduction and use of proximity and spatial technologies such as RFID (Radio Frequency Identification), GPS (Global Positioning System), and WSN (Wireless Sensor Network), allow the status of the product to be monitored from the point of origin to the final destination, along the entire route followed [27]. This significantly increases the speed and accuracy of information management [28]. In particular, they are designed to monitor and control cold supply chains [11], which are particularly important when transporting perishable products such as grapes, where any deviation from required transport conditions such as temperature, humidity, and/or vibration can affect the quality of the products themselves [28]. With real-time monitoring, it is possible to minimize the risk of loss of quality of the products in transit in the event of deviation of the transport parameters from the target values. Indeed, compared to more traditional models where monitoring is only done at specific checkpoints (with the risk of not being able to intervene to prevent damage), the use of new technologies and proposed mathematical models allows real-time decision-making. For example, Vukatana et al. proposed a real-time notification module that works as an alert system when a risk is detected [27]. In this way, the risk of product quality change is immediately identified so that action can be taken without delay. Suggested strategies include stopping the transport or re-routing it so that the product arrives in good condition, even if it goes to a different customer [28]. Furthermore, the traceability system provides consumers with transparency, allowing them to trust that they know what they are drinking [27] and giving companies the possibility to increase their brand image. Thus, while the issue of logistics and transport is being addressed in greater depth with regard to the need to maintain the high quality of the products transported, the broader issue of Supply Chain Risk Management (SCRM), which encompasses all phases of the supply chain, including cultivation and production, and all the risks associated with them, does not produce consistent results in terms of tools/methods capable of mitigating the effects of the occurrence of risky events on the overall performance of an entire supply chain operating in a highly variable and uncertain environment.

In particular, for risk management in the growing and harvesting phases, several methods (generally optimization algorithms or mathematical models) are emerging. Regarding the cultivation phase, one of the most dangerous risk events is considered to be **frost risk** [29]: due to the ongoing climate change, the frost risk windows are changing in time, frequency, and duration, and this is a problem given the increasing costs incurred to mitigate the damage. This means economic losses for producers and disruptions throughout the Wine Supply Chain (WSC).

The subsequent harvesting phase can also be difficult to manage: harvesting too early or too late can result in grapes that lack the perfect balance [4]. This can create a problem that affects the entire chain, as the harvest is the basic raw material for wine production and the primary resource for companies involved in the grape growing phase. For this reason, Allen and Schuster [21] have developed a mathematical model to manage **harvest risk**, enabling decision-makers to correctly identify the length of the season and the size of the harvest to avoid fermentation and deterioration of the grapes and, consequently, the risk of diverting the product to other uses with severe cost penalties.

However, since Supply Chain Risks (SCRs) do not work in isolation but have impact both on each actor of the SC and the performance of the entire supply chain [10], it also becomes of paramount importance to assess how the risks propagate along the chain through the close interconnections between actors, to the next stages of the process, to subsequently identify possible action plans to mitigate the overall damage and keep performance values as close as possible to target values. In this sense, Bryceson and Hine [10] developed an ontology-based Bayesian network model, using a holistic approach, to measure the propagation of risks and identify which events affect each end goal and to what percentage. Similarly, F. Jianying et al. [4] applied neural networks to improve the risk assessment in the Wine Supply Chain from a sustainability perspective. Firstly, they performed a risk identification analysis to identify the main risk factors in the supply chain and then classified them into 8 sustainable risk dimensions. Secondly, they carried out a risk assessment analysis to understand what are the main risks affecting the WSC and their interrelationships, without, however, considering the phase of generating possible solutions useful to minimize, reduce, or mitigate the defined risks. The importance of the field of SCRM is also highlighted by Vieira et al. [2] who, for the first time, implemented a Simulation-Based Decision Support System (SBDSS) for risk management at the WSC. Thanks to simulation, it was possible to consider several different scenarios in a short period of time in order to assess in advance the impact of the occurrence of certain risk events on supply chain activities, enabling authorities, institutions and/or manufacturers to design more sustainable and resilient supply chains capable of best meeting their BCOs. Therefore, the table below shows the main results obtained (Table 2). For each analyzed paper, the process stage under study, the risk event considered, the risk management steps involved in the study and the main BCOs that can be pursued through the application of the proposed methods/tools were identified and collected.

Table 2. Methods/Approach to Manage Risks in the Wine Supply Chain.

Process stage/ Sub-stage	Risk event	Risk identification	Risk assessment	Risk treatment	Business Continuity Objective (BCO)				Ref.
					Quality	Timeliness	Reliability	Cost	
Cultivation	Disastrous weather	✓	✓	✓	X				[29]
Harvesting	Improper harvesting time	✓	✓	✓	X			X	[21]
Transp.	Loss of quality	✓		✓	X	X	X		[28]
Transp.	Loss of quality	✓		✓	X	X	X		[27]
Transp.	Loss of quality	✓		✓	X		X		[11]
Entire SC	Overview	✓	✓		X	X	X	X	[10]
Entire SC	Price increase and transportation cost	✓	✓					X	[2]
Entire SC	Overview	✓	✓		X	X	X	X	[4]

As can be seen from Table 2, the only studies that focus on achieving all the BCOs mentioned above are those that look at the entire Supply Chain. However, the risk treatment phase, which is useful for defining the correct risk management strategies between acceptance, mitigation, or transfer according to the level of expected damage, is missing from the SCRM phases studied.

3.3. RQ3: Research trends and gaps

After analysing the processes and actors involved in the Wine Supply Chain activities and the approaches already developed to analyze, assess and treat risks affecting activities, the main trends and research gaps reported in the selected studies were identified to answer RQ3. The main current trends include the adoption of advanced technologies such as Blockchain [22], barcode and mobile applications [27], or RFID and GIS systems [28], which allow the digitalization of the SC and, consequently, the traceability of the process and the transparency of the products along the supply chain, to avoid the deterioration and loss of product quality and, at the same time, to prevent the risks of fraud and counterfeiting, so that customers can always know the origin of the products they purchase.

Another issue that has received increasing attention in recent years is the "environmental sustainability" in relation to WSC. Several studies focus on the search for sustainable practices to increase the level of supply chain sustainability in the fresh grape industry [4]. In particular, it is noted that achieving a good level of sustainability in the wine industry is highly complex [12] because WSC actors operate in highly traded local and international wine markets. Of particular interest is the relationship between the issue of Risk Management and the need to meet Triple Bottom Line sustainability goals [2, 4]: for a business to be sustainable, it is first necessary to understand its potential business risks, which are recognized as a major threat to sustainability [12]. In fact, Risk Management enables better financial performance and business competitiveness.

Over the last 20 years, there has been a growing trend in researching how to manage Supply Chain Risks. Various frameworks [7, 12, 26] have been developed to identify, for each phase of the process, the main sources of risk and the resulting indicators that are useful for assessing the impact of the occurrence of the risk event on the activities. On the other hand, there are few methods and/or tools that make it possible, quantitatively, to look at the entire supply chain and all its actors, to dynamically carry out the phases of risk assessment and management of mitigation strategies, to reduce the overall damage and avoid excessive deviations from the performance targets.

As can be seen in Table 2, only a few papers take a holistic approach by considering the entire Wine Supply Chain as the object of the study. Among these, there is a lack of focus on the final phase of risk management, which consists of risk treatment, aimed at identifying possible countermeasures to prevent, minimize, reduce, or mitigate the risks identified, with a subsequent risk monitoring phase to determine whether the strategies identified are leading to the expected results or whether new intervention measures are required. Given the highly variable nature of the impact of risk events on activities, risk management activities must be a continuous and equally dynamic process [12]. Overall, therefore, the carried-out analysis of the scientific literature reveals that the main gaps in supply chain risk management are:

- The lack of studies that, through a holistic approach, focused on the search for mitigation strategies to support companies operating within the supply chain itself
- The absence of engineering, rather than agricultural, approaches aimed at optimizing the processes that constitute the supply chain, focusing on the improvement of the overall performance and not on the individual node that makes up the supply chain.

4. Discussions and Conclusions

Although several studies have addressed the issue of Supply Chain Risk Management in the wine industry, it seems that researchers have not yet focused in depth on the analysis and research of the best risk management strategies that consider the entire supply chain and its impact, and not just the impact on the single player in the chain. Based on research findings, there appears to be a lack of research on how best to manage risk across the entire supply chain.

Over the years, researchers have drawn attention to SCRM in the wine industry, primarily from the perspective of traceability. To overcome inadequate coordination systems that preclude traceability and visibility of both products and information along the entire supply chain, and to reduce the high logistics and monitoring costs, the need to realize an IoT-based Wine Supply Chain is assessed. This could be useful to help managers manage risks, making the WSC more resilient from vine cultivation to wine consumption, and providing transparency, efficiency, provenance, safety, and security [30].

The evidence from the carried-out analysis shows that most of the papers that focus on the last step of SCRM (Table 2), consisting of risk treatment to prevent, minimize, or mitigate the effects of risk events and risk monitoring, have as their main objective the optimization of a single business process rather than the optimization of the entire SC activities. This can be a problem over the years because of the close interrelationships between actors along the chain: the negative effects of such disruptions can rapidly propagate to the next nodes in the chain, affecting not only the performance of the individual actor but rather the performance of the entire WSC. This is then reflected in the quality of the finished product and the image perceived by the customer. In recent years, some researchers have decided to look at the entire WSC, taking into account the entire flow from cultivation to the end customer.

However, despite the increasing focus on agricultural risk events [6, 21, 29], the carried-out analysis shows that there is a lack of comprehensive methods/tools that cover the entire Wine Supply Chain, from the farmer to the end customer, and that are capable of providing decision-makers with the ability to properly manage risks (in advance or after the occurrence of disruptions) in order to prevent or mitigate the propagation of effects, and to identify the best countermeasures to be implemented to prevent performance degradation.

Given the specific characteristics of the WSCs, this gap underscores the need for integrated risk management approaches to prevent the degradation of businesses' performance. It is clear, therefore, the need to implement mechanisms that are capable of managing uncertainty to the greatest extent possible, giving decision-makers suggestions regarding the actions to be implemented so that the main business objectives can be achieved with the best possible results.

A Decision Support System (DSS) for SCRM is suggested, capable of simulating, over time, the behaviour of the supply chain under the impact of different events, verifying the effects on individual nodes and the chain as a whole. By performing what-if analyses and measuring appropriate risk and performance indicators, it is possible to identify the best countermeasures to be implemented to prevent performance from deviating too far from the targeted values.

In conclusion, this research study has presented a scoping literature review of the recent literature on Risk Management in the Wine Supply Chain, with a particular focus on the analysis of (i) the main processes and actors that characterized the WSC as well as the main risk events that could occur during activities and (ii) the existing models/tools used by companies to manage risks and to cope with the high complexity and the dynamic nature of the environment in which they operate. The main trends and gaps in this topic have been also highlighted. The main results are reported below:

- Researchers' interest in the topic in the last 10 years and above all in the last 3
- Need to improve the resilience of WSC, more than other agri-food supply chains, given the high value of final products and the increasing trend in the market
- Lack of holistic approach for risk management over the entire supply chain. Until now researchers have mainly focused on single processes, not evaluating the interaction with the other players of the overall chain
- Many studies focused mainly on risk identification and assessment, less investigated are the mitigation strategies that could be used and the evaluation of how they affect the overall performance of the system

However, this study presents some limitations. The search strategy could be improved in different ways such as by using multiple scientific databases. Moreover, it should be interesting to focus and analyse also technical papers or real tools involved in companies (shifting from the pure scientific literature to the effective application and state of the art of risk management for single actors of supply chain).

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