THE LIVED EXPERIENCE OF MANAGING THE DYNAMICS OF PROJECT COMPLEXITY

MOGENS FRANK MIKKELSEN

IT UNIVERSITY OF COPENHAGEN, DENMARK

Abstract: Project complexity has been researched much. The majority of research on project complexity is descriptive and deploys a retrospective perspective on projects, where projects are seen as final objects. The use of an ex-ante approach, used for assessment in the initial phases of projects, is less commonly seen in research but has got some attention. However, for the involved managers, the project complexity is a lived experience as the projects evolve in dynamic interactions with the stakeholders. Not much research has focused on this perspective. This paper presents a theoretical framework explaining the unpredictability of events course by project complexity. The theorizing is based on critical realism and focuses on the identification of generative mechanisms as the methodology. The paper then discusses the potential value of the proposed theory - both to the research of project complexity and for practitioners of project management.

Keywords: Perceived Project complexity, Dynamic dimensions, lived experience

1. INTRODUCTION

Baccarini (1996) was among the first in the search stream of project complexity. The Baccarinian definition stated that project complexity is "consisting of many varied interrelated parts". This has later been labeled 'structural complexity' by other scholars, who induced more dimensions of project complexity, like uncertainty (Williams, 1999), dynamic (Xia & Lee, 2004), socio-political dimension (Geraldi, Maylor, & Williams, 2011). These dimensional frameworks of project complexity are often descriptive. The descriptive project complexity is useful when comparing projects or searches for law-like relations between project complexity and related constructs, e.g., project management success. When the purpose of the research is to understand a given project or to provide managerial guidance, the perceived project complexity need to be included because "for all practical purposes, a project manager deals with perceived complexity as he cannot understand and deal with the whole reality and complexity of the project" (Vidal & Marle, 2008, p. 1096). Adding to this, it has been argued that "Complexity is a subjective notion, reflecting the lived experience of the people involved" (H. R. Maylor, Turner, & Murray-Webster, 2013). So far, not much research has focused on the project complexity as a lived experience of projects as the managers muddle through, trying the navigate the unfolding project.

Rezende and Blackwell developed the previously mentioned work of Geraldi et al. (2011) into a guiding framework for practitioners and concluded with the request of: "… research to identify the weight of each dimension, the limitation of the proposed framework, among others. Additionally, a future research agenda can also focus on how the importance of each dimension change over the lifecycle of a project or program." (de Rezende & Blackwell, 2019, p. 139). This paper takes on that challenge and states the following research question: How can the dynamics of perceived project complexity be conceptualized?

The research uncovered an ontological problem within the mainstream models in research of project complexity. Expectations and manifestations are two different sources of information, hence there is a need to distinguish between an ex-ante and post-ante project complexity. Resolving this matter is a vital part of the above research question. To accomplich this, the paper coins the 'transitional perspective' as the intermediate between the 'ex-ante' and 'ex-post' stream of research of project complexity, hence this is a central part of the theorizing of the lived experience of managing the dynamics of project complexity.

The remainder of this paper is structured as follows: Section 2 presents the literature study on project complexity. Section 3 gives a theoretical background for the theorizing. Section 4 layout a foundation for the development of a theory. Section 5 discusses the identification of generative mechanisms of project complexity. Section 6 presents the conclusion

2. LITERATURE REVIEW

The research literature on project complexity is vast and diversified. This section presents the selection of papers viewed as relevant for the endeavor of this paper. The research of project complexity does not always have a managerial perspective, often the intention is to understand the nature of projects or to build a construct for the search of law-like relations.

While there is no commonly accepted definition of project complexity, many authors (Giezen, 2012; Luo, He, Jaselskis, & Xie, 2017; Mikkelsen, 2020b) have promoted the definition proposed by Vidal et al. (2011). Their definition states that: "Project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behavior, even when given reasonably complete information about the project system" (Vidal, Marle, & Bocquet, 2011, p. 719). This definition focuses more on the dynamics and consequences of project complexity and refrains from the assessment of the project complexity itself.

Understanding the research literature, a short history of project complexity research is helpful. This might start with Baccarini (1996), who argues that project complexity consists of many varied interrelated parts, and can be defined in terms of differentiation and interdependency and that it is managed by integration. For comparison, "general" complexity can be defined as follows: "The level of complexity depends on the character of the system, its environment, and the nature of interactions between them" (Cambel, 1993, p. 4). The essential difference is, that project

complexity includes the managerial aspect by definition.

Williams (1999) coined the definition from Baccarini 'Structural complexity' (number of elements and their interdependence) and argued for adding 'Uncertainty' (uncertainty in goals and uncertainty in methods) based on (Turner & Cochrane, 1993). However, the element of uncertainty as a dimension of project complexity is still the topic up for debate - exemplified by (Padalkar & Gopinath, 2016).

Williams´s concept of project complexity was developed further by Xia and Lee (2004), who took the input from the above-mentioned authors and argued for widening the concept of uncertainty into the concept labeled 'Dynamic complexity', defined as "uncertainty, ambiguity, variability, and dynamism, which are caused by changes in organizational and technological project environments" (Xia & Lee, 2004, p. 55). The same dichotomy of structured versus dynamic project complexity can be found in, for example (H. Maylor, Vidgen, & Carver, 2008), (Floricel, Michela, & Piperca, 2016), and (Daniel & Daniel, 2018). The latter defined the difference this way: (1) structural complexity focuses on interactions producing unexpected effects that cannot be explained or deduced, and (2) dynamic complexity focuses on processes that generate unpredictable change in systems. (Daniel & Daniel, 2018).

A systematic review of the research literature so far was conducted by (Geraldi et al., 2011) summed up the development, and concluded that the concept of project complexity had evolved to encompass five dimensions: Structural complexity, Uncertainty, Dynamic, Pace, and Socio-political. A comparable review performed five years later argued for an expansion of this understanding to encounter eight dimensions: Structural complexity, Uncertainty, Emergence, Autonomy, Connectivity, Diversity, Socio-political, and Element of context (Bakhshi, Ireland, & Gorod, 2016).

In the development of a project complexity assessment tool, H. Maylor and Turner (2017) argued for a division in structural complexity, sociopolitical, and emergence, where the latter can be assessed as the expected change of the two former constructs. A recent paper (de Rezende & Blackwell, 2019) - also based on Geraldi (2011) - argued for an assessment framework based on the following seven

dimensions: Structural complexity, Uncertainty, Dynamic, Novelty, Pace, Socio-political, and institutional.

In the research stream devoted to finding law-like relations between project complexity and other constructs, e.g., papers like (Bjorvatn & Wald, 2018), (Bjorvatn & Wald, 2018), (Luo, He, Xie, Yang, & Wu, 2016), (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011), (Qureshi & Kang, 2015), and (Lu, Luo, Wang, Le, & Shi, 2015) the construct of project complexity is often a more narrow version of dimensions than the framework mentioned previously.

Summing up, it can be argued there exists a common ground in research regarding dimensions of project complexity. There is structural complexity, and this needs to be combined with 'residual dimension' (or dimensions), where there are disagreements of the content of the residual part of project complexity. The disagreements among scholars is mostly about the division of the dynamic side of project complexity, where suggested sub-dimensions include uncertainty, sociopolitical, emergence, change, along with many other proposed sub-dimensions.

Based on a review of 420 different publications, Bakhshi et al. (2016) found three dominant schools of thought within the construct of complex projects: the PMI perspective, the System of System (SoS) perspective, and the Complexity Theory perspective. These three will be addressed in the following.

The so-called 'PMI perspective' school of thought entails by far the largest number of publications of research on project complexity. The common nominator here is the dimensional approach. The contributions are sometimes expressed as abstract frameworks and other times as measurable constructs. But the review of literature of this school holds so much diversity that calling it one school is an over-simplification. It has been suggested to divide the literature by intention of the research (Mikkelsen, 2020a), arguing for ontological frameworks, the search of law-like relations, and a managerial focus of the research.

The second school of thought was by Bakhshi et al. (2016), only exemplified by the Cynefin framework (Snowden & Boone, 2007) since not much work had been done at the time of the study. But later, more contributions on the SoS-perspective have been published, including (Kiridena &

Sense, 2016), where complicated systems, complex systems, and complex adaptive systems are used for categorizing the level of project complexity. A similar categorization is found in (Daniel & Daniel, 2018), here labeled regulated versus emerging system properties. Daniel and Daniel (2018) introduced three levels of complexity, labeled: algorithmic, stochastic, and non-deterministic.

The third school, the Complexity Theory, was introduced rather late in the research of project complexity. A renowned example is (Cooke-Davies, Cicmil, Crawford, & Richardson, 2007). The protentional of perspective looked promising, as indicated by one paper coining it: "project management second-order" (Saynisch, 2010). However, only a small amount of research literature has followed this research stream. The use of complexity theory has not caught on in the project management research communities, which might have to do with the fuzziness of strange attractors, butterfly effects, and the like.

Reflecting on the three schools of thought, the difference can be simplified as follows: The dimensional approach provides a 'vertical sliding' of a given project, assuming the same kind of system thinking can be applied to all. Counter to this, the SoS approach provides a 'horizontal' diversification for classifying projects according to what kind of system thinking can be applied. Complexity Theory, on the other hand, attempt to explain the complexity of complex projects – leaving the 'complicated' project (or part of projects) to be explained by conventional systems theory.

3. THEORETICAL FOUNDATION

The theoretical foundation of the paper is divided into two. The first half of this section develops a map of the research on project complexity using two sets of dimensions. One concerning the observer-project relation in time and another the dichotomy of perceived versus descriptive project complexity. The second half of this section presents a perspective on critical realism useful as a foundation for a theory of the lived experience of managing project complexity.

3.1 Time perspectives on project complexity

The 'time perspective describes the observations of the project based on one's position on the timeline. Logically, the observations can be made before, after, or during the project. These three time-perspective (**Figure 1**) are coined ex-ante, ex-post, and transitional. Ex-ante, meaning before the event, is a concept known from the Keynesian expectances theory (Keynes, 1937). Ex-ante and ex-post have been used in project evaluation (Samset & Christensen, 2017), but the dichotomy is perhaps more known in evaluation methods, e.g., FEDS (Venable, Pries-Heje, & Baskerville, 2016). The transitional perspective captivates the lived experience of projects, that is, the period between the ex-ante and ex-post. All three time perspectives will be addressed in the following.
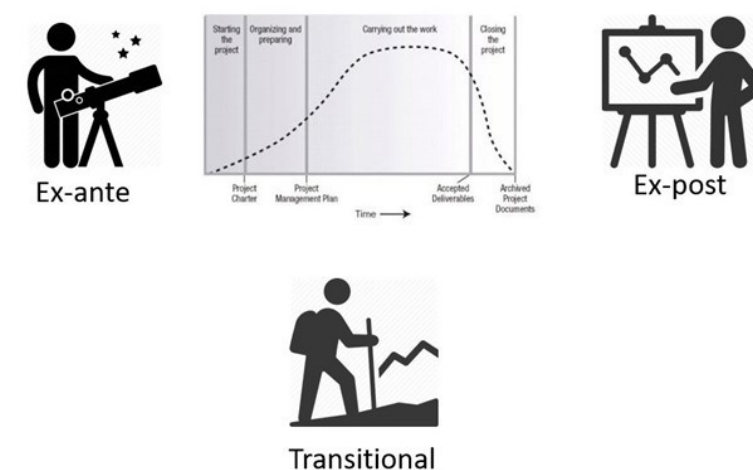

Figure 1: The three time-perspectives on project complexity

Ex-ante perspective

The ex-ante perspective on the project-based solo the initial information and assumptions. The assumption might be the participants' experience form on other projects in the past or drown from a broader knowledge relevant for the project. The ex-ante perspective on project complexity is found frequently in handbooks and tools like (PMI, 2014). Here the indicators of complexity are questions like: "Are the requirements likely to change?", "Is senior management fully committed?", "Will the supplier be able to meet the commitments?", and "Is the client prepared to accept deliverables?"

Ex-post perspective

Research in the ex-post perspective has the privilege, that all is knowable (at least in principle) since the project by then closed. All the answers in the previously mentioned assessment tool will no longer be mostly guesswork. Not only can we detect which requirements did change, but also have much they changed, why, and when they changed. Hence, a far better expiation can be given to why the project was difficult to understand, foresee and keep under control (s the definition of project complexity given in the introduction). Further, the benefits of researching projects as finalized objects give a solid basis for comparison of the projects and for searching for law-like relations.

Comparing ex-ante and ex-post

In social science, information about the future is different from information about the past. Social science does not operate like newtons laws; at best, we can compare a project to throwing crooked deices. As the deice rolls, the 'events' are only given as a probability distribution. After the roll, the 'events' are now observable manifestations. The same event will only happen again by change. Based on this allegory, it can be argued that the construct of project complexity is different when seen in the two perspectives, ex-ante and ex-post.

Since the ex-ante project complexity mainly is assumptions and expectations (probabilities), and the ex-post project complexity is observations and realizations (manifestations), arguments can be made, that ontologically they are two distinct constructs. Even if the same indicators were used,

the ex-ante and ex-post measurement of that indicator could only be the same if there was full predictability of the project. But projects are all by nature unpredictable, and complex projects are radically unpredictable (Cooke-Davies et al., 2007). The discussion of this does, however not fit into the focus of this paper.

Papers developing frameworks for project complexity assess the dynamic dimension presuming the change that has happened. "The most suitable attribute embracing all indicators related to dynamic complexity is 'a change in any of the other dimensions of complexity". (Geraldi et al., 2011, p. 980). Hence an ex-post perspective is needed. However, the utility of the framework is about the ex-ante perspective, e.g., business case development, strategic choice, etc. One can not have an ex-post perspective of a given project ex-ante; such an 'omniscience' perspective does not exist.

The research streams of the two perspectives can benefit very much from each other. The ex-post produces knowledge of projects in general, and herby inform the ex-ante perspective of a given project. Researching the ex-ante perspective of a given project and comparing this to the result of the same project in an ex-post perspective, can provide very useful information on how the perception of the complexity of a given project can change during the project life cycle.

One example of Ex-post perspective of projects supporting the ex-ante perspective of a given project is known from 'Reference Class Forecasting' (Bent Flyvbjerg, 2008), here historical data of cost, duration, and benefit of projects are organized in project classes to utilize an increased precision of the estimation of a given project from the same class. While the method does not address the project complexity as such, the classification of projects could be based on indicators complexity dimensions and indicators. The principle of a method like RCF is like the tide raising all boats. Adjusting for a historical average cost and benefit the improve the estimation accuracy is a good method when you are to adjust a portfolio of projects. The principle does, however, only a little when the focus is on the lived experience of one given project.

The transitional perspective

The perspective of the project between project initiation and termination is neither an ex-ante nor an ex-post perspective. The perspective expresses the complexity of the unfolding project from initiation until project closure terminated and the ex-post perspective of the project complexity can be applied. It could be called the ex-temporal, but to express the unfolding and intrinsic dynamics of this perspective, it is here coined 'The transitional perspective'.

There is an overlap between the three perspectives. The transitional perspective will in the initial phase be much like the ex-ante, and much like the ex-post at the project closure. But in between the transitional perspective will differ from both the ex-ante and the ex-post perspective.

The transitional perspective is different from the ex-ante perspective, not only because the two dimensions are defined differently, but due to the increasing knowledge of the behavior of the project system. Assessment of project complexity in the initiation phase is mainly based on assumption, and as the project unfolds, the assumption will gradually be substituted by observations on the indicators.

The transitional perspective succeeds the ex-ante perspective. However, it can be argued, that the ongoing assessments made in the transitional perspective could be done using tools developed for the ex-ante evaluation. However, some of the questions from the initial phase would need to change to make sense in the later phases of the project lifecycle. Likewise, in the termination phase of a project, it can be said that the ex-post perspective can overlap with the transitional perspective when it comes to the choice of tools and frameworks.

Some indicators can for obvious reasons first be determined in the transitional perspective. Hidden agenda in the socio-political dimension (Geraldi, 2011) is an example of this. One can not know a hidden agenda, until it has been revealed. If there is information, that stakeholders have competing agendas for the project, these are not hidden agendas, only conflicting interests. Likewise, the low level of trust (Remington, 2016) can be difficult to assess on the forehand, but once revealed, it is obvious to see.

Complex projects can be seen as a process of "Connecting the dots" (Curşeu, Janssen, & Raab, 2012) where learning is essential. Realizing the unsupported assumption of the

project is easier in hindsight than foresight, hence this information will come more often in the transitional than the ex-ante perspective.

Similarly, delusional optimism (Lovallo & Kahneman, 2003), leading to unrealistic expectations of what is possible within the budget and timeframe, will not reveal itself in ex-ante perspective – if it could, this would be deemed functional stupidity (Alvesson & Spicer, 2012). In the transitional perspective, where the project evolves in the unfolding universe, the actors find out which assumptions turned out as bad or sound assumptions and realize if the initial approved triple contains is realistic or not.

Descriptive versus perceived project complexity

Research of project complexity distinguishes between descriptive (objective) versus perceived (subjective) as illustrated in **figure 2**. Ontologically, the dichotomy descriptive/perceived related to the two basic traditions of science: realism versus constructivism. Realism assumes the truth to exist regardless of the observer, where constructivism is concerned with the perception made by the observer. Epistemologically, there can arise some gray zones regarding the two traditions, since some dimensions of project complexity depend on human perception of the indicators used to determine the complexity dimension (i.e., the level of conflict in the political dimension).

In descriptive project complexity, the information is 'out there' regardless of the observer - but "For all practical purposes, a project manager deals with perceived complexity as he cannot understand and deal with the whole reality and complexity of the project" (Vidal & Marle, 2008, p. 1096).

Figure 2: A common example of a breakdown of the concept of project complexity in research (Morcov, Pintelon, & Kusters, 2020, p. 13)
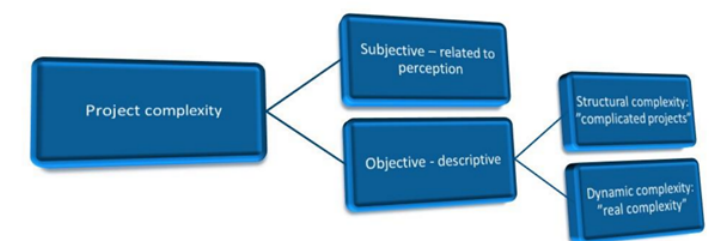
Further, the perceived complexity is not only a matter of what can be grasped, the concept of project complexity itself is perceived differently depending on which project role the perceiver holds (Mikkelsen, 2020b).

In a paper on human knowing, Schlindwein and Ison (2004) argue, that complexity resides as much in the eye of the beholder as it does in the structure and behavior of a system itself. This quote places the complexity in the gulf between the traditions of realism and interpretivism. The paper argues that from an epistemological perspective, 'descriptive complexity' is based on the assumption of the existence of an objective reality, external and independent of us, and to which we can have privileged access, resulting in the assumption that complexity can be objectively measured. In contrast to 'descriptive complexity, the epistemological assumptions of 'perceived complexity are based on the assumption that reality results from the distinctions made by an observer" (Schlindwein & Ison, 2004).

Vidal and Marle defined the difference like this: 1) "descriptive complexity considers complexity as an intrinsic property of a system, a vision which incited researchers to try to quantify or measure complexity," and 2) "perceived complexity considers complexity as subjective since the complexity of a system is improperly understood through the perception of an observer" (Vidal & Marle, 2008). Floricel et al. (2016) use 'intrinsic' versus 'representative' as a similar dichotomy to address both structural and dynamic complexity producing a 2x2 matrix.

Matrix of perspectives in project complexity

Combining the two perspectives gives a 3x2 matrix depicted in **Table 1**.

Table 2 displays samples of literature in the 3x2 matrix depicted in Table 1.

	Ex-ante perspective	**Transitional perspective**	**Ex-post perspective**
Descriptive project complexity. Information of the complexity exists 'out there' - in-depended of an observer.	Descriptive tools for assessment of the complexity of the project ahead.	Complexity Theory and abstract framework of project complexity.	Projects as finalized objects, e.g., for researching low-like relations of project complexity.
Perceived project complexity. The complexity exists in the eyes of the beholder(s), i.e., project manager or project stakeholder.	Frameworks for predictions based on a mutual understanding of the complexity of the project.	The lived experience of managing the dynamics of project complexity.	Retrospective (emancipative or interpretive) research of complexities in and around the projects

Table 1: Matrix of perspectives on project complexity

	Ex-ante perspective	Transitional perspective	Ex-post perspective
Descriptive project complexity.	(PMI, 2014) and (Bosch-Rekveldt et al., 2011)	(Cooke-Davies et al., 2007), (Zhu & Mostafavi, 2017), and (Daniel & Daniel, 2018)	(Nguyen, Nguyen, Le-Hoai, & Dang, 2015), (Qureshi & Kang, 2015), (Bjorvatn & Wald, 2018), and (Zaman, Jabbar, Nawaz, & Abbas, 2019)
Perceived project complexity.	(H. R. Maylor et al., 2013) and (de Rezende & Blackwell, 2019)	(H. Maylor et al., 2008), (Ahern, Leavy, & Byrne, 2014), and (Mikkelsen, 2020b)	(Davies, Dodgson, & Gann, 2016), (Floricel et al., 2016), and (Davies & Mackenzie, 2014)

Table 2 displays samples of literature in the 3x2 matrix depicted in Table 1.

3.2 Critical realism

A version of Critical Realism (CR) based on Bhaskar (R Bhaskar, 1998; Roy Bhaskar, 2013) and (Sayer, 1999, 2004) positioned CR in the gulf between the two traditions. In the words of Bygstad (2010)): Critical realism combines a realist ontology with an interpretive epistemology; although a real-world exists, our knowledge of it is socially constructed and fallible. Similar thinking is found in the paper of Mingers, Mutch, and Willcocks (2013); critical realism can be expressed as the search for generative mechanisms based on a realist ontology, with an interpretivist epistemology, and methodological pluralism. CR is not used as much in research of project management but much more in research of Information systems.

Figure 3 depicts the stratification of reality by Sayer (1999, 2004). **Figure 3** also illustrates different kinds of research. Using this notation, this paper is 'abstract research' analyzing project complexity through the mechanisms and structures. Events are the observable part of reality. The mechanisms generate events but are themselves not directly observable.

The concept of 'Tipping point' is a good example of a mechanism (Easton, 2010), it has an observable effect and rests on a structure of sellers and buyers. The tipping point itself can not be observed but is an inference based on the observed events. The marked expectation is an example of conditions actualizing the mechanism.

Mechanisms depend on the layer of structures. In order to generate events (or non-events), mechanisms must actualize. The actualization is contextual and can be caused by other mechanisms and/or events, and this can lead to the unpredictability of the resulting events. Mechanisms may interact with other mechanisms and hereby result in emergent behavior. Structures are the fundamental part of reality do not 'do' anything themselves, instead they give affordance to mechanisms. "Thus, structures are not deterministic, they have the potential to enable and constrain events through their inherent mechanisms" (Bygstad, Munkvold, & Volkoff, 2016, p. 2).

An overview of the methodology of identifying mechanisms in Critical Realism is here provides by (Bygstad et al., 2016), building on (Wynn Jr & Williams, 2012):

(i) Explication of events: Identify the key events of the case, building on experience and abstraction. These events are outcomes, which we want to explain.

(ii) Explication of structure and context: Identify the human, social and physical entities of the case, and the relationships between them. These relationships may reveal emergent properties.

(iii) Retroduction: Identify the mechanisms (powers and tendencies) that explain the outcomes. The analysis should give logical and analytical support for the existence of the proposed mechanisms linking the structure to events.

(iv) Empirical corroboration: Ensure that proposed mechanisms have causal power and that they have better explanatory power than alternatives: Assess the explanatory power of each proposed mechanism with the empirical evidence.

(v) Triangulation and multiple methods: Use a variety of approaches to identify causal relationships and build on different sources and data types in order to explore the diversity of underlying structures and to control for bias.
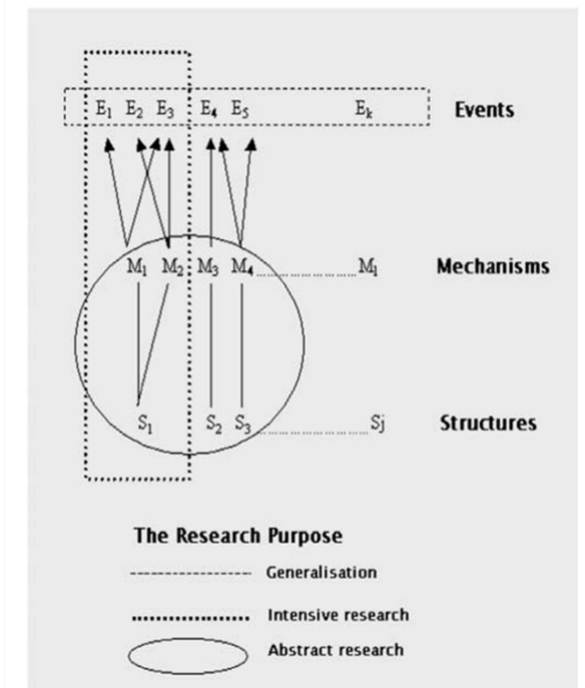

Figure 3: The layered ontology of critical realism and research strategies (Sayer, 1999).

4. THEORY OF PROJECT COMPLEXITY MANAGEMENT

The theory of the lived experience of managing the dynamic project complexity use the definition: "Project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behavior, even when given reasonably complete information about the project system" (Vidal et al., 2011, p. 719). Following Bhaskar and Sayer, the theory stratified the project and its environment in three levels of reality: event, mechanism, and structure. Compared to the definition above, project behavior eThe proposed theory makes a presumption that structural complexity is more fundamental than dynamic complexity, hence the structural complexity equals the structure layer in CR as it is defined by Sayer (2000). Further, the multiply dimensions that together form the dynamic complexity can be found in the mechanisms and conditions as explained by Sayers version of Cquals events. The project complexity can be explained as the result of actualized and interacting mechanisms resting on a structure of interrelated elements.

The proposed theory states that the project behavior, which is difficult to understand, foresee and keep under control, is generated by mechanisms in the project and its environment. To generate an effect, the mechanisms need actualization. The actualization is contextual and can depend on other mechanisms and/or conditions. The more mechanisms actualized the less predictable a project. The implication of this is that the research not only should account for mechanisms in project complexity, the contextual setting of a given project must also be investigated.

As demonstrated in the literature review, there is a common acceptance of dividing project complexity into structural complexity and dynamic complexity. Building of the division and stretching it a bit further, the argumentation is that structural complexity in project complexity equals the structural level in the stratification of critical realism. In a conceptual paper on project complexity, Kiridena and Sense (2016, p. 65) argue for the stratification of project complexity, where the structural complexity is the lower level and the dynamic aspect is the top level. There, the structural complexity is divided into technology, organization, and

environment - like in the TOE-framework (Bosch-Rekveldt et al., 2011).

While the dichotomy of structural complexity and dynamic complexity does not state the workings of reality like this, there is not found any argument against it either. There the presumption can be made, that mechanism of project complexity can be found in the so-called dynamic complexity.

The theory has a realist ontology of project complexity, meaning that the information of the property of the project exists 'out there' regardless of the observers. The challenging effect of project complexity can be found in the events. However, like the CR the theory uses an interpretive epistemology. All stakeholders (the project manager included) interact based on their perception of the given project and their individual understanding of the concept of complexity. These multiple perceptions are an intrinsic part of the ontology of project complexity.

With inspiration from Sayer's version of critical realism, the theory states that no event comes from structures directly. A mechanism needs to be actualized to generate the events, and the actualization depends on the context. Mechanisms can interact and herby generate the emergence of unexpected events in and around the projects. Events are the result of the actualized mechanisms. The unexpected and/or unwanted events that are causing the challenges for the project management (see the definition of the project complexity).

Based on the above stated, a theory of the lived experience project complexity management can be depicted as illustrated in **Figure 4** depicting the stratification of project complexity in three layers.

The project manager is selected during the project initiation. Here, the pre-ante perspective of project complexity applies to the given project. At the time of project initiation, the expectation of the given project is based on the perception of a similar historical project gained from an ex-post perspective of them.

The managerial challenges of project complexity are first and foremost to control events in and around the project. Since not all events are controllable, the management of project complexity should also attempt to enable or dampen the mechanism and to investigate options for changes to the
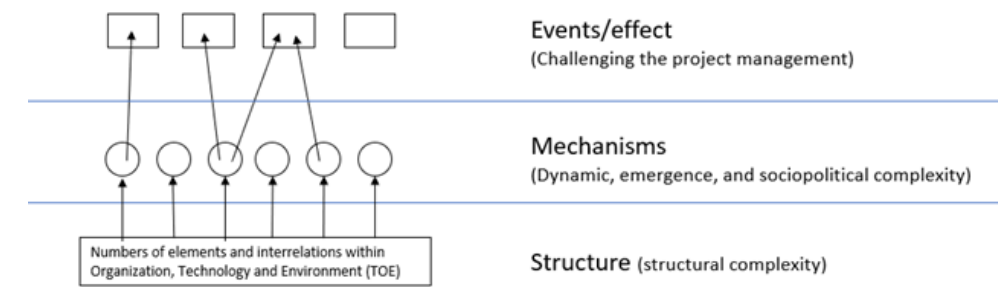

Figure 4: Stratification of project complexity in three layers

structural level. The engagement of the project manager has ended when the ex-post perspective of the given project. Throughout the project lifecycle, the project manager has lived experience of the project, including the so-called transitional perspective on the project complexity.

In the perspective of critical realism, a project can be seen as a sequence of events – some planned, others spontaneous, or random. There are also planned events that never realized, the so-called non-events. In the environment of the project, there will be events influencing the project as well as initiated by the project. Part of the controls, project managers use to influence the project outcome can be regarded as a mechanism. Project complexity can result from the lack of control mechanisms.

The lived experience of managing the project and its complexities is based on the perception of the events unfolding during the project lifecycle, from initiation to closure. No stakeholder – no even the project manager – has a full understanding of the mechanisms and their contextual uncertain actualizations. The structural complexity can be objectively assessed, but the causal connection explaining the events and outcome is beyond full understanding.

On determinism in the proposed theory

In research of project complexity, the positivist approach assumes linearity between the indicators of project complexity and the dependent variable, i.e., project management efficiency. Some examples are (He, Luo, Hu, & Chan, 2015) and (Bjorvatn & Wald, 2018). In (H. R. Maylor et al., 2013) and (PMI, 2014) the assessment is based on a questionnaire adding the score as an indicator of severity.

One indicator can add one point no matter how extreme the given indicator is in the context of the project being assessed. In the case of descriptive frameworks for the assessment of project complexity, like the one from (Geraldi et al., 2011) and (de Rezende & Blackwell, 2019) mentioned in the literature review, the assumption is seldom articulated. The proposed theory assumed interactions across the dimensions posed by the framework. In other words, the dimensions could enable or constrain each other, as it would be expected from a Complexity Theory point of view (Byrne, 2002). The relations are presumed to follow the thinking in Critical Realism, stating that "Thus, structures are not deterministic, they have the potential to enable and constrain events through their inherent mechanisms" (Bygstad et al., 2016, p. 2).

The mechanisms need to be actualized to generate effects and/or events. To exemplify this, multiple stakeholders with opposed interests do not in itself do generate events, like a conflict. Between the structure of interest and the event, there needs to be actualized mechanisms for the causation to work. One of these might be information flow between stakeholders (internal or external). Another being stakeholder with contracting interests and capacity to pursuit own interest. Still, the mechanisms need to be actualized to generate events. The actualization is contextual, meaning in this case that conflict can only arise in case of supporting context. If, for example, one stakeholder might be short on time to own pursuit interests, and then the 'conflict event will not be generated. Another example is a strong stakeholder with a hidden agenda, if the condition is that his/she is buzzy with other matters, the hidden-agenda-mechanism will not be activated.

The proposed theory assumes enabling and constraining interactions between the dimensions (explained as structure and mechanisms) as depicted in **Figure 5**. The actualization of the mechanism is contextual, meaning that the conditions in or around the project must enable the mechanism. Adding to this, other mechanisms can serve as actualizing factors for the given mechanism. A low level of trust has been identified as a source of project complexity by Remington (2016). In the context of research of project management, trust seems to be more a condition than a mechanism.
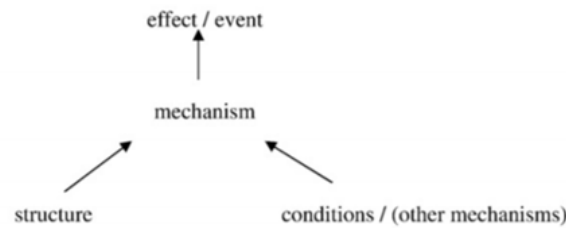

Fig. 2. Critical realist view of causation (Sayer, 2000, p15).

Figure 5: Critical realist view of causation (Sayer, 2008)

5. DISCUSSION

The paper set out to investigate how the dynamics of perceived project complexity can be conceptualized. The theoretical foundation in section 3 provided a structured view over the existing literature that serves as a lens magnifying the area in focus: The lived experience of managing a project with all its unpredictability caused by project complexity. Section 4 proposed a theory of the dynamics of the perceived project complexity. The discussion in section 5 is sectioned into three parts. First, the proposed theory is compared to a central framework of researching project complexity. Second, examples of mechanisms of project complexity are provided. Thirdly, consideration of the contributions is given.

5.1. Comparing dimensions of project complexity to the proposed theory

The first part of the discussion compares the proposed theory to the work of Geraldi et al. (2022).

The CR view of causation in Figure 4 from Sayer (2008) sheds new light on the interaction of the five project complexity dimensions: structural complexity, uncertainty, socio-political, dynamic, and pace Geraldi et al. (2011). In

the following, it will be argued that the dimensions pace and uncertainty is conditions rather than mechanism.

The pace of a project is, in most cases be a reflection of market conditions or legislation. When pace is seen as a condition in the theory of project complexity management, then the pace is influencing events and effects through other mechanisms. In the framework from de Rezende and Blackwell (2019), they argue for a division of pace into speed and criticality. The given pace of a project is, to a large degree, a result of decisions making, often as a reaction to market needs or internal stakeholder expectations (including the decision-makers' ambitions). Due to the biased delusion of success, the decisions making regarding pace is overoptimistic, leading to overrun (Bent Flyvbjerg, 2006). All else been equal, a short timeframe will challenge the project management, because more work and activities are going on at the same time. Therefore, there is less time to handle risk and fix errors and misunderstandings. A high pace can also lead to the actualization of resistance to change. There is reason to presume that the pace dimension in project complexity will have a U-shape relation to the challenge of project management. With a low pace, more changes in the project environment can happen during the project's lifetime. The lack of time pressure can be a driver of complexity since a prolonged life cycle might expose the project to external dynamics like organizational changes, changing priorities, new competition, etc., and is exposed to external risk for a longer time. As one example of this, a slow pace of the project will give more time for political influence to be actualized.

Like pace, uncertainty can hardly be seen as a mechanism within the paradigm of critical realism. The uncertainty dimension in project complexity derives from the definition given by Williams (1999), where it is defined as the uncertainty of goals and uncertainty of methods. From a critical realist point of view, uncertainty is related to the contextual actualization of the mechanisms. Using pace and uncertainty as conditional dimensions in the proposed theory of the lived experience of project complexity management, the framework of Geraldi et al. (2011) can be illustrated as shown in **Figure 6**
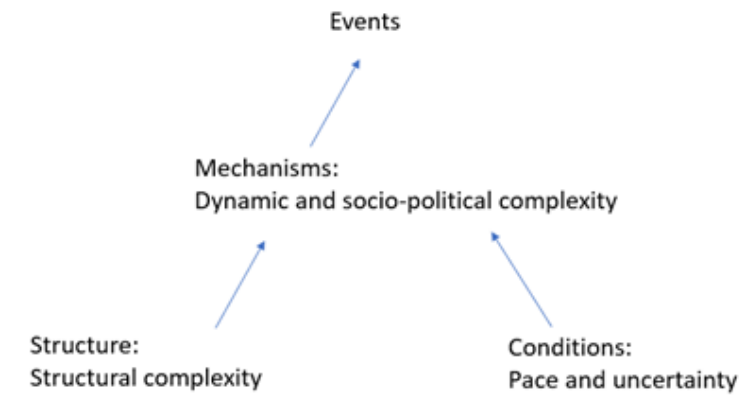

Figure 6: The five dimensions of Geraldi et al (2011) with Sayer (2008) as a lens

5.2. Exemplification of mechanisms in of project complexity

The second part of the discussion is an illustration of the search for mechanisms. To do this, some examples have been selected, as displayed in Table 3. A sample of examples has been selected to demonstrate both specific and more general mechanisms. The theoretical search for mechanism has been based on 'reverse engineering', meaning the methodology order 1) Explication of events, 2) Explication of structure and context, and 3) Retroduction of mechanisms, that has been explained previously has been turned around, starting with the mechanisms found in literature where plausible structures/context has been found based on the first principle, and then probable events/effect has been assumed. The purpose of Table 3 is only to demonstrate stratifications that might be found in future research based on the proposed theory.

5.3. The potential benefits of the theory of project complexity

The proposed theory of project complexity management can enrich the research on project complexity by adding a better understanding of the lived experience of project complexity management. The dimensional frameworks are good for the research of project complexity in general but lack the affordance of a context-specific explanation of what is going on in the specific project. The theory of project complexity, on the other hand, gives rigor to the softer interpretive understanding of the working of a project. Further, the proposed theory provides a practical explanation of the radical unpredictability of projects leading to them having an emergent structure; hence the contribution might also fit into the development of a theory of emergence.

1: Explication of events/effects	2: Explication of structure and context	3: Retroduction: Identify the mechanisms
Un-expected stakeholder behavior	Many stakeholders together with a low level of trust	Hidden agenda (Geraldi et al., 2011)
Resistance to change	Several organizational units involved the projects benefits realization efforts	Unactualized Top management support (H. R. Maylor et al., 2013)
Change in project goals	Powerful stakeholders with divergent interests and available time for power jogging	Power struggles (H. Maylor et al., 2008)
Radical unpredictability	Interrelations among elements with more than one equilibrium	Tipping point (Cooke-Davies et al., 2007)
Decision making based on unrealistic expectations	Interrelations giving support to functional stupidity and high levels of delusional success bias	Stupidity (Mikkelsen, Marnewick, & Klein, 2020)

Table 3: Theoretical examples mechanism of project complexity

The benefit for the practitioners of project management from the theory of project complexity management derives from the focus on the unpredictability of actualization of the mechanisms, lead to a higher focus on early detection. The number one recommendation to practitioners based on the project complexity theory is: Early detection is vital to an appropriate managerial approach to handle the project complexity. Some practitioners might use the theory to take comfort in the observation, that they cannot be expected to explain the events and outcome based on the initial information about the project.

The theory also stresses the importance of a proactive mindset for the project manager. A reactive managerial response to project complexity is to wait for the events (or the lack of events) to manifest. A more pro-active managerial approach is to influence the context of mechanisms to dampen (or enhance) actualization – depending on the view of the resulting events. A pro-active approach may even influence the structural level – e.g., divide the project into smaller projects to be carried out successive or change the method and/or goals to something less uncertain.

6. CONCLUSION

The paper set out to theorize the lived experience of managing project complexity. Based on different perspectives regarding the time of observations versus the descriptive/perceived project complexity, a matrix of perspectives on project complexity was developed. The matrix positioned the research of lived experience of managing project complexity in the overall research literature on project complexity.

With inspiration from critical realism, a theory has been proposed. The paper then when on to discusses the utility of the theory. Particularly the recommendation for identifying the generative mechanism. While there is still much to be researched, the presented theory of project complexity holds the potential for contributing to the research of project complexity, especially the management hereof. Adding to this, the theory might prove very practical, given support for the practitioner struggling with the complexity of their projects.

Future research may include the identification of mechanisms and context actualizing them. Much research is needed to excavate the mechanism of project complexity. Building on this, research of strategies for enabling or dampening the mechanisms may help practitioners of managing project complexity.

7. REFERENCES

Ahern, T., Leavy, B., & Byrne, P. (2014). Complex project management as complex problem solving: A distributed knowledge management perspective. International Journal of Project Management, 32(8), 1371-1381.

Alvesson, M., & Spicer, A. (2012). A stupidity-based theory of organizations. Journal of management studies, 49(7), 1194-1220.

Baccarini, D. (1996). The concept of project complexity—a review. International Journal of Project Management, 14(4), 201-204.

Bakhshi, J., Ireland, V., & Gorod, A. (2016). Clarifying the project complexity construct: Past, present and future. International Journal of Project Management, 34(7), 1199-1213.

Bhaskar, R. (1998). The Possibility of Naturalism: A Philosophical Critique of the Contemporary Human Sciences: Hemel Hempstead: Harvester Wheatsheaf.

Bhaskar, R. (2013). A realist theory of science: Routledge.

Bjorvatn, T., & Wald, A. (2018). Project complexity and team-level absorptive capacity as drivers of project management performance. International Journal of Project Management, 36(6), 876-888.

Bosch-Rekveldt, M., Jongkind, Y., Mooi, H., Bakker, H., & Verbraeck, A. (2011). Grasping project complexity in large engineering projects: The TOE (Technical, Organizational and Environmental) framework. International Journal of Project Management, 29(6), 728-739.

Bygstad, B. (2010). Generative mechanisms for innovation in information infrastructures. Information and Organization, 20(3-4), 156-168.

Bygstad, B., Munkvold, B. E., & Volkoff, O. (2016). Identifying generative mechanisms through affordances: a framework for critical realist data analysis. Journal of Information Technology, 31(1), 83-96.

Byrne, D. (2002). Complexity theory and the social sciences: An introduction: Routledge.

Cooke-Davies, T., Cicmil, S., Crawford, L., & Richardson, K. (2007). We're not in Kansas anymore, Toto: Mapping the strange landscape of complexity theory, and its relationship to project management. Project Management Journal, 38(2), 50-61.

Curşeu, P. L., Janssen, S. E., & Raab, J. (2012). Connecting the dots: Social network structure, conflict, and group cognitive complexity. Higher Education, 63(5), 621-629.

Daniel, P. A., & Daniel, C. (2018). Complexity, uncertainty and mental models: From a paradigm of regulation to a paradigm of emergence in project management. International Journal of Project Management, 36(1), 184-197.

Davies, A., Dodgson, M., & Gann, D. (2016). Dynamic capabilities in complex projects: The case of London Heathrow Terminal 5. Project Management Journal, 47(2), 26-46.

Davies, A., & Mackenzie, I. (2014). Project complexity and systems integration: Constructing the London 2012 Olympics and Paralympics Games. International Journal of Project Management, 32(5), 773-790.

de Rezende, L. B., & Blackwell, P. (2019). Revisiting project complexity: a new dimension and framework. The Journal of Modern Project Management, 6(3).

Easton, G. (2010). Critical realism in case study research. Industrial marketing management, 39(1), 118-128.

Floricel, S., Michela, J. L., & Piperca, S. (2016). Complexity, uncertainty-reduction strategies, and project performance. International Journal of Project Management, 34(7), 1360-1383.

Flyvbjerg, B. (2006). From Nobel Prize to project management: Getting risks right. Project Management Journal, 37(3), 5-15.

Flyvbjerg, B. (2008). Curbing optimism bias and strategic misrepresentation in planning: Reference class forecasting in practice. Journal of European planning studies, 16(1), 3-21.

Geraldi, J., Maylor, H., & Williams, T. (2011). Now, let's make it really complex (complicated) A systematic review of the complexities of projects. International journal of operations & production management, 31(9), 966-990.

Giezen, M. (2012). Keeping it simple? A case study into the advantages and disadvantages of reducing complexity in mega project planning. International Journal of Project Management, 30(7), 781-790.

He, Q., Luo, L., Hu, Y., & Chan, A. P. (2015). Measuring the complexity of mega construction projects in China—A fuzzy analytic network process analysis. International Journal of Project Management, 33(3), 549-563.

Keynes, J. M. (1937). The" ex-ante" theory of the rate of interest. The Economic Journal, 47(188), 663-669.

Kiridena, S., & Sense, A. (2016). Profiling project complexity: Insights from complexity science and project management literature. Project Management Journal, 47(6), 56-74.

Lovallo, D., & Kahneman, D. (2003). Delusions of Success. Harvard business review, 81.7 (2003): 56-63.

Lu, Y., Luo, L., Wang, H., Le, Y., & Shi, Q. (2015). Measurement model of project complexity for large-scale projects from task and organization perspective. International Journal of Project Management, 33(3), 610-622.

Luo, L., He, Q., Jaselskis, E. J., & Xie, J. (2017). Construction project complexity: research trends and implications. Journal of Construction Engineering and Management, 143(7), 04017019.

Luo, L., He, Q., Xie, J., Yang, D., & Wu, G. (2016). Investigating the relationship between project complexity and success in complex construction projects. Journal of Management in Engineering, 33(2), 04016036.

Maylor, H., & Turner, N. (2017). Understand, reduce, respond: project complexity management theory and practice. International journal of operations & production management.

Maylor, H., Vidgen, R., & Carver, S. (2008). Managerial complexity in project-based operations: A grounded model and its implications for practice. Project Management Journal, 39(1_suppl), S15-S26.

Maylor, H. R., Turner, N. W., & Murray-Webster, R. (2013). How hard can it be?: actively managing complexity in technology projects. Research-Technology Management, 56(4), 45-51.

Mikkelsen, M. F. (2020a). The complex project complexity–Identification of five ideal research types. The Journal of Modern Project Management, 7(4).

Mikkelsen, M. F. (2020b). Perceived project complexity: a survey among practitioners of project management. International Journal of Managing Projects in Business.

Mikkelsen, M. F., Marnewick, C., & Klein, L. (2020). On Stupidity in Project Management - A critical reflection of PM in a VUCA world. Journal of Modern Project Management.

Mingers, J., Mutch, A., & Willcocks, L. (2013). Critical realism in information systems research. MIS quarterly, 37(3), 795-802.

Morcov, S., Pintelon, L., & Kusters, R. J. (2020). Definitions, characteristics and measures of IT project complexity-a systematic literature review. International Journal of Information Systems and Project Management.

Nguyen, A. T., Nguyen, L. D., Le-Hoai, L., & Dang, C. N. (2015). Quantifying the complexity of transportation projects using the fuzzy analytic hierarchy process. International Journal of Project Management, 33(6), 1364-1376.

Padalkar, M., & Gopinath, S. (2016). Are complexity and uncertainty distinct concepts in project management? A taxonomical examination from literature. International Journal of Project Management, 34(4), 688-700.

PMI. (2014) Navigating Complexity: A Practice Guide.

Qureshi, S. M., & Kang, C. (2015). Analysing the organizational factors of project complexity using structural equation modelling. International Journal of Project Management, 33(1), 165-176.

Remington, K. (2016). Leading complex projects: Routledge.

Samset, K., & Christensen, T. (2017). Ex ante project evaluation and the complexity of early decision-making. Public Organization Review, 17(1), 1-17.

Sayer, A. (1999). Realism and social science: Sage.

Sayer, A. (2004). Why critical realism? Andrew Sayer. Critical realist applications in organisation and management studies, 11, 6.

Saynisch, M. (2010). Beyond frontiers of traditional project management: An approach to evolutionary, self-organizational principles and the complexity theory—results of the research program. Project Management Journal, 41(2), 21-37.

Schlindwein, S. L., & Ison, R. (2004). Human knowing and perceived complexity: implications for systems practice. Emergence: Complexity and Organization, 6(3), 27-32.

Snowden, D. J., & Boone, M. E. (2007). A leader's framework for decision making. Harvard business review, 85(11), 68.

Turner, J. R., & Cochrane, R. A. (1993). Goals-and-methods matrix: coping with projects with ill defined goals and/or methods of achieving them. International Journal of Project Management, 11(2), 93-102.

Venable, J., Pries-Heje, J., & Baskerville, R. (2016). FEDS: a framework for evaluation in design science research. European journal of information systems, 25(1), 77-89.

Vidal, L.-A., & Marle, F. (2008). Understanding project complexity: implications on project management. Kybernetes, 37(8), 1094-1110.

Vidal, L.-A., Marle, F., & Bocquet, J.-C. (2011). Measuring project complexity using the Analytic Hierarchy Process. International Journal of Project Management, 29(6), 718-727.

Williams, T. M. (1999). The need for new paradigms for complex projects. International Journal of Project Management, 17(5), 269-273.

Wynn Jr, D., & Williams, C. K. (2012). Principles for conducting critical realist case study research in information systems. MIS quarterly, 787-810.

Xia, W., & Lee, G. (2004). Grasping the complexity of IS development projects. Communications of the ACM, 47(5), 68-74.

Zaman, U., Jabbar, Z., Nawaz, S., & Abbas, M. (2019). Understanding the soft side of software projects: An empirical study on the interactive effects of social skills and political skills on complexity–performance relationship. International Journal of Project Management, 37(3), 444-460.

Zhu, J., & Mostafavi, A. (2017). Discovering complexity and emergent properties in project systems: A new approach to understanding project performance. International Journal of Project Management, 35(1), 1-12.

ABOUT AUTHOR

Mogens Frank Mikkelsen. Ph.D. from IT University of Copenhagen. Worked 16 years as facilitator in the field of Project Management from 2005. Worked 15 years as practitioner of Project Management from 1990 to 2005. Certification of project management: PMP, IPMA level C, PRINCE2 practitioners, MSP and Scrum master Member of Danish Project Management Association. Published handbook for practitioners in Danish "Ledelse af komplekse projekter", 2016 (title translation: Leading complex projects). Master of Science, Danish Technical University. 1990