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Project resilience: a conceptual framework

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Abstract:
Resilience is a novel but promising concept in project management studies. Resilience thinking can help projects maintain their performance through flexible, systemic and context-specific approaches once faced with disruptive events. That said, the main goal of this paper is to advance an interdisciplinary understanding of project resilience by proposing a definition and a conceptual framework of this concept. To achieve this article's objectives, the literature on project risk management is first reviewed to identify current research effort and limitations of dealing with disruptions. Consecutively, the concept of resilience in its broader applicability is explored, where two dimensions are sieved; awareness and adaptive capacity. The literature on the new concept of project resilience is also scrutinized, where its novel nature, the lack of scientific studies to conceptualize it, and its significance to project management are demonstrated. These facts helped propose a definition and a conceptual framework of project resilience, where a set of relationships are instigated, which constitute a base line to perform further disquisitions to assess their validity. Implications for future contributions advocate conceptual exchanges with more advanced research fields (e.g. organizational resilience). These exchanges can assist in the development of indicators to evaluate the ability of projects to deal with disruptive events and enhance their resilience.

Keywords:
project risk management; resilience; project resilience; awareness; adaptive capacity; recovery.

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1. Introduction

A project is a temporary organization, where diverse and skilled resources work together, on a specific endeavor, for a limited period of time, in order to achieve unique objectives [1]. During the project life-cycle, disruptive events, either known or unknown at the beginning of the project, can cause interruption of planned tasks, and, in many cases, the whole project to fail [2], [3]. These events can affect "*everything from technical feasibility to cost, market timing, financial performance, and strategic objectives*" [4, p. 1]. Thus, responding to these disruptions is considered a major challenge for practitioners as well as a relevant research topic [5], [4], [3], [6].

Project risk management (PRM) is the knowledge area responsible for dealing mainly with disruptions. It aims to reduce the impact of negative risks (disruptive events that may or may not occur [6]) while taking advantage of positive risks to help ensure project success [7], [8]. However, current PRM practices are often described as time-consuming and inflexible under high-uncertainty conditions [9]. These practices tend to focus on sources of disruptions, to reduce vulnerabilities, without developing a general capacity to recover from their negative consequences [10]. Therefore, these practices "… *should incorporate the capacity for projects to evolve in response to the consequences of unexpected risks"* [10, p. 410].

To overcome the PRM limitations, recent studies have suggested integrating the concept of resilience into project management [2], [3], [5], [11]. Resilience can be broadly defined by the system's ability (e.g. ecological, organizational, psychological, etc.) to be aware of its surroundings and to adapt for recovering once faced with disruptions [12]. This multidimensional concept has been the subject of several research studies over time in many disciplines and domains. The concept of resilience helps recognize the inherent fallibility of a project so it can successfully recovers, when confronted with disruptive events [5].

Therefore, the aim of this study is to define the concept of resilience from a project management perspective, which requires an in-depth analysis of its various components. A conceptual framework of project resilience is formulated to set the foundations for future studies of resilience in project management. This article tackles Thomé et al.'s challenge when they recently suggested that [13, p. 1342]*:* "*the lack of coverage of the concept of resilience project management literature deserves more attention by scholars and is an opportunity to aid project management*."

Consequently, this paper is organized into four parts. First, the literature on PRM, resilience and project resilience is reviewed. The objectives are to explore the limitations of PRM practices, to sieve the resilience dimensions in their broader applicability, and to understand the current research efforts on the concept of project resilience. Second, the methodology adopted to achieve this study is discussed. Third, a definition and the conceptual framework of project resilience are presented where the relationships between its building blocks are exposed. Finally, implications for future disquisitions are proposed.

2. Literature review

2.1 Project Risk Management

The knowledge area of Project Risk Management includes the processes to identify risks, analyze risks, plan risks' responses, and control risks through the project life-cycle [7], [8]. It adds value to other project management methods by helping in the mitigation of uncertain conditions [6], [14]. Project risk management has a direct effect on project success because it maximizes the efficiency of processes such as decision-making and communication, among others [15].

Many approaches have been proposed to manage project risks. The latter often refer to complex and sophisticated concepts and architectures. To name few examples, Lee and Baby (2013) [16] developed a conceptual framework for risk management based on the principles of service-oriented architecture (SOA). According to these researchers, this framework helps identifying risks related to the dynamic interactions that exist between human resources, processes and technology. Alternatively, López & Salmeron (2014) [17] have proposed a fuzzy logic system to mathematically model the risks associated with the maintenance of ERP implementation projects. This system makes it possible to analyze the impacts of risks on the objectives of the project with a reasonable degree of precision.

Despite this advancement, PRM still faces several challenges when dealing with disruptive events mostly due to the project increased complexity [4], [18]. This complexity is caused by many varied and interrelated elements operationalized in terms of differentiation and interdependence [19]. It mainly leads to "*uncertainties, ambiguities, and arrays of risk factors that are often intricately connected*" [4, p. 21]. Uncertainty is defined as the inability to evaluate the project's objectives and characteristics, as well as the consequences of actions and decisions on the entire project environment [20]. It tends to be high at the beginning of a project and is supposed to diminish when approaching the closure phase [6], [21].

Alternatively, ambiguity is "*associated with lack of clarity because of the behavior of relevant project players, lack of data, lack of detail, lack of structure to consider issues, working and framing assumptions being used to consider the issues, known and unknown sources of bias, and ignorance about how much effort it is worth expending to clarify the situation.*" [6, p. 99]. Ambiguity often derives from cultural differences and optimism levels by stakeholders [22] consequently increasing the probability of project failure [14].

Finally, As mentioned by Vidal [8], non-linear and dynamic interdependencies exist between the components of the project and between the project and its environment. So, every change in any facet of the project may propagate through the other elements and therefore lead to additional, unforeseen and unpredictable risks [23].

2.2 Limitations of Project Risk Management

As noted by Crawford et al. (2013), PRM practices are criticized for being time consuming and inflexible when dealing with disruptive events that require quick response. Geambasu (2011) explains this inflexibility by referring to the "hard" theories behind these practices. "*These theories emphasize the planning and control dimensions of a project anchored in a system of engineering methods and related tools*" [3, p. 19].

She also mentions that in many cases the poor performance of projects is due to the optimism bias and strategic misrepresentation of the projects' scope, budget and schedule. The latter lead stakeholders to ignore or underestimate risks [3].

On the other hand, Blay (2017) notes that current PRM practices focus on the source of the disruptive events in order to minimize the level of vulnerability. For instance, risk management helps manage known sources, whereas uncertainty management and crisis management focus on unknown sources [7], [6], [11]. This vulnerability-reduction perspective is limiting because the "*focus is on identifying strategies to implement on disruptions perceived and also work towards predicting threat, without critically developing the general capacity (response and preparedness) for dealing with shock (sudden distress) these disruptions cause*" [2, p. 1].

To address these challenges, the following avenues are proposed:

1. More flexible and context-specific methods need to be integrated in PRM. This adds a dynamic and proactive perspective to PRM where the focus is on the evolution of the project, and its ability to deal with disruptive events during its life-cycle [9].

2. PRM practices necessitate progressing beyond the common and simplistic perspective of detecting obvious risks during the project planning phase and monitoring and controlling them on a regular basis. New methods are required to cope with unknown, unpredictable and completely unexpected disruptive events [10].

3. The focus should not only be on vulnerability reduction, but also on factors and conditions' identification that enables a successful response to disruptive events [3]. Recognizing the inherent fallibility of projects helps understand how projects maintain and recover their performance once faced with disruptive events [5].

That is why recent academic research are exploring the concept of resilience in project management. In fact, "*responding to emerging unknown unknowns requires that we make our systems—and, by extension, our development projects located within these systems—more resilient. Resilient projects are nimble, flexible, and adaptable*" [10, p. 412].

2.3 Resilience and Its Definitions

Resilience is a widely used concept in many domains including ecology [24], psychology [25], climate change [26], critical infrastructure [27], [28] and organization science [29]–[31]. Its definitions vary depending on the subject to be analyzed whether it is a community, an organization, a project, an engineering system or others [12].

In 1973, Holling [24] pioneered studies in resilience from the ecological perspective. He differentiates between stability and resilience. Stability is the ability to emphasize the presence of a unique steady state for a system, and to conserve equilibrium around it. Resilience, on the other hand, focuses on maintaining existence of function. It is related to a complete change of the system's state into another regime of behavior.

Later, in 1996, Holling [32] advanced his research and distinguished between engineering and ecological resilience. Engineering resilience accentuates efficiency, constancy, rigidity and predictability of a system as measured by resistance to disturbance and speed of recovery [12], [32]. Consequently, a system that follows this perspective of resilience is designed to recover quickly from small disruptive events with difficulties to recover from the large ones. It is a highly controlled system that works within limited possible states [33].

Alternatively, ecological resilience focuses on the persistence, change, renewal, reorganization and unpredictability of a system. It is measured by the levels of disturbance that can be absorbed before necessitating changes to the system's structure (changes are made on variables and processes that operate the system behavior). Hence, the system that follows this perspective of resilience endures larger disruptive events through adaptation and evolution. It functions within an expansive spectrum of possible states and tends to return gradually to its equilibrium point. Under certain circumstances this system may switch to a new equilibrium point with major changes to its requirements and structure [33].

The differentiation between engineering resilience and ecological resilience shaped the studies on resilience from many perspectives [12], [34].

Table 1 presents a summary of the resilience's definitions in diversified contexts. From these definitions, key words and key activities are observed. First, resilience usually refers to a specific unit of analysis (a system, an organization, an individual, etc.). Second, it often corresponds to a function (capacity, ability, capability, etc.) of the unit to be aware of its surroundings (proactive activities) and adapt (reactive activities) to recover following a disruptive event. Therefore, resilience is composed of two dimensions: awareness and adaptive capacity [12], [35]–[38].

Table 1. Definitions of resilience

Context	**Definition**	**Reference**
Ecological systems	Measure of resistance of systems, and ability to absorb shocks, while maintaining relationships among state variables.	(Holling, 1973) [24]
Ecological systems	The capacity of a system to absorb a disturbance and reorganize itself while retaining its functionality and structure.	(Walker et al., 2004) [39]
Engineering systems	The ability to sense, recognize, adapt and absorb disruptions.	(Hollnagel et al., 2006) [40]
Organizational	The ability of firms to develop specific responses to disruptions and engage in transformative activities.	(Akgün & Keskin, 2014) [41]
Organizational	The ability of an organization to adapt to changes and maintain its operation.	(Murray, 2013) [42]
Organizational	The capacity to adapt to changes in the environment to prevent disruptions.	(Mafabi et al., 2013) [43]

Context	Definition	Reference
Psychology	The ability to improvise, accept reality, and maintain the belief that life is meaningful.	(Coutu, 2002) [25]
Socio-ecological systems	Ability to maintain functionality of a system under perturbations, or ability to maintain elements when disturbances alter system structure or function.	(Walker et al., 2004) [39]
Psychology	Acquired capacity to rebound from adversity.	(Luthans et al., 2006) [44]
Disaster management	The application of learning, innovation, and development skills at individuals, communities and operational level to recovery from disasters.	(Crawford et al., 2013) [9]
Disaster management	The ability to function at a higher psychological level based on individual abilities and experiences.	(Paton & Johnston, 2001) [45]
Engineering systems	The ability to anticipate, adapt and recover from disruptions.	(Madni & Jackson, 2009) [46]
Engineering systems	The ability of a system to adjust function to disturbances and maintain operations under certain conditions.	(Saurin et al., 2014) [47]
Ecological systems	The magnitude of disturbance absorbed by a system before its structure and behavior are transformed.	(Gunderson, 2000) [48]
Supply chain	The ability of the supply chain to prepare for unexpected events, adapt to and recover from disruptions.	(Ponomarov & Holcomb, 2009) [34]
Supply chain	The ability of a system either to return to its original state or to shift to a superior state desirable following disturbance.	(Carvalho et al., 2012) [49]

2.3.1 Awareness

Awareness is a holistic understanding of the system's internal and external elements [50], [51]. This understanding enhances responsiveness to disruptive events due to effective monitoring of the changes in the system environment [25], [44]. Responsiveness means knowing the actions and/or the modes of functioning that need to be adopted in order to face future disruptions, while monitoring is knowing what to look for and what can affect the system's performance [40].

Awareness requires proactive behavior towards disruptive events and knowledge of the system inputs, outputs and vulnerabilities [27]. Vulnerability can be represented by a system's disturbance thresholds that can potentially prevent it from maintaining an acceptable functioning [52]. Hence, deficiencies in system internal connectivity, and lack of available resources, among other factors, are internal and external threats that increase susceptibility to disruptive events [27]. The longer the system is vulnerable, the most likely it will face disruptions, and its probability to fail increases [53]. The level of the system's vulnerability is measured by the gap between available versus required resources to operate [50].

2.3.2 Adaptive Capacity

The concept of adaptive capacity has its origins in biology and denotes structural and functional changes in species as a result of an environmental change [54]. It refers to structural and behavioral transformation [55]. Therefore, adaptive capacity requires a specific system (ecological, organizational, etc.) to be aware of its surroundings in order to alter its structure, operations, and strategies and to cope with disruptive events [56].

From the engineering perspective, adaptive capacity is the ability of the system to return quickly to its equilibrium point once faced with a disruptive event. Therefore, the speed to return to the equilibrium point is a main characteristic of the system. On the other hand, adaptive capacity from the ecological perspective, also includes the ability to transform its structure and behavior when a return to its equilibrium point is no longer viable [32].

Woods & Wreathall [57] and Vogus & Sutcliffe [58] also confirm this by distinguishing two types of adaptive capacity. The first type is when the system bounces back using existing predetermined planning and strategies. The second type is when the system develops new capacities to respond to events that are outside of its preconfigured design. Accordingly, as proposed by Hémond [27], a system can adapt by the application of existing available responses, of an existing response in a new context, or of a novel response to address a disruptive event.

However, regardless of the adaptive capacity's types and the perspective from which it is perceived, the main objective of the adaptation, once faced with a disruptive event, is to recover. This recovery can be achieved by returning to a steady state or by changing to a new equilibrium point (a new state) [34], [59]. Learning through adaptation is essential to reinforce what worked well and change or adjust what was considered a failure [40], [60]. Thus, knowing what happened to acquire the right lessons can improve the system's global awareness and its capacity to adapt to future disruptive events [59]. This learning can also be achieved through negative feedback [34], which allows systems to cross boundaries, explore alternative new situations and collect information to avoid potentially non-viable states. Negative feedback is also the main principle of the cybernetics theory, which is mainly concerned with the functioning of self-regulating systems. To this matter, learning through negative feedback loop "*minimizes discrepancies between environmental characteristics and relevant reference criteria*" [61, p. 238]. Thus, resilience is linked to the cybernetic theory through the adaptive capacity dimension especially from the "engineering resilience" perspective [62].

2.4 Project resilience

The concept of project resilience is still new and largely undefined and ambiguous despite the growing recognition of this concept within academic publications [13].

Geambasu [3] was the first to introduce the concept of project resilience after an empirical study on major infrastructure projects. The author defines it as "*1) the project system's ability to restore capacity and continuously adapt to changes 2) to fulfill its objectives in order to continue to function at its fullest possible extent, in spite of threatening critical events.*"[3, p. 133]. Geambasu proposed a framework for project resilience composed of three levels; Strategy, culture and structure. For each level, a set of resilience enablers (project resilience facilitators) is suggested. For instance, the legitimacy and clear vision of the project objectives facilitate the strategic level of resilience. On the other hand, partnerships, risk attitude, safety culture, effective communication, proactive planning, positive work relationships, and the diversity of skills and expertise are enablers for the cultural level of resilience. Finally, having a flat organizational structure to facilitate communication, having a financial structure, using technology to reduce complexity, and having flexible contracting practices are all enablers for the structural level of resilience.

In 2017, Blay [2] conducted an empirical study to conceptualize project resilience. Thus, the author defines this concept as the capacity to respond to, prepare for, and reduce the disruptions' impact to recover and ensure successful completion of project objectives. Her conceptual framework of project resilience is composed of four dimensions; proactivity, coping ability, flexibility, and persistence. Each dimension has several antecedents (similar to enablers in Geambasu's conceptual framework of resilience). First, project management procedures, project management mechanisms and experience are antecedents for proactivity. Second, contract, training, contingency and experience are antecedents to the coping ability dimension. Third, open-mindedness, planning, continuous monitoring and continual identification of ideas are antecedents for flexibility. Finally, the continuous monitoring, planning, and negotiation are the antecedents for the persistence dimension.

Turner & Kutsch (2015) [11] proposed another interpretation of project resilience. These authors elaborated on the meaning of project resilience and defined it as the art of detecting changes in the project environment, understanding these changes, planning answers, minimizing damage when a change occurs, and adapting to a new reality.

Prevention, response, and adaptation were also present in the definition of project resilience proposed by Giezen et al. (2015) [63]. These researchers mentioned the presence of two types of project resilience; reactive resilience and proactive resilience. Reactive resilience takes into consideration that the project is in a stable situation that allows it to protect itself against disruptive events. On the other hand, proactive resilience emphasizes the project's environment and considers that an unstable environment requires some form of adaptation. For these authors "*Resilience related to the availability of a redundancy of options, alternatives, and recombinant pathways*" [63, p. 171].

Alternatively, being a significant part of a project, the resilience of the project team is an important aspect of the project's resilience as a system [60]. Amaral et al. (2015) [64], and after conducting a quantitative study among project teams, define the team's resilience as the team's ability to deal with issues, bypass obstacles, or resist to adverse cases without being ruptured. They suggest 10 actions to improve the team's resilience. These actions emphasize the collaboration and solidarity between project team members, the recognition, appreciation and efficient use of the team members' competences, the ability to learn from mistakes, the stimulation of a positive team environment, and the capability to be creative and innovative. Table 2 presents the definitions of project resilience found in the literature.

Table 2. Definitions of project resilience

Definitions	**Reference**
The ability to restore capacity and continuously adapt to changes, and to achieve its objectives in the face of disruptive events.	(Geambasu, 2011) [3]
The capacity to evolve in response to f risks emerging after the project planning stage.	(Schroeder & Hatton, 2012) [10]
The capacity to maintain purpose and integrity under external or internal shocks.	(Hillson, 2014) [23]
The art of noticing, interpreting, containing, preparing for and recovering from disruption.	(Turner & Kutsch, 2015) [11]
The capacity to overcome unexpected events.	(Giezen et al., 2015) [63]
The ability to cope with uncertainty.	(Zhu, 2016) [5]
The capability to respond to, prepare for and reduce the impact of disruptions caused by changes in the project environment.	(Blay, 2017) [2]

As noticed and already discussed, the concept of project's resilience still new and largely undefined and ambiguous despite the growing recognition of this concept within academic publications [13]. In fact, resilience, in project management, can help projects maintain their performance through flexible, systemic and context-specific approaches [9], [65]. Resilience helps focus on the project behavior, and the efficient utilization of resources once faced with disruptive events or conditions [66]. In other words, resilience is concerned with how processes, methods, organizational structure, etc. evolve and realign to face disruptive events. This is achieved through continuous monitoring of the project complexity and uncertainty levels during the project life-cycle [5]. As mentioned by Schroeder and Hatton (2012) [10], the focus should be on redundancy, diversity, transparency, decentralization in processes and structures, decreased connectivity between methods, and increasing communication and sharing of information. In fact, unlike the critical success factors that do not take into consideration the context of the project once faced with the disruptive event, resilience offers insights to which elements mostly contribute to maintain an acceptable project functioning at a specific point in time (the time once the project is faced with a disruption) [3].

3. Methodology

This theoretical article aims to develop a clear understanding of the concept of project resilience. Therefore, a theory building approach is adopted to develop the project resilience conceptual framework and to set the foundation for future research studies. The main characteristic of theory building is to develop definitions and relationships, and to compare existing emergent key concepts, constructs and theories in order to draw conclusions [67]–[69].

Accordingly, the importance of developing a conceptual framework is to provide a general understanding of the main elements of a concept [69]. Therefore, the proposed conceptual framework of project resilience will set the basis for future research activities on this newly emergent concept by borrowing the previously discussed dimensions of resilience; awareness and adaptive capacity. Consecutively, this framework will also describe the link that exists between current project risk management practices and the concept of resilience to successfully respond to disruptive events during the project life-cycle.

The development of the project resilience conceptual framework is achieved by following the same process as many authors (e.g. the works of [34], [70]) who utilized literature review to establish a conceptual framework. As noted by Burnard and Bhamra [69] "*conceptual frameworks aid in not only providing construct validity, but also provide an outline for future research activities*" [69, p. 5585]. Therefore, to build this conceptual framework, the literature was reviewed to identify current research efforts and limitations of project risk management. Consecutively, the concept of resilience in its broader applicability was reviewed where two main dimensions were sieved: awareness and adaptive capacity. The literature on the newly introduced concept of project resilience was also reviewed where its novel nature, the lack of scientific studies to conceptualize it, and its significance to project management were demonstrated. This confirmation will help propose a definition and a conceptual framework of project resilience where a set of relationships will be instigated. The definition and the conceptual framework, proposed in this paper, constitute a base line to perform further studies to assess their validity.

4. Project Resilience: A General Definition and Conceptual Framework

In this section, a definition and a conceptual framework for project resilience are presented. Thus, given the plethora of definitions and perspectives summarized in the previous literature review, a generalized definition of project resilience is proposed: It is *the capacity of the project system to be aware of its surroundings and vulnerabilities, and to adapt in order to recover from disruptive events and achieve its objectives.* This definition borrows the dimensions from the previously reviewed literature on resilience; awareness and adaptive capacity. It also emphasizes the visualization of the project as a system.

4.1 Project as a System

The main unit of analysis in studies on resilience is the system [12], [34], [71]. Systems are delimited by spatial and temporal boundaries, determined by structure and objectives, and influenced by their surrounding environment [72], [73]. Two types of systems are distinguished: while open systems constantly interact with their environments by exchanging information, resources, or energy, closed systems are isolated from their environments. As a result, closed systems are more autonomous and able to self-adapt [74], [75], whereas open systems are required to adapt to changes imposed by the environment in order to preserve its equilibrium. Therefore, either self-adaptation or adaptation to environmentally imposed changes are crucial to the survival and functionality of systems [72].

Figure 1 presents the project system and the interaction with its environment.

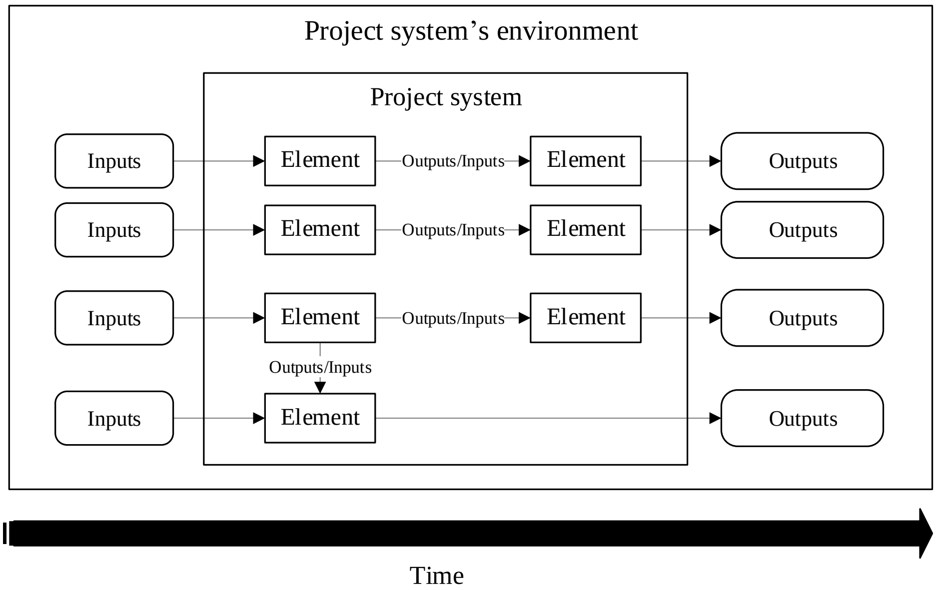

Fig. 1. Representation of the project system and its interaction with its environment

Applications of systems thinking in project management have been proposed for a number of years [5], [8], [75]–[77]. From the system perspective, projects are composed of several interdependent subsystems including processes, activities, tangible and intangible resources, and information. Those elements or activities convert inputs into outputs, which are mostly resources such as tangible and intangible assets, and knowledge [27]. The project system's environment is the main provider of inputs and the main receptor of outputs. It is where the project goes through its life-cycle to fulfill its objectives. Given its continuous interaction with the environment, it must be concluded that project systems are open systems.

4.2 Project Resilience: Conceptual Framework

The framework provided by the concepts of awareness and adaptive capacity related to resilience also applies to the specific context of project management. Project resilience depends on awareness of disruptive events and of the gap between available versus required resources; projects' vulnerabilities.

Adaptive capacity is also central to the transformation (e.g. changes on structure, processes, methods, etc.) of the project system to recover from negative known or unknown risks (*disruptive events or conditions that may or may not occur*) [3], [5]. Therefore, recovery is the result of a successful adaptation. For instance, when unpredicted changes related to budget or schedule contingencies, critical paths, or client satisfaction provoke modifications in the project trajectory and development, project systems can either adapt and restore the original baseline, or, after approval of main stakeholders, create a new baseline [78]. Both cases exemplify successful recovery as they avoid a terminal or dead state where the project can no longer achieve its original objectives [14]. Thus, shifting from a state to another while avoiding the "death state" is a main attribute of a project system. Furthermore, project resilience should be classified as an example of ecological resilience, as projects exhibit multiple baselines or equilibrium points over time (possible multiple baselines).

To this matter, three adaptation strategies are suggested at the elements level of the project's system: deploying new inputs recruited from other project elements or environments, changing input-output conversion mechanisms, or changing outputs after consultation with stakeholders. The relationship between awareness and adaptive capacity is essential to ensure an efficient recovery once faced with a disruptive event. In fact, awareness is the force driving the project's capacity to adapt when facing a disruptive event. Thus, the following relationship between awareness and adaptive capacity is proposed:

RP1: the greater the project's awareness, the better it adapts and successfully recovers once faced with disruptive events.

Developing project awareness and its capacity to adapt when facing disruptive events, increase the project's capacity to assess the impact of events, actions and decisions as to predict and control the project evolution [20]. This is done by evaluating the project elements' objectives and characteristics, as well as the actions and decisions' consequences on the entire project environment [21]. In other words, developing project resilience helps manage the consequences of uncertainties over the project life-cycle and efficiently deal with unpredictable or unknown risks [10], [79]. Therefore, the following relationship between project resilience and managing uncertainties is proposed:

RP2: The greater the project's resilience, the better is the management of uncertainties during the project life-cycle

Developing project resilience helps deal with ambiguities. It improves the stakeholders' knowledge about the elements of the project and their characteristics. It helps eliminate the bias of the stakeholders' perception about the project and its environment. This perception is influenced by the stakeholders' mental representations and cultural differences [22]. Therefore, a project without well-developed awareness and adaptive capacity will have great challenges to face risks related to factors such as change management and user resistance, requirements management, project planning (budget, schedule, quality, communication, etc.), organizational structure, etc. [80]. Therefore, the following relationship between project resilience and managing ambiguities is proposed:

RP3: The greater the project's resilience, the better is the management of ambiguities during the project life-cycle

Focusing on the development of project awareness and its capacity to adapt when dealing with disruptive events, helps manage the risks caused by the interdependencies that exist between the elements of the project and between the project and its environment. These interdependencies can be strong enough to modify the characteristics of certain, already identified, risks and potentially lead to additional unknown risks [10]. Therefore, the following relationship between project resilience and managing risks caused by non-linear and dynamic interdependencies is proposed:

RP4: The greater the project's resilience, the better is the management of risks caused by non-linear and dynamic interdependencies during the project life-cycle

The continuous evolution of the project environment increases the likelihood that contingency and risk response plans, which were developed at the beginning of the project, become ineffective for managing known risks [3], [81]. Therefore, developing project resilience empowers current PRM practices to better deal with known risks by continuously monitoring changes to their characteristics during the project life-cycle. To this matter, the following relationship between project resilience and the management of known risks is proposed:

RP5: The greater the project's resilience, the better is the management of already identified and analyzed risks by current PRM practices.

Figure 2 presents the overall conceptual framework underlying project resilience and including the capacity to learn from successful recoveries. This capacity enhances project resilience by developing, context specific, new strategies, processes and practices to better deal with future disruptions. The learning aspect provides the means for project resilience to continuously evolve, advance and grow [34].

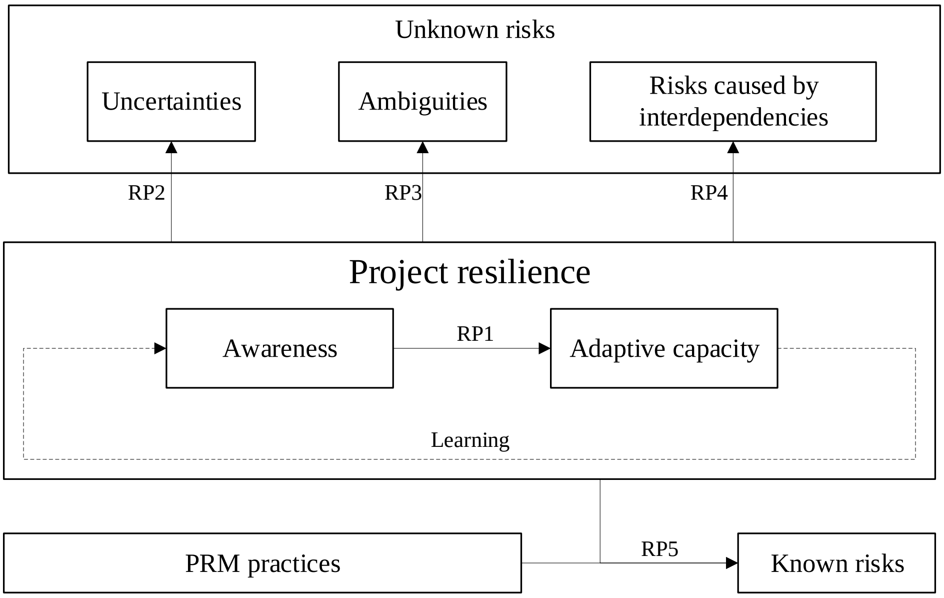

Fig. 2. Conceptual framework of project resilience

5. Conclusion

The presented framework of project resilience provides a new conceptual methodology to identify intrinsic risks of project systems and to accelerate project adaptation to known and unknown risks, thereby reinforcing risk management approaches and enhancing risk management strategies.

However, project resilience is still a very recent field of research that needs to be reinforced by qualitative and quantitative academic studies. From this perspective, the main objective of this paper is to propose a conceptual definition and framework of project resilience. Therefore, project resilience is defined by the capacity of the project system to be aware of its surroundings and vulnerabilities, and to adapt in order to recover from disruptive events and achieve its objectives. Also, a conceptual framework of project resilience is presented that potentially can set the basis for additional research on this new, very promising, concept.

However, as any new research concept, what is presented is one of many possible ways to define project resilience. As such, this is considered an obvious limitation. Thus, to continue reinforcing what was presented in this paper, the following agenda is suggested.

Next steps should firstly include conceptual exchanges with more advanced research fields. For example, organizational resilience is a more established concept among researchers and could catalyze the conceptual development on project resilience.

Second, a set of indicators to estimate the ability of projects to manage disruptive events should be developed. The goal of this development is to provide project stakeholders with a diagnostic tool to assess the impact of efforts required to improve current and future projects' resilience. This tool can help determine the project's strengths and weaknesses as well as suggest action plans to improve its resilience.

Third, once a validated set of indicators is developed to assess project resilience, rigorous empirical studies are required to validate the propositions and the developed conceptual framework of project resilience.

Finally, the concept of project resilience neither eliminates the need nor denies the relevance of current PRM practices and may, instead, redirect and strengthen them. Project resilience strategies should coexist with the current PRM practice to promote more efficient project management.

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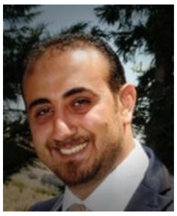
Biographical notes



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