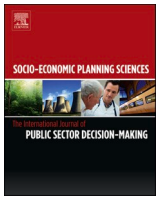
Socio-Economic Planning Sciences 92 (2024) 101832

Contents lists available at ScienceDirect

Socio-Economic Planning Sciences

journal homepage: www.elsevier.com/locate/seps



Delphi-based scenarios and risk management: A parallelism between paths destined to meet

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ARTICLE INFO

Keywords:
Risk analysis
Risk assessment
Mixed methods
Futures scenarios
Family

ABSTRACT

The complexity that characterizes our current society expresses new, articulated and not always punctually classifiable problems. Traditional risk management processes are typically based on projections obtained from historical data and are not suitable to address new, unexpected or complex risks. A proactive and forward-looking approach to risk management should be followed, which can be defined as future risk management.

In the case of novel and complex issues, in presence of high uncertainty and little experience (typical situations when data are scarce), multiple approaches and techniques might be used and, in particular, organized and combined in a mixed methods approach. The aim of this paper is to provide a comprehensive framework to manage effectively emerging and future risks by adopting a strategic foresight approach, which exploits a future scenario planning method and includes quali-quantitative tools. Our proposal consists of an integrated approach which, as in a protocol, indicates where and how to use each technique, in a consequential chain, in which the output of a step is the input of the following step. A four-year research project on future scenarios for contemporary families will serve as a representative example of this framework.

1. Introduction

Societies around the world are undergoing significant changes that are rapid, complex, and often unanticipated [1,2]. This rapidly changing setting has driven a significant evolution of risk management processes in recent years. In fact, public and private organizations face new risks that are emerging at an unparalleled pace. These risks can derive from multiple sources: technological progress, new economic conditions, environmental changes, geopolitical events, shifts in social, cultural and legislative norms, and many others [3]. To give an example, the Covid-19 pandemic has forced governments around the world to face an unexpected scenario and the associated risks. If Covid-19 was an unexpected event, the climate change process has been going on for many years, but the way multiple drivers of climate change, as well as the associated risks, interact is constantly evolving, needing a framework for complex risk assessment [4]. Effective management of emerging and future risks is the key point of organizational resilience and success [5] since these kinds of risks can disrupt operations, damage reputation, and affect the financial and social stability of all types of organizations.

Traditional risk management processes are typically based on projections obtained from historical data and are not suitable to address such unexpected or complex risks, also because they are unable to consider interactions across different elements that generate risk. A proactive and forward-looking approach to risk management should be followed, which can be defined as "future" risk management.

When it comes to risk, an important and recent document to refer to is the International Standard IEC-ISO [6] regarding the selection and application of techniques for assessing and treating risk, and in particular, to assist decision-makers in uncertain situations. Indeed, as stated by Luhmann [7] decisions are the connection between the present and the future, through the projection of key aspects of a described future onto the present.

The complexity of the situation, its novelty and the relevant knowledge and understanding are all factors that influence the way in which risk is evaluated and managed. Sometimes the complexity derives from interactions between cognitive problems of a different epistemological nature, qualitative and quantitative, which require the advancement of new and not always tested proposals. Modern societies, more than in the past, are dominated by surprises - the notorious "black swans" - and "in spite of our progress and the growth in knowledge, […]

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https://doi.org/10.1016/j.seps.2024.101832
Received 28 February 2023; Received in revised form 18 December 2023; Accepted 24 January 2024
Available online 28 January 2024

the future will be increasingly less predictable" [8]. In the case of novel and complex issues, we are often in the presence of high uncertainty and little experience, and in a situation of scarcity of data and information conventional techniques of analysis might not be useful or meaningful [6].

In these cases, different approaches and techniques might be used and, in particular, organized and combined in a mixed methods approach, which proposes techniques and solutions that are appropriate to both the nature of the data and the cognitive questions. In fact, faced with complex phenomena, many scholars claim that a mixed methods approach – namely a research approach which combine in a single strategy a mix of methods as well as involve collecting, analyzing and exploiting different types of data - is desirable, given the need to analyze the problem from many perspectives [9,10]. Many other authors recommend the use of mixed methods as the respective strengths and weaknesses of quantitative and qualitative approaches complete each other [11,12].

Along these lines, the aim of this paper is to provide a comprehensive framework to manage effectively emerging and future risks by adopting a strategic foresight approach, which exploits a future scenario planning method and includes quali-quantitative tools like Delphi surveys and focus groups, composite indicators, fuzzy clustering, cross-impact analysis and multi-criteria methods like the analytic hierarchy process.

Therefore, the innovative proposal of this paper consists of using a strategic foresight approach, called Delphi-based scenario development [13,14] to implement a risk management process. This approach is based on a six-step procedure in which the qualitative and quantitative methods used follow each other in a sort of chain, with the outputs of one technique being the inputs of the next.

If on the one hand ISO [6] proposes a risk management procedure divided into five phases (scope, identification, analysis, evaluation, and treatment) and identifies a list of both qualitative and quantitative techniques useful for each phase, it does not propose a single path that from the first phase arrives to the last. In our proposal, instead, we suggest an integrated approach which, as in a protocol, indicates where and how to use each technique, in a consequential chain, and how to use the output of a step as input of the following.

In this way, we provide a sort of "statistical tools guide" for implementing a risk management model for an organization. The benefits and limitations of this new approach in risk management are discussed. A research project on future scenarios for contemporary families, realized by the Authors [15] will serve as a representative example of the application of this framework.

The paper unfolds as follows: Sect. 2 provides an overview of the concept of risk focusing on the relationship between future risk management and scenario-based methods, Sect. 3 presents the theoretical framework to face risks through a mixed-method procedure. In Sect. 4 the "Tomorrow in the family project" was described in detail. Concluding remarks and suggestions for further research are in Sect. 5.

2. Risk management and future scenarios

Since the 1970s, studies of risk have become a very large and active interdisciplinary field of research and, in recent years, also embraced statistics. In a search on the Scopus database with the keywords "risk management" and "statistics", until 1990 the scientific documents do not exceed 5 units per year, while in the following years, there was an exponential growth up to over 300 documents per year in the period from 2015 to today. This can be interpreted according to Price's theory on scientific productivity [16], according to which the growth of science goes through three phases. The *precursor phase* (little increase rates in the scientific literature), the *exponential growth* phase (the research field attracts many scholars and the production growths exponentially), and the *stabilisation* phase (strengthening of the body of knowledge and stabilisation of the total scientific productivity). In general, Price's law follows a logistic function. Therefore, we can state that for statistics and risk management, we are in the full exponential phase. The use of mixed-methods in the context of risk management is also seeing exponential growth, which starts around 2010 and continues in these years. This is also due to the expansion of mixed-methods in many research fields, precisely because they make it possible to make the most of both quantitative and qualitative approaches, a requirement which in complex problems (such as risk management) is increasingly felt and recommended [12]. If Price's law is not broken, we can expect further growth in this field of research in the coming years.

On the other hand, if we consider the literature on Futures Studies (a booming field of research), only in recent years we can observe evidence of relevant scientific research dealing with risk management. In fact, still from Scopus, the search with the keywords "risk management" and "futures studies", returns very few documents published until 2007 (about two/three per year) and then begins a growth which, however, reaches only 48 documents published in 2022. By assuming Price's law, this means that we are towards the end of the precursor phase, and we can therefore hypothesize an exponential growth of scientific production in the years to come.

2.1. Risk managment

There is a plethora of definitions of risk, to the point that maybe it is better not to define risk and let each author define it in his own way [17].

Generally speaking, the term "risk" refers to situations in which an undesirable event will occur with a certain probability. In specialized contexts, the word has different meanings [18]. For example, in the health context, a risk regards an unwanted event (say x) that may or may not occur, like a disease linked to a wrong lifestyle.

From a purely quantitative point of view, risk can be seen simply as the probability of an unwanted event [18], which is a quantification of its occurrence on a scale between zero and one: $P(x)$. But, if we take into account also a measure of the severity of the occurrence of x, a more useful definition of risk (which is also the standard technical meaning in many fields) corresponds to the expectation value of the unwanted event, namely the product of its probability by some measure of severity: $E(x) = P(x)I(x)$. Risk severity - $I(x)$ - can be intended also as risk impact, that is the undesirable effects that may occur due to the occurrence of x. The number of killed persons as a consequence of a terrorist attack is an example of $I(x)$. Given that very often it is difficult, or impossible (lack of data, not comparable circumstances, new events), to quantify $I(x)$, a common way to describe it is using an ordinal scale, like for example a Likert type scale from 1 (negligible) to 5 (maximum). This aspect necessarily implies the use of subjective judgments (such as those that can be elicited by experts) which are therefore indispensable whenever there is no data to quantify the severity of the event. Similarly, when there is no data to calculate $P(x)$ in classical or frequentist terms, the only way to estimate $P(x)$ is to rely on subjective probabilities [19].

Regardless of how it is defined and/or measured, risk is a characteristic of the future. According to Fischhoff et al. [20], the most significant aspect of risk is the attribution of consequences to future events. It is all about the capacity to define what may happen in the future and to choose among alternatives. At the same time, the future is the only field in which we can act, and to borrow the words of de Jouvenel [21], "the future is the only field of power, for we can act only on the future".

The consequences of a future event are probable but never certain, since if $P(x)$ were equal to 1 or 0, one does not face a risk [22,23]. Therefore, ultimately, the risk concerns only the consequences of a future characterized by uncertainty. When dealing with uncertain futures, it must therefore always be kept in mind that uncertainty is the necessary prerequisite for the existence of risk [24].

When dealing with the issue of risk, it is also important to distinguish between *risk assessment* and *risk management*. The first regards only the qualitative and/or quantitative estimation of risk, while risk management (at a macro level) includes plans, actions, strategies or policies set

to reduce the probability and/or impact of risks.

In risk management, it is not possible to eliminate subjective elements completely [25] and this consideration, shared by many authors, lay the foundations for greater use of the scenario method and so of the Delphi-based scenario method we propose. If on the one hand risk assessment implies the prediction of the future, on the other hand, long-term predictions are only possible with isolated and repetitive systems, but according to Popper society is not such a system [26]. In this regard, Barabási [27] affirms that predictions are impossible at the level of society, and in this direction, future scenarios do not intend to predict the future but try to explore a range of possible or plausible futures, thus helping in the risk assessment and management of a social system.

2.2. Future scenarios

But how can we describe the future in a way useful to calibrate the right decisions in the present to reduce risk? One answer is by means of scenario methods.

Scenarios can be defined in various ways and are used in different disciplines. In the methodological corpus of *Futures Studies* (FS), and in its application counterpart - known as *Strategic Foresight* - scenarios are recognized as "*a set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points*" [28]. They do not intend to predict static futures, but are "*hypothetical sequences of events constructed in order to focus attention on causal processes and decision points*" [28] useful to reduce risk. According to the European Commission Research Directorate General [29], Foresight is "*a systematic, participatory, future intelligence-gathering and medium-to-long-term vision-building process aimed at present-day decisions and mobilizing joint actions*". Although this definition applies to all kinds of organizations, technically speaking Strategic Foresight refers to the foresight activities of governments, international organizations and corporations. In this context, scenarios are described as narratives of the future, containing a range of possible futures useful to explore how a system would change if various events were to occur [30]. In this way, future scenarios are a means of reviewing/calibrating existing policies or encouraging the development of new policies. Said in other words, scenarios can be used for risk assessment and, more generally, for risk management.

The use of scenarios in risk management is not new, but scenarios are almost always used as one of many available tools, more or less suitable in a specific phase of the risk management process. For example, according to the International Organization for Standardization [6] scenarios are strongly applicable in the steps of risk identification and risk analysis (see Fig. 1). What we propose in this paper is totally different, because we start from a specific scenario planning approach, called Delphi-based Scenario development [13,14] that refers to a recognized strategic foresight approach [31], which contains a series of steps that in our proposal can be related to the classical steps of the risk management. In each step of the Delphi-based scenario planning, a specific technique is proposed that can be used to outline the aim of a precise phase of risk management; thus, the scenario planning covers all phases of risk management, from the definition of the context to the treatment of the risk and communication of the results.

Future scenarios derived with this approach allow us to depict a number of inclusive and joint pictures of future uncertainties, but also of the factors that influence and guide decisions that have to be taken in the present. In the scenario-planning process (Fig. 1), the critical factors that contribute to an adverse event are identified and the resulting narrative must describe the circumstances and consequences in case that event were to happen [32]. In this sense, the scenario development process is useful in risk assessment, but it also depicts the key elements necessary for the next steps, and since one of its main functions is to communicate to decision-makers how, where and why adverse and uncertain events can occur, it is also a crucial tool in the risk treatment phase.

Finally, an important feature of any scenario planning is the involvement of stakeholders [33], which is also a very important aspect of the risk management process [6]. In the Delphi-based approach, stakeholders are an integral part of the process and are involved from the earliest steps of framing and scanning (see Fig. 1).

2.3. Risk managment: a path of decisions

In this paper, we propose an integrated framework for building future scenarios (known as Delphi-based scenario development) typical of the Futures Studies and adapted for a complete risk management process, which takes the form of a flexible protocol applicable in different contexts, in which the qualitative and quantitative methods

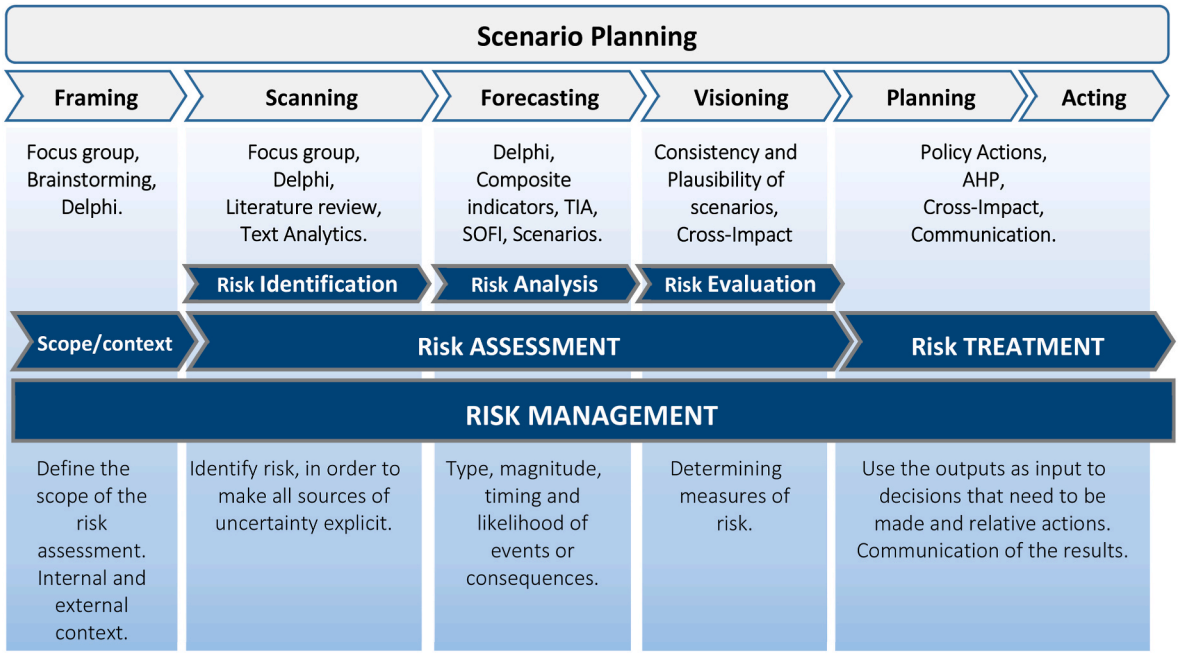

Fig. 1. Matching the Delphi-based scenario planning with the risk management process.

used follow each other in a sort of chain, with the outputs of one step being the inputs of the next. To the best of our knowledge, no approach is already available in the literature with the same completeness, wide scope and integrability than ours, see also the literature searches in Section 2. In fact, our approach allows building a number of future scenarios of a social system, to identify risks and opportunities in order to support today's decisions in terms of public policy actions. By following this approach, we consider risk only when it is possible to identify a decision (or a set of decisions) which have a significant impact on the future. This paves the way for a proactive approach to the future, abandoning a passive approach according to which we can only suffer the consequences of future events. Instead of passively accepting the future, we pro-actively engage in it, in order to calibrate decisions in the present to increase the probability of desired future events and decrease that of risky events. If from one side the future is not predetermined (therefore it is unpredictable), from the other side it is not independent of today's decisions [34]. Furthermore, placing an emphasis on the decision when discussing risk also helps explain the difference between risk and hazard. According to Bonss [35], the uncertainty of risk is different from the uncertainty of hazard, and the difference relies on the decision. While hazard uncertainties exist independently of human actions, risk uncertainties derive from the possibility of action, so hazard depends on the circumstances while risk depends on decision-making.

3. A new integrated approach to risk management using delphi-based scenario planning

ISO 31000 is the international standard for an effective risk management framework proposed by the International Organization for Standardization (ISO), that provides guidance for organizations of all types and sizes on managing risk. More precisely, ISO 31000 guidelines assist organizations to identify, analyze, evaluate, treat, and communicate risks.

For each of these stages, the International Standard suggests a number of techniques (with varying degrees of suitability), together with their characteristics, and the possible range of application, as well as their inherent strengths and weaknesses [6].

This paper proposes a comprehensive framework, that goes through all the classic steps of risk management as described also by ISO 31000 adopting Futures Studies - in the specific approach of the Delphi-based scenario planning.

As already mentioned, an emerging and future risk management process includes different steps that aim at identifying, analyzing, evaluating, treating and communicating potential risks that may arise from new or mutating sources. It is a step-by-step process involving the phases described in Fig. 1.

In particular, we propose to use the Delphi-based scenario development referring to the strategic foresight approach proposed by Bishop et al. [31], which involves six steps for the development of future scenarios: Framing, Scanning, Forecasting, Visioning, Planning and Acting (Fig. 1). As we will see in the following, these steps cover all the phases of risk management.

In particular, we suggest a combination of techniques organized in a specific sequence, where the outputs of one technique become the inputs of the next [13,14], in an overall approach that fully falls within the logic of mixed-methods [12]. This new approach to risk management contains, in our opinion, enormous future potential in terms of methodological, applicative and even epistemological developments.

Below we describe each phase of this approach and to this end, the title of each paragraph contains the risk management phase alongside the corresponding scenario planning phase.

- Scope and context - Framing

According to the ISO, in the first step of a risk management process, the purpose and scope of the assessment should be established, with a clear description of what is included, and what is excluded. At the same time, it is necessary to understand the context, in order to be aware of the broader circumstances in which the final decisions and actions will be made, that is understanding and becoming aware of the "bigger picture".

Within the Delphi-based scenario approach that we propose here, the first step is Framing, which consists of defining the scope and focus of issues requiring strategic foresight, to clarify the objective of the process and how to address it [31]. The framing phase also involves developing a set of questions/hypotheses that the scenarios will seek to answer, and this is important in helping to ensure that the developed scenarios are relevant and helpful for the intended purpose.

It is evident the parallelism between the two contexts (risk and future scenarios) and a number of techniques are suitable in this step, such as focus group, brainstorming and Delphi. The use of one or more of these techniques will depend on the specific case study.

- Risk identification - Scanning

Identifying risk enables explicitly taking into account uncertainty, by considering all its possible sources. The purpose of risk identification is to find, identify and describe risks to help an organization in achieving its objectives.

From our side, in the Scanning phase of scenario development, all relevant information on the system under study (trends and key drivers) must be collected as comprehensively as possible. Scanning involves gathering and analyzing information about the issues that may influence the future, which goal is to identify the key trends, drivers, and uncertainties that are likely to shape the future of the system under investigation. External factors and internal factors must be identified. In the particular context of Delphi-based scenarios, the information gathered during the scanning phase is used to develop a list of potential future projections. This list, refined and prioritized by a panel of experts, becomes the input of the following Forecasting phase.

This step can involve different techniques, such as brainstorming sessions, focus groups, surveys, Delphi with stakeholders, or a literature review. Brainstorming sessions and focus groups, allowing for rich discussion and probing, are particularly useful in this stage, whose aim is to identify all possible sources of risk. Stakeholders are able to discuss their ideas, get feedback from other participants, and be stimulated in proposing new ideas.

The Delphi technique consists of collecting judgments through a set of sequential questionnaires, generally administered to a panel of experts. Participants receive feedback on the responses of others after each round. It is a qualitative method particularly useful in eliciting views for risk identification, suitable for any time horizon and it does not need starting data. Most recently, new techniques are also being used, among which we mention text analytics, an approach that uses natural language processing (NLP) to transform free unstructured text into structured data [36], and so it turns out to be very useful in the rapid scanning of large quantities of documents for identifying potential and emerging risks.

- Risk analysis - Forecasting

The aim of risk analysis is to assess consequences, risk likelihood, as well as interactions and dependencies between risks, in order to evaluate the possible impacts. Risk analysis allows an understanding of the nature of risk, together with its characteristics and level. According to ISO, in this phase, it is important to analyze the type, magnitude and timing of consequences. The likelihood must be analyzed as well, which can regard an event or a specified consequence. The likelihood can be described in various ways, such as expected probability or frequency, or plausibility. Finally, interactions and dependencies between risks must be considered and analyzed as well. The ISO also highlights the importance of the changing of consequences over time, so the time variable must be taken into account.

In the Forecasting phase of scenario planning, the information gathered in the scanning phase is used to make judgments about future events or developments. This involves generating a range of future scenarios or estimating the future states of the key drivers according to specific variables, such as for example plausibility of occurrence, probability, impact, desirability or relevance. Also, the interactions between the key drivers must be analyzed, because the future must always be understood and analyzed as the result of an interconnected chain of events, and not as a fixed image disconnected from the present.

In this phase, qualitative and quantitative methods can be used, in particular Delphi surveys and scenario development. Delphi surveys can be particularly useful to obtain from a group of experts an assessment of the risks identified at the previous stage, being an iterative and participative procedure, which can involve both experts and stakeholders. The Delphi technique is crucial in the approach we propose, given that the projection towards the future of potential and emerging risks (identified in the previous steps) takes place through the Delphi, and the outputs of the Delphi survey - suitably treated statistically - become the basis for the construction of the risk scenarios. The passage from the Delphi outputs to the scenarios can be achieved by using composite indicators and fuzzy clustering techniques [13,14].

In this phase, also statistical models which extrapolate trends based on time series are very useful. Given that the long-term future is hardly a mirror image of the past, these extrapolations only serve to construct one of the many plausible scenarios, which in the literature of FS is called *baseline scenario* or *surprise free scenario*.

As an important contribution from the Italian school on this point, we can cite the statistician Giorgio Marbach [37] according to whom econometric models for forecasting purposes are useful for answering "what if" questions. Thus, they are not a sufficient prediction tool, but they can certainly help in simulating the functioning of a real system. In this sense, they are considered by Marbach as a natural support to be used in the construction of the baseline scenarios [37].

In the literature there are also well-known *hybrid* models typical of Futures Studies (hybrid in the sense that they are based on a mixed-methods approach, by combining statistical models and subjective evaluations by experts) and among the many we mention here the Trend Impact Analysis (TIA) and the SOFI. The first is a technique that does not produce a single prediction but a range of outcomes. TIA starts with an extrapolation of a time series (the baseline forecast) and a list of developments (technology, societal changes, employment processes, political actions etc.). Then experts are asked to evaluate the impacts, in terms of probabilities, of each development on the baseline extrapolation, to produce a range of futures that consider the impacts of possible future events on the trend derived from the mere extrapolation [38].

The SOFI (State Of the Future Index) is an index developed to study whether the future outlook of a system is improving or not. It combines variables into a single measure, to form an overall indicator of the state of the future. Unlike many composite indicators (concerned with the present or past), the SOFI is designed to explore the future and to identify the factors responsible of changes [39]. It is evident how these models are suitable to analyze the type, the magnitude and the timing of consequences of risks, so we believe that for risk analysis purposes, the futures studies approach is very useful, also due to the fact that the focus is on future projections and developments of risks and consequences.

- Risk evaluation – Visioning

Risk evaluation requires comparing the outputs of the risk analysis with the established risk criteria to move towards the next phase which requires concrete actions. Sometimes it is necessary to have some measures of risk, based on combinations of the magnitude of potential consequences and the likelihood of those consequences [6]. As specified by ISO, a measure in the strict sense is not meant here but this phase can involve qualitative, semi-quantitative or quantitative measures.

On the strategic foresight side that we propose here, we find the Visioning phase, during which the experts and/or stakeholders are asked to consider the implications of the various scenarios that were developed in the preceding forecasting phase. They may be asked to evaluate how different scenarios would impact the context under study and the long-term consequences of each scenario. In other words, the goal is to measure the potential consequences of future scenarios and/or of the key drivers contained therein. Therefore, this approach is very useful in the evaluation of emerging and future risks, in their likelihood and impact, thus providing a new approach to measuring risk.

A central aim of this step is pushing the organization to remain proactive in its risk management operations so as to address as quickly as possible any change in the risk background.

Among the many techniques, Cross Impact Analysis [40] is very useful in this stage to evaluate changes in the probability of the occurrence of a given set of events consequent on the possible occurrence of the scenarios defined in the previous step. It is a semi-quantitative method suitable for short/medium time horizons, which need starting data and can be applied during the risk analysis phase. The plausibility and consistency of the future scenarios can be assessed by expert consultation, and the advantage of this approach consists of allowing priorities to emerge in the list of risks arisen up to this step.

- Risk treatment – Planning & Acting

The aim of risk treatment is to select concrete actions for the mitigation of the impact of emerging and future risks [6]. The goal of this phase is the definition of mitigation strategies, preventative care, and/or contingency plans, based on the evaluation made in the previous step.

In our approach, the Planning phase of the Delphi-based scenario protocol may be fully suited to achieve the previous purposes because consists of developing a plan of action starting from the developed scenarios. This implies identifying specific strategies, policies, and resources that will be needed to implement the plan.

About the techniques useable in this phase, we find Multi-Criteria Analysis (MCA), a family of techniques for comparing options in a way that makes trade-offs explicit. In this family, we suggest the Analytic Hierarchy Process - AHP [41,42] - which does not require particular starting data, can be used for any time horizon and is suitable also in the risk identification and risk evaluation phases. Also, Cross-Impact Analysis - CIA [40] - is useful in this phase, and we suggest using it for evaluating the impacts of the selected actions on future scenarios and, therefore, on the negative consequences of risk.

Afterward, in the Acting phase, concrete actions to give concreteness to the previous planning phase must be defined. This may involve taking specific actions and/or making recommendations to policy-makers and local and governmental authorities.

Lastly, in this final step of both risk management and strategic foresight scenario planning, we include the important aspect of communication. Communication with external/internal stakeholders and policy-makers about emerging and future risks is a crucial step to enable them to make informed decisions to mitigate the risk impact. First of all, it is important to identify the stakeholders (customers, shareholders, employees, regulators …) and their specific interests in relation to each risk. Then, a communication plan that outlines information about risk likelihood and impact should be prepared.

The central goal of risk communication is sharing information about the management of emerging and future risks with important stakeholders, and composite indicators are important tools to achieve this goal. Composite indicators are familiar in applied sociology to assess multidimensional issues that cannot be directly measured, like human development, technological achievement and sustainability. Examples are the Human Development Index [43], the Environmental Performance Index [44], the Global Peace Index [45] and the Index of Trust in Public Institutions [46]. Composite indicators are commonly employed for policy analysis and public communication [47]. Composite indicators combine several or many variables (simple indicators) into a

single rating or ranking score, therefore helping stakeholders to understand more easily for example the rank of the level of a particular risk respect to others, or the most important factors contributing to that particular risk. Incorporating composite indicators into the risk management framework allow us to monitor its performance over time, as well as adjust and update risk treatment options when needed to ensure that they continue to be effective in addressing emerging risks.

In the Delphi-based approach for future scenario planning that we propose here, the future scenarios which emerge are important tools of communication. In the basic form of storytelling or in more advanced forms (e.g. images or videos) future scenarios are very useful in communicating future changes, risks and opportunities.

4. The "tomorrow in the family" project

The "Tomorrow in the family" project is a four-year research project carried out to figure out the possible dynamics that will affect family life in the near future [15], with a time horizon of ten years and reference to the North-East of Italy, one of the richest and best organized regions in Europe (Eurostat 2021). The main idea underlying this project was to build some possible scenarios in order to stimulate the reflection on which risks the family will have to face in the near future. Consistently with the theoretical framework proposed in Section 4, the relevant questions the project "Tomorrow in family" tried to answer were.

a) Which phenomena involving families will be more "visible" in the near future? Which risks are connected to these phenomena?
b) What policy responses will become relevant and needed?

A Delphi-based scenario development design was applied, since it was not possible to study family dynamics only considering the trends of the demographic structure of the population or looking at the main socio-economic indicators. "Tomorrow in the family" has been supervised as principal investigator by M. Bolzan, who also secured some public funding, and has seen during different stages of development, the active participation of the other authors of the present paper.

4.1. Family: a changing organization

Family is the social organization that has changed mostly in the last years, with changes that concerned different aspects, as family formation, household structure and work-life balance. Analyzing in statistical terms the main past changes inherent the family sphere is a useful step before looking ahead. In the last 20 years, the average household size of Italian families fell from 2.7 persons in the two-year period 1998–1999 to 2.3 twenty years later [48]. Multiple sociodemographic trends are related to this phenomenon: declining fertility may be the most important, by reducing directly the number of members per family [49]. Aging provides another explanation for why household sizes have continued to decline rapidly even in developed countries where fertility rates have been stable for decades [50]: older people are living longer and maintaining small households longer after their children move out of households. In 2020, approximately one third of the households are made up of single people, 10 % points more than 20 years before. With marriage rates down and divorce rates up, there are an increasing number of children growing up in sole-parent or reconstituted families. The total number of marriages passed from 280,330 in 2009 to 184,088 in 2019 [51,52], whereas approximately in the same years the number of cohabiting unions increased from 340,000 to 1.370,000 [52]. The average divorce rate passed from 0.92 to 1.48 divorces per 1000 people in approximately 10 years, from 2008 to 2018. As a consequence, approximately in the same period reconstituted households increase by 3 % points, from 6.1 to 9.2. Sole-parent families are of particular concern due to the high incidence of poverty among such households [53].

But the changes did not concern only the way families are formed or dissolved, but also some aspects that condition the daily life of the family. Increasing female participation in higher education has contributed to changing female aspirations regarding labor market participation. The female employment rate, in Italy, has grown by about 10 % points in 20 years, going from 41.2 % in 1999 to 50.1 % in 2019. Thus, the growth in the proportion of women in the labor force has led to growing numbers of mothers re-entering the labor force or remaining in employment, implying changes in the household labor allocation as well as in child care. Maternal employment can improve children's intellectual performance by increasing household income [54], but it may also negatively affect it [55,56], if not supported in the right way both by the family and by social policies. In any case, female employment needs supportive policies. It has been shown that employment rates react to changes in tax rates, in leave policies, but the rising provision of childcare formal services to working parents with children not yet three years old is a main policy driver of female labor force participation.

In this context, grandparents have become increasingly important within family relationships. The greater presence of mothers in the labor market and the lack of public services for children have contributed to make their role fundamental for what it concerns the care of the grandchildren. In 2016, the 86 % of children (up to 13 years) are looked after by their grandparents [57].

As regards older children, their prolonged permanence in the family of origin is particularly significant in Italy. In 2019, the share of young adults co-residing with at least one parent in Italy is 69.4 % more than 20 % points higher than the EU-28 average value (48.6 %).

The way family and household structures are likely to evolve in the future will have important consequences for forward planning in a wide range of policy areas, including childcare, education, housing, elderly care, and even urban planning. In the following section, the project "Tomorrow in the family" will be described in detail in each of its phases.

4.2. A step by step description of the project

4.2.1. Framing & scanning: scope and context & risk identification

After a literature review, the project started with some expert focus groups conducted with the aim of identifying the main areas of interest for the evolution of dynamics involving the family sphere. In particular, seven sections have been identified: Parents; Spouses; Extended Family; Children; Housing; Family Models; Policy and Services; Communication; and Solidarity. After these focus groups, several brainstormings have been realized in order to identify the key drivers (called items) for each section. Each item consists of a brief statement aimed at describing a specific phenomenon, relating to one of the seven themes under consideration, whose future visibility may decrease, increase or remain the same. The set of all items (41 in total) includes the key elements that experts have identified as fundamental in the future development of the family system (declined in its seven sections) and which can lead to the identification of both risks and opportunities. Therefore, each item represents a variable for which we want to study the ways in which it can unfold in the future. An example of an item is "'Virtual' communication (mobile, social networks, etc.) among young people will be frequent".

4.2.2. Forecasting: risk analysis

The next step was to apply a Delphi Survey with a panel of 32 experts. In order to investigate the future development of each item, the experts were asked to provide two assessments using an ordinal scale of 0–100, the first concerning Evolution, that is the spread of the phenomenon indicated in the item, the second regarding Relevance (or importance). Both evaluations were provided considering the situation hypothesized in 10 years compared to the current time. Scores lower than, close to, or above 50 indicate a reduction, substantial immutability, and an expansion respectively. The two dimensions, if considered jointly, are intended to represent the future visibility of the phenomenon itself.

To compute a summary of experts' scores on the items the most common approach would have been the arithmetic mean, which can be seen as an extremely simple composite indicator, using the sum as combining function and the equal weighting rule. The main advantage of this approach is the simplicity, making it readily comprehensible by most if not all stakeholders, including those with low numeracy skills. However, this approach presents several disadvantages too.

- using equal weights means assuming all experts as having the same level of expertise, but this assumption is generally not met in practice since expertise is generally unevenly distributed among experts;
- the arithmetic mean combines expert's scores even if they have different locations and variability, and therefore they cannot be directly combined. Experts' opinions should be made comparable by normalization before combination;
- the arithmetic mean corresponds to a very particular combining function, the additive one, but other functions are available, such as the multiplicative one, with their advantages and disadvantages.

The previous points are addressed by Di Zio et al. [13] by proposing a robust method to combine experts' opinions. The design of a composite indicator is a central issue because unsound composite indicators are easily liable to criticism and misuse [58]. Uncertainty analysis is central in the development of composite indicators as emphasized by OECD [47], and this analysis in fully incorporated into Di Zio et al. [13] method. The method is very flexible and can be easily modified to handle other common scales, such as ordered categorical ones. Moreover, it can be used to develop robust composite indicators, useful in most steps of risk management, other than for combining Delphi experts' opinions. By applying the uncertainty analysis, several formulas for normalizing, weighing and combining experts' scores are considered simultaneously through a Monte Carlo procedure, so that the final result does not depend on just one particular formula, with its pros and cons. Conversely, the uncertainty analysis gives a distribution rather than a single value for each item, for example it gives a distribution of ranks (based on the simultaneous consideration of many different formulas) rather than a single value for the rank for each item. A single value is dependent on the particular formula that have been used to combine experts' scores, and a different formula tends to give a different value. The rank distribution can be summarized by computing the median that is almost independent of the formulas used, being based on the simultaneous consideration of many different formulas. Moreover, a distribution is much more informative: we can compute the variability of the ranks, for example considering its 5th–95th percentile interval. Of course, results variability is impossible to be assessed having just one single rank value for each item, making it not possible to understand whether a result is stable (narrow uncertainty interval) or unstable (wide uncertainty interval). Another important information given by uncertainty intervals is related to the presence of partially or completely overlapping intervals. If two or more items have non-overlapping intervals, it means that their ranks are really different, whereas if they have partially or completely overlapping rank intervals, it means that their ranks are not very different. Therefore, rank intervals give a much more complete picture of the results and can be also used as input for further analyses.

This procedure has made it possible to identify some items that have a consensus of the experts on high values of evolution and relevance and that deserve, also with respect to their content, to be the subject of analysis for a reflection regarding possible family support solutions. The three items selected are.

a) For the mother, the organization of family life will be conditioned by professional commitments,
b) The networks of solidarity between generations (elderly, adults, young people) will be intense,
c) Young people will stay with their parents once they find a job".

These items provided also stability, convergence speed and consensus level parameters which show satisfactory performance. Starting from these three key factors, a scenario was hypothesized putting beside a substantial increase of the conditioning in the family organization for the mother by the professional commitments, a similar presence to the current solidarity networks between generations and a permanence of young people in the family more conspicuous of today. The scenario that emerged from expert evaluations is also confirmed by the data, as we have highlighted in Section 4.1.

In addition to this scenario, also three other scenarios have been identified, which contain a variable number of the 41 items which, in their different evolution and future relevance, provide the magnitude and likelihood of future events or consequences.

4.2.3. Visioning: risk evaluation

The scenarios obtained from the Delphi Survey by means of the robust ranking procedure were resubmitted for evaluation by a further panel of experts. In particular, the scenarios were evaluated according to two criteria: plausibility and consistency. Scenario plausibility is correlated with scenario probability, however, without being identical. In futures studies, the key concept is that in the future the number of scenarios is enormous, therefore the probability of each of them is close to zero. Plausibility, on the other hand, does not take into account the number of scenarios but only considers that a future scenario is composed of elements that are to a sufficient degree grounded in what we consider 'real' [59]. In other words, sufficient plausibility is the quality of a scenario to hold enough evidence to happen, to become real, given the present state of a system; it is what de Jouvenel [21] calls *Futuribles*.

While all consistent scenarios are not plausible, in order to be plausible a scenario must be consistent. A consistent scenario is one in which all scenario elements 'fit together' [60], and the occurrence of any scenario element (for us item) does not make impossible the occurrence of any other element (item).

Following these definitions, the experts were called to assign a score of plausibility and consistency from 1 to 10. The four scenarios resulted all plausible and consistent, albeit with different degrees, and this can be very useful in terms of measuring the risks that each scenario encompasses.

4.2.4. Planning and Acting: risk treatment

Once the plausibility and consistency of the future scenarios were assessed, a panel of experts identified eight intervention proposals (see Table 1) to support the family members, particularly women, in the context of one of the four scenarios (a scenario that concerns, in particular, the future of the mother and her role within the family). The main objective was therefore to identify the best policies capable of mitigating the risks associated with the scenarios. The analytic hierarchy process (AHP) was considered particularly suitable for achieving this goal since it relates with multiple-criteria decision problems [41,42]. The AHP started by formalising the problem in a hierarchy such that the main objective is at the top, two different criteria identified by the experts (efficacy and feasibility) are in the intermediate levels, and the eight alternatives are at the bottom. Each element in a level of the hierarchy is used to compare the elements in the level immediately below.

The AHP was applied involving $n = 74$ experts. The priority of each criterion was captured by asking the experts the importance of each criterion with respect to the other using a scale ranging from 1 to 9, where 1 meant that "both criteria are equally important" and 9 meant that "the i-th criterion is extremely more important to the other one". Then, the eight alternatives/actions were compared according to each criteria using the same scale described above.

By denoting with l_i ($i = 1,2,\ldots,8$) the i^{th} alternative and with k_r the r^{th} criterion ($r = 1, 2$), the 8×8 matrix – denoted here by $\mathbf{A}^r$ – which compares all the alternatives according to the criterion k_r can be rep-

Table 1
Local weights (for feasibility and efficacy) and global weights associated to each intervention.

Action	$w_{f,i}$	$w_{e,i}$	w_i
Facilitate a greater autonomy of the young children	0.0914	0.0669	0.075
Strengthen the support and assistance networks within the family (e.g. grandparents, relatives, etc.)	0.1129	0.0870	0.096
Strengthen the support and assistance networks outside the family (e.g. among peers, families, etc.)	0.1145	0.1079	0.110
Provide direct financial subsidies to families with children, the elderly, etc. …	0.1758	0.0830	0.115
Increase the accessibility and availability of family counselling services in situations of family difficulties of different types (not only psycho-emotional, but social, economic, etc.)	0.1138	0.1333	0.117
Improve public welfare (e.g., availability of services to the person, the elderly, children)	0.1422	0.1340	0.137
Promote a cultural change in family members (father, mother, children) through training actions (to promote awareness of shared responsibilities)	0.0860	0.1663	0.139
Improve corporate welfare to support workers with dependent children and elderly	0.1634	0.2215	0.202

$n = 74$.
$w_{\text{Feasibility}} = 0.34$, $w_{\text{Efficacy}} = 0.66$.
$\text{CR}_f = 0.0092$, $CR_e = 0.0095$.

resented as follows:

$$\mathbf{A}^r = \left[a_{ij}^r\right] = \begin{bmatrix} 1 & a_{12}^r & \cdots & a_{1n}^r \\ 1/a_{12}^r & 1 & \cdots & a_{2n}^r \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n}^r & 1/a_{2n}^r & \cdots & 1 \end{bmatrix}.$$

With 8 alternatives and 2 criteria, 2 pairwise matrices of size 8× 8 and one pairwise matrix 2 × 2 were collected.

Given the matrix $\mathbf{A}^r$, the goal is (for each r) to assign a set of numerical weights $w_1, w_2, \ldots, w_8$ to the alternatives $l_1, l_2, \ldots, l_8$, which mirror the judgements of the experts, the so-called local weights. The same applies to the matrix containing the comparisons between the two criteria. Among the various techniques used for the estimation of the local weights, the eigenvalue/eigenvector method is the standard one, originally proposed by Saaty [41]. According to this method, the weights correspond to the normalised eigenvector associated with the maximum eigenvalue (here denoted by λ_{max}) of the matrix. Once the weights of various levels of the hierarchy are obtained, the AHP procedure provides for the calculation of the vector of global weights, which serves as ratings of the alternatives in achieving the most general decision problem.

The local weights for the criteria result very asymmetrical: $w_{\text{Feasibility}} = 0.34$, $w_{\text{Efficacy}} = 0.66$. This means that for the experts involved in this AHP procedure efficacy is a predominant criterion with respect to feasibility. The priority weights of each alternative according to feasibility $(w_{f,i})$ and efficacy $(w_{e,i})$ are shown in Table 1. Overall the experts provided 4218 evaluations (0.88 % missing data, replaced with geometric mean according to general practice). The global weights w_i are obtained according to formula (1):

$$w_i = w_{\text{Feasibility}} w_{f,i} + w_{\text{Efficacy}} w_{e,i} \tag{1}$$

The first support intervention with a weight of 0.202, quite distinct from the others, is “Improve corporate welfare to support workers with dependent children and elderly family members”. This action is the first in terms of efficacy and the second according to feasibility. In contrast, in the final position with a weight of 0.075, we have “Facilitate a greater autonomy of the young children”. Actually, the research is focused on a cross-impact analysis, to evaluate the impact that the support intervention considered most important by experts would have, if they were implemented, on the future evolution of the scenario.

Human judgements are never perfectly consistent and, consequently, the consistency of the matrix in any AHP application must be verified. The analysis goes through the computation, for each matrix of the hierarchy, of the following consistency index:

$$CI = (\lambda_{max} - n) / (n - 1)$$

In the theoretical case of a perfect consistency, we would have $\lambda_{max} = n$ and thus $CI = 0$. But, in real applications, the closer λ_{max} is to n, the more consistent the matrix is. The average of the consistency indices computed on a huge number of random square matrices (reciprocal and positive), is called random index (RI). The ratio between CI and RI is called Consistency Ratio (CR), which is used to check for consistency [61,62]:

$$CR = CI/RI$$

A rule of thumb introduced by Saaty [41] is the following: if $CR \leq 0.1$ then the judgements of a matrix can be considered consistent. If $CR > 0.1$, then the matrix is considered inconsistent, and the judgements should be revised by the expert until $CR \leq 0.1$.

For our first matrix (feasibility) we get a Consistency Ratio $CR_f = 0.0092$ and for the second matrix (efficacy) $CR_e = 0.0095$. Therefore, we can say that the two matrices are excellently consistent, and we did not have to consult the experts further. Note that the matrix comparing the criteria is 2×2, containing only one pairwise comparison. Therefore, the matrix is, by definition, consistent.

All information related to the AHP procedure are represented in Table 1.

This application shows that our approach is a practical and useful tool to decision-makers in terms of quantification of the efficacy and feasibility of actions for risk mitigation and also in terms of impacts that any action taken in the present could have on the future.

5. Conclusions

The definition and knowledge of new risks arise from new hypotheses, scenarios, interpretations and perspectives of the expected and/or undesired futures. New problems require studying new solutions and new approaches. Risk studies and futures studies are - in this work - described separately to evaluate their aims and potential, to grasp both the parallelism of the objectives and, even more, to verify the possibility of developing synergies useful for the construction of adequate learning for knowledge needs emerging in our complex society.

A complex society expresses problems to which science cannot always give classical answers but must take new and innovative paths. The very definition of risk, as we have seen, is not unique and risk management in the social sphere inevitably becomes a complex issue.

The proposal of this paper starts from a specific scenario planning approach, called Delphi-based Scenario development [13,14] that refers to a recognized strategic foresight approach [31], which contains a series of steps that can be related with to the classical steps of the risk management. In each step of the Delphi-based scenario planning, a specific technique is proposed that can be used to outline the aim of a precise phase of risk management; thus, the scenario planning covers all phases of risk management, from the definition of the context to the treatment of the risk and communication of the results. The strategic foresight methodology presented in this paper surpasses and advances well beyond the recommendations outlined in the ISO manual. While the ISO manual provides a comprehensive list of tools and methods applicable throughout the various stages of the risk management process, it lacks specific guidance on actions to be taken in each phase and, more importantly, on how to interconnect the diverse methods across the different stages. Consequently, the decision-making process for selecting methods in each phase and the formulation of a comprehensive procedure encompassing specific operational steps are entirely left to

the discretion of the practitioners. Our proposal is introduced precisely to address these shortcomings: it indicates the most appropriate methods for each phase and how to use outputs from one phase as inputs for the subsequent phase, therefore offering to the practitioner a fully integrated approach to risk management.

The connection between two different areas (futures studies and risk management) apparently different, and that to date have only seen a point of contact in the use of the scenarios as one of the many tools to be used in the phases of risk identification or risk analysis, find in this paper a completely new and different connection, which can open up new avenues of research. The scenario, here, is no longer a technique at the service of risk management, but the very process of future scenario development runs parallel to the risk management process, in a step-by-step journey in which one approach draws from the other.

At the conclusion of the work, some indications or proposals emerge which seek to go beyond the classic dichotomous approach "quantitative or qualitative", trying instead to follow a proactive approach based on the so-called mixed methods.

Effective management of emerging and future risks is critical for the success of organizations in today's rapidly changing social, political and economic environment. Organizations adopting the quali-quantitative risk management approach discussed in this paper will be better posed to ensure their long-term resilience and success. It is important for organizations of all types, sectors and dimensions to recognize that managing emerging and future risks should be a continuous process that needs flexible tools for monitoring and adaptation, and which can adequately and efficiently involve - in the various stages - the stakeholders.

About the future evolution of a system, we believe that in the risk management of a social context, quantitative forecasting techniques, typical of statistics, are of little use, if they are not flanked by qualitative techniques. Therefore, the future scenarios approach - and more generally the mixed-method approach - that we propose in this paper can offer a useful alternative in the direction of decision support for policy-makers.

The research conducted on the "Tomorrow in the family" project represents a specific application in the process of evaluating actions in support of a specific scenario, in order to support public decisions to mitigate and/or prevent the effects of the risks that have emerged from that scenario.

The work has also made it possible to highlight open problems, objects and provocations to proceed in this area of research.

a. In deciding between qualitative or quantitative techniques, it is necessary to consider the availability of high-quality data. When data is not available or not sufficient, quantitative techniques are not enough and must be used in combination with qualitative ones.
b. It is necessary to promote greater awareness of mixed methods which is not always easy among researchers with a strong unilateral identity.
c. We believe it is important to enhance and verify the applicability and effectiveness of these approaches in operational contexts and not just substantive research (e.g., in politics or business).
d. Is worth exploiting other aspects of both methodology and data base for the application of this approach, such as the Bayes' theorem.

However, it should be emphasized that this quali-quantitative approach has also limitations, like the need for proper and updated data and expertise to forecast the key drivers, develop plausible and consistent future scenarios, build sound composite indicators, and select appropriate policy actions.

In conclusion, organizations that effectively integrate scenario methods and, more generally, futures studies into their emerging and future risk management process will be better posed to identify and mitigate risks, maintain and improve their performance, and protect and improve their reputation. As the environment continues to change, the use of scenario methods and strategic foresight will become increasingly important for organizations [29] looking to remain well-performing, being large or small, for-profit or not-for-profit ones.

CRediT authorship contribution statement

Simone Di Zio: Conceptualization, Formal analysis, Methodology, Software, Validation, Visualization, Writing – review & editing. **Mario Bolzan:** Conceptualization, Methodology, Project administration, Resources, Supervision. **Marco Marozzi:** Funding acquisition, Investigation, Resources, Writing – review & editing. **Manuela Scioni:** Data curation, Investigation, Software, Validation, Visualization, Writing – original draft.

Data availability

Data will be made available on request.

References

[1] Nowak A, Vallacher RR. Nonlinear societal change: the perspective of dynamical systems. Br J Soc Psychol 2019;58(1):105–28.
[2] Smith LG, Livingstone AG, Thomas EF. Advancing the social psychology of rapid societal change. Br J Soc Psychol 2019;58(1):33–44.
[3] Adam B, Van Loon J, Beck U. The risk society and beyond. Newbury Park, CA: Sage Publishing; 2000.
[4] Simpson NP, Mach KJ, Constable A, Hess J, Hogarth R, Howden M, Trisos CH. A framework for complex climate change risk assessment. One Earth 2021;4(4):489–501.
[5] Burnard K, Bhamra R. Organisational resilience: development of a conceptual framework for organisational responses. Int J Prod Res 2011;49(18):5581–99.
[6] IEC-ISO. International standard: risk management - risk assessment techniques, IEC 31010, edition 2.0 2019-06. Geneva, Switzerland: IEC; 2019.
[7] Luhmann N. Risk: a sociological theory. Berlin: Walter de Greuter; 1991.
[8] Taleb NN. The black swan: the impact of the highly improbable. London: penguin. 2008.
[9] Johnson RB, Onwuegbuzie AJ. Mixed methods research: a paradigm whose time has come. Educ Res 2004;33(7):14–26.
[10] Sale JEM, Lohfeld LH, Brazil K. Revisiting the quantitative–qualitative debate: implications for mixed-methods research. Qual Quantity 2002;36(1):43–53.
[11] Brewer J, Hunter J. Multimethod research: a synthesis of styles. Newbury Park, CA: Sage Publishing; 1989.
[12] Clark VLP, Huddleston-Casas CA, Churchill SL, Green DO, Garrett AL. Mixed methods approaches in family science research. J Fam Issues 2008;29(11):1543–66.
[13] Di Zio S, Bolzan M, Marozzi M. Classification of Delphi outputs through robust ranking and fuzzy clustering for Delphi-based scenarios. Technol Forecast Soc Change 2021;173:121–40.
[14] Marozzi M, Di Zio S, Bolzan M. Robust weighted aggregation of expert opinions in futures studies. Ann Oper Res 2022. https://doi.org/10.1007/s10479-022-04990-z.
[15] Bolzan M. Domani in Famiglia: possibili scenari fra 10 anni. Milano: Franco Angeli; 2018. 978-88-917-6172-9.
[16] Price DJ. Little science, big science. New York: Columbia University Press; 1963.
[17] Johansen IL, Rausand M. Defining complexity for risk assessment of sociotechnical systems: a conceptual framework. Proc Inst Mech Eng O J Risk Reliab 2014;228(3):272–90. https://doi.org/10.1177/1748006X13517378.
[18] Hansson SO. Risk. In: The Stanford encyclopedia of philosophy, winter 2022 edition. Edward N. Zalta & Uri Nodelman; 2022. https://plato.stanford.edu/archives/win2022/entries/risk/.
[19] de Finetti B. Sul concetto di probabilità. Rivista Italiana di Statistica Economia. e Finanza 1933;5:723–47.
[20] Fischhoff B, Watson S, Hope C. Defining risk. Pol Sci 1984;17:123–39.
[21] de Jouvenel B. L'art de la conjecture. Monaco: du Rocher; 1964.
[22] Adams J. Risk. London: UCL Press; 1995.
[23] Bernstein P. Against the gods- the remarkable story of risk. New York: Wiley; 1996.
[24] Renn O. Concept of risk: a classification. In: Krimsky S, Golding D, editors. Social theories of risk. Westport, CT: Praeger; 1992. p. 53–79.
[25] Vasvári T. Risk, risk perception, risk management – a review of the literature. Public Finance Quarterly 2015;60(1):29–48.
[26] Thornton S. Karl Popper. In: Zalta Edward N, Nodelman Uri, editors. *The Stanford Encyclopedia of philosophy,* winter 2022 edition; 2022. https://plato.stanford.edu/archives/win2022/entries/popper/.
[27] Barabási AL. Bursts: the hidden patterns behind everything we do. New York: Dutton; 2010.
[28] Kahn H, Wiener AJ. The next thirty-three years: a framework for speculation. Daedalus. 1967. p. 705–32.
[29] European Commission Research Directorate General. A practical guide to regional foresight (FOREN). 2001. http://foresight.jrc.ec.europa.eu/documents/eur20128en.pdf.

[30] OECD. Preparing governments for long-term threats and complex challenges. 2016. www.oecd.org/gov/Preparing-governments-for-long-threats-and-complex-challenges.pdf.
[31] Bishop P, Hines A, Collins T. The current state of scenario development: an overview of techniques. Foresight 2007;9(1):5–25.
[32] ISACA. The risk IT framework. *2nd edition*. Information Systems Audit and Control Association. Schaumburg, IL, USA. 2020.
[33] Andersen PD, Hansen M, Selin C. Stakeholder inclusion in scenario planning - a review of European projects, vol. 169. Technological Forecasting and Social Change; 2021.
[34] Renn O. Risk Governance. Coping with uncertainty in a complex world. London: Earthscan; 2008.
[35] Bonss W. Risk. Dealing with uncertainty in modern times. Soc Change Rev 2013;11(1):7–36.
[36] Calleo Y, Di Zio S, Russo V. Exploiting Text Mining and Network Analysis for future scenarios development: an application on remote working. In: Balzanella Antonio, Bini Matilde, Cavicchia Carlo, Verde Rosanna, editors. "Book of the short papers, SIS 2022", 51th scientific meeting of the Italian statistical society, 22-24 June 2022, Caserta; 2022. p. 1797–802. 9788891932310.
[37] Marbach G. Sulle previsioni di lungo periodo: un quadro d'assieme. In: Marbach Giogio, editor. Previsioni di lungo periodo: Analisi esplorative. Milano: Franco angeli; 1980. p. 15–50. 1980.
[38] Gordon TJ. Trend impact analysis, futures research methodology. AC/UNU Millennium Project; 1994.
[39] Gordon TJ, Hughes B, Solórzano JR, Stelzner M. Producing state of the future indexes using the international futures model. Technol Forecast Soc Change 2011;78:75–89.
[40] Turoff M. An alternative approach to cross-impact analysis. Technol Forecast Soc Change 1972;3(3):309–39.
[41] Saaty TL. The analytic hierarchy process. New York: McGraw-Hill; 1980.
[42] Saaty TL. How to make a decision: the analytic hierarchy process. Interfaces 1994;24:19–43.
[43] UNDP (United Nations Development Programme). Human development report 2021-22: uncertain times, Unsettled lives: shaping our future in a transforming world. New York: UNDP; 2022.
[44] Wolf MJ, Emerson JW, Esty DC, de Sherbinin A, Wendling ZA, et al. 2022 environmental performance index. New Haven, CT: Yale Center for Environmental Law & Policy; 2022. Available from: http://epi.yale.edu.
[45] Institute for Economics & Peace. Global Peace index 2022: measuring Peace in a complex world. Available from:. 2022. http://visionofhumanity.org/resources.
[46] Marozzi M. Measuring trust in European public institutions. Soc Indicat Res 2015;123:879–95.
[47] OECD. Handbook on constructing composite indicators. Paris: OECD; 2008.
[48] ISTAT. Popolazione e famiglie. Available at: https://www.istat.it/it/files/2020/12/C03.pdf; 2020.
[49] Bongaarts J. Household size and composition in the developing world in the 1990s. Population Studies—A Journal of Demography 2001;55(3):263–79.
[50] Peterson MN, Peterson TR, Liu J. The housing bomb: why our addiction to houses is destroying the environment and threatening our society. Baltimore, MD: Johns Hopkins; 2013.
[51] ISTAT. Matrimoni, separazioni e divorzi. Anno 1999. Available at: https://ebiblio.istat.it/digibib/Matrimoni%20Separazioni%20Divorzi/VEA0018064Matrsepdiv1999.pdf; 1999.
[52] ISTAT. Statistiche report. Matrimoni, unioni civili, separazioni, e divorzi. anno 2019. 2019. Available at: https://www.istat.it/it/files/2021/02/Report-matrimoni-unioni-civili-separazioni-divorzi_anno-2019.pdf.
[53] Nieuwenhuis R, Maldonado L. The triple bind of single-parent families: resources, employment and policies to improve well-being. Bristol: Policy Press; 2018.
[54] Blau F, Grossberg A. Maternal labor supply and children's cognitive development. Rev Econ Stat 1992;77:231–49.
[55] Baum C. Does early maternal employment harm child development? An analysis of the potential benefits of leave taking. J Labor Econ 2003;21(2).
[56] James-Burdumy S. The effect of maternal labor force participation on child development. J Labor Econ 2005;23(1):177–211.
[57] ISTAT. Rapporto annuale 2016. 2016. Available at: https://www.istat.it/it/archivio/185497.
[58] Saisana M, D'Hombres B, Saltelli A. Rickety numbers: volatility of university rankings and policy implications. Res Pol 2011;40:165–77.
[59] Emery F. Futures we are in. Leiden: Martinus Nijhoff; 1977.
[60] Tietje O. Identification of a small reliable and efficient set of consistent scenarios. Eur J Oper Res 2005;162(2):418–32.
[61] Brunelli N. A survey of inconsistency indices for pairwise comparisons. Int J Gen Syst 2018;47(8):751–71.
[62] Kou G, Ergu D, Shang J. Enhancing data consistency in decision matrix: adapting Hadamard model to mitigate judgment contradiction. Eur J Oper Res 2014;236(1):261–71.

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