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Getting a grip on IT project complexity – Concluding to underlying causes

by

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Abstract

Research appraises that the substandard management of complexity is one of the common reasons for IT project failure. As such, companies need to improve their management of complexity. However, doing so requires an unambiguous understanding of what is meant by complexity, which has not yet been examined. In this study, we therefore strive to provide conceptual clarity regarding the construct complexity, by considering causalities of complexity aspects presented in extant literature. We develop a two-dimensional framework based on generic complexity antecedents and context-specific project areas. We evaluate its practicability by drawing on semi-structured interviews with IT project management experts. The resulting framework will help researchers and practitioners to understand how complexity can occur in IT projects, as it provides insights into what causes complexity and where it is located within an IT project. Furthermore, it provides a basis for the development of appropriate management strategies and quantification methods for complexity.

Keywords: IT project complexity, complexity determinant, complexity assessment, framework.

1 Introduction

Increasing market competition requires a high level of adaptability to rapidly-changing market conditions and customer expectations. This forces companies to continuously progress. Since projects enable change within a company, they are increasingly important [70]. However, projects also face a high risk of failure [45]. Projects fail when they do not meet their objectives, concerning schedule, budget, or projected outputs. The failure of IT projects can cause devastating problems, and even total business failures, for companies [22]. With this in mind, managers should aim to manage IT projects properly [49].

Although the exact relationship between IT project failure and IT project complexity has not yet been sufficiently investigated, many authors agree that complexity contributes to IT project failure [19, 23, 53]. For example, Vidal and Marle [65] have found that while this relationship needs to be clarified, complexity seems to be one of the main reasons for IT project failure. Xia and Lee [74] argue that one of the reasons for IT project failure can be a high level of complexity, as in such cases, there are many different factors that influence a project at the technological and organizational levels. Baccarini [3] states that since complexity has an impact on cost, time, and quality, it can hamper the achievement of a project's objectives [3, 74]. Wallace et al. [68] empirically confirm that complexity risk is one of six risk dimensions that influence the success or failure of software projects. A steady general increase in complexity, which has been regularly found in past research, reinforces the effects of this problem [32]. IT projects are particularly affected by high levels of complexity, as they need to cope with various dependencies within a single project, or between different projects [6, 23, 77]. The prevalence of IT project failure has been studied in depth, and has been found to be generally related to a lack of managerial approaches for coping with highly-complex projects, rather than to information technology per se [35]. This indicates the need for appropriate means to successfully manage IT project complexity. However, IT project complexity is very difficult to understand, and there is no academic consensus about what is behind it or how it should be approached [67]. Therefore, instead of concluding to the underlying causes of IT project complexity, most researchers have only addressed specific aspects that can be observed within complex IT projects, and which are thus assumed to somehow relate to IT project complexity [32, 52, 63]. Accordingly, different categorizations of aspects have been proposed [3, 65, 67]. In fact, the explanation of a phenomenon like IT project complexity, which is crucial to deriving solutions, often requires an investigation of underlying causes [29], and so a comprehensive and structured assessment of IT project complexity, including causalities of observed aspects, is needed. Furthermore, the various existing designations of complexity aspects, that partly are even used contradictory, hamper a clear and unambiguous understanding.

With these considerations in mind, we strive to provide conceptual clarity regarding the construct of IT project complexity and its underlyings. Based on that, an appropriate assessment and management of IT project complexity may empower companies to mitigate their overall risk of IT project failure [32, 41]. We thus aim to answer the following research question:

How can complexity in IT projects be assessed with respect to its influencing factors?

To do so, we develop a structured and elaborate framework for complexity assessment, which relates manifestations of complexity to generic causes and specific areas of occurrence. Following Gregor and Hevner [30], we provide an overview of underlying theoretical knowledge. We then explain our research approach and the methodology used. We derive hypotheses about the causalities of complexity by structuring the aspects of complexity identified in literature within a framework. Following the design search process [30], we test and enhance the quality of the derived framework on the basis of manifestations of complexity stated in literature. In terms of evaluation, we conduct five interviews with experts from different industries to validate the comprehensiveness, applicability and utility of the framework. Finally, we discuss the framework's contributions for practice and research, existing limitations, and the outlook for future research.

2 Theoretical Background

Complexity is a topic that has been discussed in a variety of research fields, including philosophy, biology, mathematics, and informatics. Accordingly, understandings of complexity tend to vary greatly [58]. In general, there are two major streams of literature that analyse "complexity in projects" and "complexity of projects" [26]. While the first stream focuses on the integration of complexity theory in projects [e.g. 8, 16, 56], the second one deals with the characteristics of complex projects [e.g. 26, 35, 36, 75]. In the following, we stick to the second stream and assess the complexity of information system (IS) and information technology (IT) projects, which we hereafter simply refer to as complexity. We consequently refrain from any specific definitions of computational complexity [20], software complexity [69], or any other complexity that only concentrates on a specific sub-area of IS/IT projects. Moreover, as a common agreement on a definition of complexity in a general context does not exist [59], we also refrain from simply adopting an existing or introducing a new one, but rather endeavour to proceed to a deeper level of understanding by discovering antecedents of complexity and the project areas where it manifests and might be observed. In the following sections, we thus examine existing literature in order to clarify what is behind complexity and how it can be assessed in a structured and practical way. Thereby, we strive to discover causalities of complexity in general.

Complexity is determined by various circumstances, and is thus very difficult to grasp [74]. Hence, related works in existing literature can be considered as assemblages of different observations within this context, rather than detailed and structured assessments or sharp definitions. The majority of articles on this topic addresses influence factors that are supposed to somehow relate to complexity, but which are derived from a narrow subjective perception of the topic. In adopting a more general perspective, we strive to provide conceptual clarity regarding the construct of complexity. Therefore, we introduce a uniform designation and distinguish between aspects, characteristics, and manifestations to facilitate comprehension:

Aspects, as the vaguest category, refer to any kind of influencing factor that is supposed to somehow relate to complexity.

Characteristics are considered to be aspects of complexity that exist independently of specific areas of occurrence (i.e., characteristics can be observed independently of a specific context).

Manifestations are considered to be aspects that arise from a specific area of occurrence (i.e., manifestations can only be observed within a specific context).

Some approaches to complexity in existing literature primarily describe different manifestations [20, 21, 48, 69], whereas others try to determine comprehensive characteristics of complexity [3, 32, 63]. However, the majority of studies address single aspects that are supposed to somehow relate to complexity [3, 32, 63]. These aspects are not treated consistently within and across different studies, and in some cases, are even used contradictory. Moreover, since most studies do not strive to address complexity as a whole but rather focus on side issues, they lack a comprehensive and systematic structure or approach concerning this matter. Since complexity as a cause for IT project failure has risen more and more attention in recent years, researchers increased their effort in providing structured categorizations to complexity, e.g. by dividing complexity aspects “into […] more intuitive groups, which were cited in several of the references” [67]. While doing so, Vidal et al. [67], however, strive to empirically examine several manifestations of complexity found in literature by the means of a Delphi study. Inspired by an initial categorization of Baccarini [3], who distinguished complexity manifestations on an organizational and a technological level, Lee and Xia [43] proposed a framework along two dimensions, *locus* and *nature*. *Locus* refers to whether complexity "is associated with *organizational factors* or *IT factors*" [43] and thus addresses its areas of occurrence like intended by Baccarini [3]. By contrast, *nature* distinguishes between *structural* and *dynamic complexity*. According to Lee and Xia [43], *structural complexity* pictures "a function of the number of project components and the form and strength of the relationships [in]between" while *dynamic complexity* "refers to complexity due to changes in business and technological environments", which is claimed to be consistent with Woods definition of dynamic complexity [73] and Campbells notion of uncertainty [12]. Continuing their research, Xia and Lee [75] validated their initial framework with a survey among 541 managers and derived a measurement model for complexity. As this endeavour was one of the first approaches focusing on complexity assessments, it established and served many researchers as basis for continuing investigations in this respect. Gregory and Piccinini [31], for instance, build upon Xia and Lee [75] and extend their structuring by adding *variety* and *interdependency* as structural and *uncertainty* and *ambiguity* as dynamic "constructs" of complexity in IS projects. To do so, they conducted a literature review and identified several manifestations, which they categorized according to their enhanced structuring. Drawing on a Delphi study, they continued their research by empirically investigating to what extent the identified manifestations influence the complexity of IS projects [54]. Based on a systematic review of complexity literature, Geraldi et al. [26] propose a contingency framework based on five dimensions of project complexity: *structural complexity*, *uncertainty*, *dynamic*, *pace*, and *socio-political*. However, as *dynamic* complexity might be seen as a concept that addresses "the unpredictable situation and emergent events that occur over time", it can be considered to include "different types of uncertainty influencing the progress of a project" [11]. Consequently, Brady and Davies [11] propose a conceptualization of project complexity that merely distinguishes between *structural* and *dynamic complexity*, whereas in comparison to Geraldi et al. [26], *dynamic complexity* comprises the *dynamic*, *uncertainty* and *pace* dimension and *structural complexity* includes the *structural* and *socio-political* dimension. Thus, in contrast to Lee and Xia [43, 75], Geraldi et al. [26] and Brady and Davies [11] rather focus on the *nature* of complexity and neglect the area within a project where complexity might occur (*locus*).

Despite the undoubted contribution of the previously mentioned investigations, they mostly investigate manifestations of complexity rather than concluding on common characteristics or antecedents. Furthermore, they often lack concrete delimitations between different complexity aspects and consequently lack clarity regarding causalities. The hesitation of researchers to state causes for the phenomena that they investigate is a well-recognized issue in IS research [2, 4]. Yet doing so is crucial, since the explanation of an investigated phenomenon often requires an examination of the underlying causes [29]. Conceptual clarity of complexity is further hampered, as different studies came up with various different wordings regarding complexity aspects like dimensions, constructs, groups, areas, etc., which are partly even used contradictory. Therefore, the contribution of existing research on complexity is to provide a structured list of possible aspects of complexity to be thought of when managing an IT project, rather than to provide elaborate guidance on how to assess complexity or explain what is concealed within it. An approach that assesses complexity from a managerial perspective, by providing insights about causalities for the genesis does not yet exist to the best of our knowledge.

3 Research Methodology

To develop an approach that is able to assess complexity, we follow a Design Science Research (DSR) approach [30, 33], like illustrated in Figure 1. In doing so, we stick to the publication pattern for DSR studies [30] and at first specify the purpose and scope of our artifact in Section 1 *(Introduction)*. After, examining existing descriptive or prescriptive knowledge concerning complexity within Section 2 (*Theoretical Background)* and explaining our research approach in Section 3 (*Research Methodology)*, we move on to the artifact description in Section 4 (*Framework for the Assessment of Complexity).* In this section we provide detailed insights on the iterative design search process that led to the development of the final artifact represented by a structured and elaborate framework to assess complexity. According to Gregor and Hevner [30], the artifact should be evaluated in terms of various different "criteria that can include validity, utility, quality, and efficacy" [30] to ensure scientific and practical impact. To do so, many potential evaluation techniques like expert reviews, case studies or simulations are available [30]. However, depending on the defined criteria that is to be evaluated, some techniques might be more or less appropriate to derive rigor results. Since a rigor evaluation regarding multiple criteria requires multiple evaluation techniques, it would exceed the scope of this paper. Thus, we limit Section 5 (*Evaluation*) to two criteria: validity and utility. As validity strives to evaluate that the artifact works as it is meant to do, and utility that it does so even in a real world environment, we draw on expert reviews with practitioners for this evaluation purpose. We are aware that a rigor evaluation of the artifact requires also further evaluation regarding additional criteria like quality and efficacy, which also includes an empirical investigation of the causality hypothesis generate by the proposed framework. Since this, however, is not feasibly within the scope of this paper, it is subject to further research. Finally, we present general learnings in Section 6 (*Discussion*) and conclude in Section 7 (*Conclusion*), highlighting limitations and the important findings of the research paper.

Figure 1

4 Framework for the Assessment of Complexity

Based on common properties of findings from existing literature, we create our initial framework. As indicated, complexity generally depends on observation contexts and its areas of occurrence within an IT project [43]. Thus, areas of occurrence are considered as the first dimension of our two-dimensional framework, and are henceforth referred to as project areas. A more detailed explanation of the included project areas is given in Section 4.2. To indicate how complexity is evoked within different project areas, we determine antecedents of complexity. Assuming that antecedents evoke manifestations within specific project areas, and considering them as our second dimension, we come up with a resulting framework, which is supposed to encompass all manifestations evoked by the derived antecedents within the included project areas. Hence, we set up a two-dimensional framework based on generic antecedents and context-specific project areas, with the former describing what causes complexity and the latter describing where complexity is located. This approach is illustrated in Figure 2.

Figure 2

To find the antecedents of complexity, as a first step, we focus on the characteristics of complexity that have been documented in existing literature and that are observable independently of the observation context. Therefore, Section 4.1 examines the different characteristics listed in existing literature and whether they can be considered as antecedents of complexity.

4.1 Determining antecedents of complexity

In existing literature, several aspects are mentioned that can be considered as characteristics of complexity, as they are observable independently of specific project areas. These characteristics mostly appear in studies with diverging and inconsistent definitions of complexity. However, the fact that characteristics seem to be comprehensively observable is not sufficient to consider them antecedents of complexity. Based on existing literature, we derive some requirements which a complexity characteristic specified in literature has to reflect, in order to be considered as a complexity antecedent in the context of this research.

A framework in its proper sense should feature a delineable structure to ensure scientific rigor as well as comprehensibility and applicability. Therefore, not only the contained dimensions should be disjoint but also the segmentation within each particular dimension of the framework should be mutually exclusive. To provide clear and reasonable causalities of complexity, we consequently state the following requirement:

Requirement (Req.) 1 – Distinctness: A complexity antecedent should be distinct and easily separable from other complexity antecedents, meaning that it is not listed among others [5].

When people speak of something as being complex, they use "everyday language to express a feeling or impression that [they] dignify with the label complex" [14]. Thus, when two people talk about complexity in the same case, they will not necessarily be talking about the same thing. This is because "like truth, beauty, good and evil, complexity resides […] in the eye of the beholder" [14]. From a subjective point of view, complexity can be influenced by personal "knowledge, experience, or intelligence" [32]. This kind of complexity is the result of a particular perception of a situation by a subjective observer [59], and is described as "subjective complexity" in this paper. However, since subjective perceptions are unique to every individual, they do not allow for a generally valid assessment of complexity [3].

A different perspective is provided by Cilliers and Spurrett [17], who state that "complex systems do have characteristics that are not merely determined by the point of view of the observer." Schlindwein and Ison [59] also explain that complexity can be "understood as an intrinsic property of a certain kind of system, or as occurring in a certain kind of natural and social phenomena." This understanding is based on the assumption that there is an objective reality that can be independently assessed and is not influenced by subjective perception [59]. Although it is probably impossible to separate the underlying objective reality from its subjective perception, it should be possible to make some conclusions regarding an objective situation by exploring similar properties that different subjective observations have in common. In this paper, we assume that subjective perceptions follow from objectively observable properties. In deciding whether to buy a new car, a customer must use subjective personal judgement, but that judgment is always based on objective properties, like design, features, and price, as well as their relationships to one another. In accordance with this perspective, we focus on properties of objective complexity as the basis of subjective perceptions and state the following requirement:

Requirement (Req.) 2 – Objectivity: A complexity antecedent should not refer to subjective perceptions or cognition, which means it should not depend on human abilities like "knowledge, experience or intelligence" [32].

The "bounded rationality [60] and the constructed nature of complexity [40] hampers its definition as a complete, general, 'perpetual' and precisely measurable set of characteristics" [26]. Thus, the assessment of a transient and alterably construct like complexity by the means of a rather rigid and inflexible framework is a challenging endeavour. Especially, if such a framework is supposed to cover the emergence of unpredictable and random events over time that may influence the progress of a project. Since the assessment of any subject, be it a business case calculation or the appraisal of complexity, is based on information that is available at that specific point in time, future changes that may or may not occur over time cannot be covered anyway. In fact, these imponderables generally are considered vicariously by a risk discount, which is based on possible changes as to the underlying parameters of the assessed subject. Whereas these parameters might be interest rate or different cost factors for a business case calculation, they are antecedents in case of complexity assessment, which means that each antecedent of complexity is prone to changes over time. Argumentum e contrario we consider changes over time as reinforcing influences to complexity antecedents rather than complexity antecedents themselves. Thus, in contrast to Lee and Xia [43, 75] and other research building upon [31, 54, etc.], we do not include factors that relate to changing circumstances over time into our framework and state the following requirement:

Requirement (Req.) 3 – Robustness: The extent to what an underlying antecedent is able to influence complexity should not depend on the point of time at which it is actually assessed. This means that the influence of an antecedent on complexity must not automatically increase or decrease with the time passing, but just depends on the actual observable value at the specific point of assessment.

Literature mentions many aspects that are supposed to be characteristics of complexity. Furthermore, one and the same characteristic is often described by different expressions. Therefore, we consolidate expressions that describe the same phenomenon and consider these as characteristics only if they have been listed by previous frameworks or are mentioned by several different authors. In doing so, we found uncertainty, difficulty, multiplicity, interdependency, diversity, and ambiguity as characteristics of complexity. Although, the selection of these characteristics features some subjective judgement and they represent a certainly incomplete list, it provides a sound reference point to approach the assessment of complexity.

Below, we discuss the identified characteristics and examine whether and how they meet the requirements introduced above, and thus whether they can be considered as complexity antecedents in the sense of this paper.

Uncertainty is the extent to which a project is subject to potential future changes [74]. The dynamics of projects can be described as their variability over time [32]. The probability of varying over time represents the uncertainty of a project. Due to the similarity of the definitions of dynamics and uncertainty, we consider them as equals. Like proposed by Brady and Davies [11], we furthermore assume pace to be part of uncertainty, since it relates to "changing relationships among companies within a system and between the system and its environment over time" [11]. Numerous researchers refer to uncertainty as a characteristic of complexity [e.g. 25, 38, 61, 62, 64, 72, 74]. As uncertainty is not only able to influence any identified antecedent of complexity, but is omnipresent in each planning activity, it cannot be assessed distinctly and thus falls short of *Req. 1*. At the same time, uncertainty can be examined objectively, as an absence of information exists regardless of the concrete abilities of individuals (*Req. 2*). However, it again falls short of *Req. 3*.The uncertainty involved in a project always declines with the project's progress (for a more detailed explanation, see Boehm's [9] "cone of uncertainty" principle). As such, the extent to which uncertainty is able to influence complexity is strongly dependent on the point in time of its assessment. Furthermore, opinions vary as to whether uncertainty is a characteristic of complexity or should be considered separately. Whereas, for instance, Williams [72] or Xia and Lee [74] assert that uncertainty is a characteristic, Baccarini [3], Laufer et al. [42], and Lindemann et al. [44] consider uncertainty to be a consequence of complexity, or even a separate concept. We consider uncertainty as a reinforcing influence to any antecedent, rather than an antecedent of complexity itself.

Things that are "difficult" can be defined as hard to achieve, comprehend, handle, or express [13, 20] and thus **difficulty** refers to something that is "complicated, involved or intricate" [3]. Various authors describe difficulty as a characteristic of complexity [e.g. 3, 13, 18, 20, 27]. With regard to the distinctness of difficulty from other complexity antecedents, different opinions exist in prior literature. Although some authors argue that difficulty is a characteristic of complexity, others claim that it is just the result of multiplicity and interrelatedness [18]. Gove [28] furthermore states that if a project includes many varied project elements, it is difficult to understand as a whole. Thus, difficulty cannot be observed distinctly from other complexity antecedents and falls short of *Req. 1*. Furthermore, since whether something is hard to comprehend strongly depends on subjective perceptions and underlying human abilities, difficulty does not fulfill *Req. 2*. This is confirmed, for instance, by Baccarini [3], who explains that difficulty as an "interpretation of complexity is in the eyes of the observer" [3]. The extent to which difficulty influences complexity does not, however, depend on the time of its assessment (*Req. 3*). Based on the previous examination, we consider difficulty to be a subjective consequence of other complexity antecedents, and not an antecedent in itself.

We assume that **multiplicity** is equivalent to multitude and frequency, and refers to the number of project elements that a project involves (e.g., the number of subprojects that a project is split into). Multiplicity is considered to be a characteristic of complexity by numerous authors [13, 18, 27, 32, 42, 44, 47, 72]. Multiplicity can be distinctly separated from other antecedents (*Req. 1*). As the actual number of project elements is not influenced by human perception, multiplicity can be assessed objectively (*Req. 2*). Furthermore, as quantity is a time-independent measure, the extent to which the number of elements is able to influence complexity is independent of the time of its assessment (*Req. 3*). Since multiplicity thus satisfies all criteria, we consider it to be an antecedent of complexity.

Interdependency is assumed to be equivalent to connectivity and interrelatedness, and is characterized by the relationships and interactions within a project or between different projects (e.g., the interaction between the project's organizational elements). Various authors consider interdependency to be a characteristic of complexity [e.g. 3, 18, 27, 32, 38, 42, 44, 47, 72]. Interdependency can be considered distinctly from other antecedents (*Req. 1*). It can be considered objectively, since relations between technologies, departments, products, or other elements can be assessed without the influence of human abilities (*Req. 2*). Furthermore, the extent to which interdependency is able to influence complexity does not change over time (*Req. 3*). Consequently, since interdependency fulfills all criteria, we consider it to be an antecedent of complexity in this paper.

Diversity can be defined as the variety within a project. This implies that a project can have different variants of the elements that define it (e.g., the diversity of the knowledge or cultures of team members). A large number of authors regard diversity as a characteristic of complexity [e.g. 3, 25, 27, 38, 42, 44, 61]. In terms of distinctness from other antecedents, it is clear that diversity is related to multiplicity. However, diversity addresses a separate issue, and can thus be considered distinctly from other antecedents (*Req. 1*). The diversity of project elements is quantitatively assessable and therefore independent from the perceptions of the observer (*Req. 2*). Moreover, the extent to which diversity - whether qualitatively or quantitatively assessed - is able to influence a corresponding complexity measure does not depend on the point of time at which it is assessed during a project's life cycle (*Req. 3*). Thus, as diversity fulfills all criteria, we consider it as an antecedent of complexity.

Ambiguity is considered as characteristic by Gregory and Piccinini [31] and is referred to by manifestations mentioned by several different authors [e.g. 8, 15, 37, 39, 76]. It can be understood as a lack of clarity regarding specifications. Ambiguity can be considered distinctly from other antecedents (*Req. 1*). The objectivity of ambiguity is more doubtful. The perception whether e.g. a task is clearly specified in part certainly depends on the abilities, knowledge, and experience of the perceiving person. However, comparing a very detailed task specification to a poor specification, the former one, in relative terms, is able to reduce complexity independent of the abilities of the task-executing person. Thus, we consider ambiguity as objective with respect to *Req. 2*. Moreover, the extent to which ambiguity is able to influence complexity does not change over time (*Req. 3*). Consequently, we consider ambiguity as antecedent of complexity. To ease the comprehensibility, Figure 3 describes the coherences between the investigated characteristics of complexity.

Figure 3

In conclusion to our investigation of the characteristics and antecedents of complexity, Table 1 makes clear that only multiplicity, interdependency, diversity, and ambiguity fulfil all criteria for complexity antecedents in this paper. They consequently form the horizontal axis of our initial framework.

Tabel 1

4.2 Identification of project areas

Lee and Xia [43] and Baccarini [3] already propose to consider the area of occurrence of complexity and thus distinguish "organizational" and "technological" complexity. As this classification is quite rough, we want dive deeper into the project organization in order to understand the project areas in which manifestations of complexity can arise, and to enable a structured allocation of complexity within a project. Thus, we divide the project organization into different project areas, based on existing project management literature. Furthermore, we do not distinguish organizational and technological aspects as in times of digitalization and also beforehand, the importance of IT continuously grows and influences all areas of an organization. Thus, technological aspects can occur in any project area.

To identify an appropriate categorization of project areas, we synthesized several studies. The Project Management Institute [55] gives an overview of different enterprise environmental factors that surround or influence a project, like e.g. organizational structure, culture, and processes, or marketplace conditions. They give a quite long list of twelve factors, which can be used as a guidance. Since projects are executed within functional organizations, Edum-Fotwe and McCaffer [21] suggest to use the traditional functions required to manage enterprises, like e.g. finance and accounting, sales and marketing, and operational planning. Nevertheless, both publications point out that additional factors need to be considered. As both categorizations do not incorporate all relevant areas of a project, they do not serve our purpose and thus cannot be used as a categorization scheme for the project areas.

The categorization introduced by Belassi and Tukel [7] is rather generic and serves as a basis for several other studies. They introduce critical success factors for projects and categorize them according to the four factor groups “factors related to the project”, “factors related to project manager and team members”, “factors related to organization” and “factors related to external environment”. Hyvari [34] further elaborates these areas and differs between “factors related to project manager” and “factors related to team members”. She furthermore gives examples of success factors that should be categorized in this area, and thus supports a clear understanding of the scope of the different areas.

Westerveld [71] uses these areas as a basis and proposes an “overall framework for the management of projects” based on the European Foundation for Quality Management (EFQM) Excellence Model. As the EFQM was developed for “traditional, functionally organized, permanent organizations” [71] it cannot be directly used for project-focused organizations without adjustments. Thus, Westerveld [71] introduces six organizational areas (contracting, leadership and team, project management, resources, stakeholder management, and policy and strategy) that represent the areas that project managers can work on to "increase the likelihood of achieving a successful outcome of their project" [71]. Even though this categorization seems to be more graspable than the ones introduced before, the missing explanation of the concrete scope of the areas lead to a missing distinctness and gives rise to misunderstandings. Thus for example it stays unclear how the author distinguishes between topics that can be categorized as policy and strategy, and the ones that can be categorized as stakeholder management.

Within complexity literature Jaber et al. [36] group complexity factors for innovative product development projects into seven categories "current product complexity", "project characteristics", "project governance", "project team", "resources", "stakeholder", and "environment complexity". However, as these areas are not based on a literature analysis and are not empirically validated.

To enable an objective, impartial assessment, we adhere to the general and validated areas by Hyvari [34] based on Belassi and Tukel [7]. Nevertheless, as each project differs from another, it might be useful to incorporate further subcategories within each area. In the following we stick to the introduced project areas, which form the vertical axis of our initial framework.

Factors related to the project: This area includes all manifestations of complexity that are directly related to the project [7]. It includes all activities inherent in a project, as well as size, value, project life cycle, resources, project outcome, and planning and scheduling of project activities [7, 34].

Factors related to the project manager / leadership: This area covers all aspects concerning the project manager and leadership in the project [34]. We include all aspects that affect the way that a project is led by a project manager, leadership style, managerial competence, the ability to coordinate, objectively oberservable relevant past experience of the project manager, required competence, and management commitment in this area [7, 34].

Factors related to the project team members: This area comprises the skills and characteristics of the project team members [34]. We include all kinds of competences of the team members, and the way tasks and responsibilities are distributed within a team in this area. We also consider staff constellation, working habits, communication skills, and technical skills, as well as working experience, as these play an important role in this area [7, 34].

Factors related to the organization: This area is concerned with the position of the project within the organization [7]. We include top management support, negotiation and positional power within the organization, as well as the project organization structure in this area [7, 34].

Factors related to the environment: This area includes all factors “which are external to the organization but still have an impact on project success or failure” [7]. The environmental factors imply external political, social, and economic influences, and even influences by nature. Furthermore, the client is included here. In some IT projects clients are part of the organization and should in this case be considered in the organization area. Moreover, factors related to competitors and contractors / subcontractors, or external service providers are summarized here [7, 34]

4.3 Framework Design Validation

After determining the dimensions and designing the framework, we refine the designed artifact in accordance with Gregor and Hevner [30]. Therefore, we validate the framework against existing literature and assess whether all of the manifestations of complexity described in literature are covered by the framework. We examined various studies in our validation phase including but not limited to Baccarini [3], Geraldi et al. [26], and Xia and Lee [75] and thus gained a huge number of aspects concerning complexity. To improve operability, we merged different verbalizations of the same manifestation. As already outlined in chapter 4.1, uncertainty is not an antecedent of complexity and needs to be considered as a separate concept. Thus, we excluded all verbalizations concerning uncertainty and change. While several manifestations were only mentioned in literature, the causality of others has already been empirically tested by certain authors. The manifestations that have already been empirically validated to cause complexity are highlighted in italic. In total we obtained 166 manifestations that were assigned to the framework.

In the first step we are able to assign 140 of 166 manifestations to the derived framework. The other 26 either did not fit one of the four antecedents or could not be sorted into a specific project area or even both. Thus, the framework in its initial state covers about 84% of the manifestations mentioned in the context of complexity in existing literature. Table 2 provides an overview of all of the manifestations that can be assigned to the framework.

As an overview of 140 manifestations is quite encompassing, we furthermore used a subcategorization of the general project areas. For example, the manifestations assigned to project area “project” and antecedent “multiplicity” can be subcategorized into manifestations concerning “tasks / transactions”, “input”, “scope / product”, “financial aspects”, “output”, and “data”. This subcategorization was inductively derived by the available manifestations as it simplifies clear depiction. Thus it can be adapted for each project.

Tabel 2

In line with the design search process proposed by Gregor and Hevner [30] we improve the framework based on an iterative procedure. Therefore, after setting up the initial framework, we analyze whether an extension of the dimensions could possibly increase the framework’s coverage of context-specific manifestations. Thus, we examine the 26 manifestations that could not be assigned to the framework, in order to determine whether they exhibit the same properties.

As all 26 manifestations can be assigned to one of the project areas, thus an adjustment of the project areas does not seem necessary. However, we further examined the similarities of the 26 manifestations concerning potential antecedents of complexity. The only similarity that could be obtained between these manifestations is that 13 of them address the degree of novelty within a project (see Table 3). Novelty addresses whether different aspects of the project are already known in the organization, if they have been accomplished before or if best practices are available. To investigate whether novelty could reasonably be considered a further complexity antecedent, we check the requirements stated above. Since the 13 manifestations could not yet be assigned to any of the previously stated antecedents, we can consider novelty as distinct in terms of *Req.1*. Furthermore, the evaluation whether something is new does not depend on human perception or experience, but only on the availability of information. Thus, novelty can be assessed objectively *(Req.2)*. The extent to which novelty is able to influence complexity does not depend on the point of time of its assessment. Therefore, as it also fulfils Req. 3, we extend our initial framework by considering novelty as a separate antecedent.

Table 3 gives an overview of the manifestations that can be assigned to the new antecedent novelty and the manifestations that can be assigned to a project area, but not to an antecedent.

Table 3

Despite the adjustments, 13 manifestations (see Table 3) that were identified in literature still cannot be adequately assigned to the framework. Even though they can be assigned to a project area, they do not adequately fit any antecedent. While five of them cope with the complexity within the “project” like the impact of a fixed deadline for the project or the flexibility of the project budget, seven manifestations can be assigned to the project area “environment”. Even though those manifestations should be considered, we could not find another cluster to derive a further antecedent. Nevertheless, 92% of the manifestations mentioned in literature can be assigned to the revised framework and thus we consider the framework to cover the most relevant aspects. Figure 4 depicts the final framework, including adjustments based on the evaluation against existing literature.

Figure 4

5 Evaluation

In line with Gregor and Hevner [30], the purpose of the evaluation in this section is to examine the validity and utility of the revised framework, using semi-structured interviews with practitioners. The focus of this evaluation is on the adequacy and comprehensibility of the complexity antecedents, the applicability of the project areas as holistic and reasonable structures for projects, and the practicability and utility of the framework to assess complexity in real world circumstances.

Therefore, we conducted five semi-structured interviews with project management experts from different industries. We identified potential interview partners based on (i) different industry sectors and (ii) years of experience in the project management field to cover a wide and valid spectrum of knowledge. Three interviewees work for leading strategy consultancies with widespread experience in the field of IS/IT projects within different industries. The other two work as IS/IT project manager within the manufacturing industry. Each interviewee has experience as an IS/IT project manager for at least seven to ten years. Each interview lasted approximately 45 minutes to 1 hour and was audio recorded. Due to the global dispersion of the experts, the interviews were conducted either via telephone or video conference. However, according to long established evidence, telephone interviews are just as effective as face-to-face interviews [57] and we observed no shortcomings in the data collected for this project. Table 4. gives an overview of the experts.

Table 4

By conducting five interviews, we have been able to gain valuable insights into the benefits and obstacles involved in our concept, from a practical point of view. Nevertheless, before incorporating the annotations to our framework, we critically discussed any feedback received in the interview with other researchers.

As a guidance for the semi-structured interviews, we divided the inquiry into three phases. First, to set the stage, the general idea and the purpose of the interview was introduced [50] and the interviewees were asked open questions concerning their understanding of complexity and the related antecedents and manifestations. After gaining a common understanding, we chose a two-staged process to analyze adequacy and comprehensibility. First, the experts analyzed the distinction between subjective and objective level of complexity (Figure 3), to gain a common understanding of the scope. Afterwards the actual framework (Figure 4) was introduced and reviewed with the experts. Finally, we discussed the practical implications and usability of the framework.

General understanding of complexity and problem relevance

All interviews had in common that the experts mainly explained their understanding of complexity by describing different manifestations like e.g. number of people involved (expert 2, 3, 4), interdependencies between systems involved (expert 2, 5), and size of the project (expert 4, 5). Furthermore, they mentioned that the project content as well as the environment of the project need to be considered. Even though the manifestations and general statements did not significantly differ from each other, there was no clear understanding of the overarching aspects of complexity and all experts had difficulties in explaining their concrete perception. Thus, they agreed that it would be useful to gain a common understanding of complexity.

General concept

Expert 2, 3, 4, and 5 agree, that the personal perception of how difficult a task is differs from one person to another. As this personal feeling is not comparable, the experts agree that a differentiation between the subjective difficulty and the objective (or objectified) complexity is a useful step to enable a graspable and comparable assessment of complexity. Nevertheless, as the management of projects is highly influenced by feelings and perceptions, those subjective influences should be regarded in the process of managing a project. Thus, the experts agree that the assessment of objective complexity is a reasonable procedure to gain comparable assessment of projects, if the subjective component is regarded on the management level. Furthermore, the structuring of complexity in a two-dimensional framework including “antecedents” and “project areas” is a reasonable and useful approach, as it is easily applicable in practice according to all experts.

Antecedents of complexity

The most important complexity antecedents from a practical point of view are included in our framework (all experts). In general, the complexity antecedents correspond to reality, especially with regard to interdependency, multiplicity, and diversity. While expert 1 made it clear that an unambiguous distinction between multiplicity and diversity should be maintained, he confirmed that it is possible to understand these distinctions clearly in our framework, due to our definitions of complexity antecedents. However, expert 1 suggested including examples in the descriptions of every complexity antecedent, in order to increase the precision and comprehensibility of the concepts. To follow this advice, we integrated explanatory examples into the definitions for each complexity antecedent.

Even though ambiguity and novelty did not come up in the first thoughts of the experts, they are convinced that it is important to consider those antecedents. While expert 2 was not sure if novelty influences complexity on an objective level, expert 3 and 5 emphasized the influence of novelty on objective complexity especially in case of innovative projects without best practices available. Thus, we decided to remain the antecedent in the framework.

The appraisal of uncertainty as a reinforcing factor on complexity antecedents was confirmed by all experts. As changes can occur in any complexity antecedent, according to the experts it should not be considered as an additional antecedent, but as a reinforcing factor on the other antecedents.

Applicability of project areas

The experts furthermore confirmed that the introduced project areas are appropriate for dividing a project into different segments. For expert 2 it is especially important to consider all aspects within a project. Thus, all areas of a project need to be covered. Within this context, expert 1 emphasized that the importance of project areas can differ for specific projects, which makes it necessary to specify project areas according to the characteristics of the particular project. In this context, the generic level of our project areas was considered advantageous, since it leaves enough latitude to further subdivide and customize them to particular project demands. Nevertheless, all areas need to be clearly delineated, to prevent doubling and overlaps of certain factors.

Validity and utility

The experts generally confirmed that there is a lack of structured methods for the analysis of complexity in practice, although this is a relevant aspect of daily business. By establishing the proposed framework, we strive to provide conceptual clarity regarding the construct of complexity to ease the management of complexity in science and practice. Thus, we discussed with the experts whether the artifact serves these purposes under real-world circumstances [30]. In this context, all experts confirmed that the framework increases the transparency of complexity as it relates the observable manifestations with objective antecedents and project areas and consequently makes complexity more graspable. According to expert 1 it gives structured guidance in considering the relevant aspects, already during project planning, and thus serves as a tool for the ex-ante assessment of complexity. Expert 3, furthermore, highlights that this enables a better management of IT projects, as based on an early complexity assessment more experienced project managers might be allocated to more complex IT projects. In terms of assessment, expert 2, 4 and 5 emphasized that the framework eases the management of complexity, as the provided list of manifestations is able to serve as a reference list to identify the relevant complexity aspects of particular IT projects more easily. Based on this initial assessment of complexity, experts 2-5 consider the highlighting of particular complex project issues as another opportunity of the proposed framework, which enables to properly allocate resources and take actions to avoid or reduce complexity in this particular areas. Furthermore, expert 1 considered the framework to serve as a steering instrument during the lifecycle of a project or as a continuous controlling measure that detects reasons for project failures, like exceeding time or budget. Consequently, based on the feedback of the business experts, we consider the frameworks appropriate to serve its purposes also under real-world circumstances.

However, as already mentioned in Section 3, this evaluation is just a modest first step towards validating the framework. There are several further aspects which need to be investigated in order to validate the framework. This also includes an empirical investigation of the frameworks related hypothesis. Although we already made first efforts to proof the validity of the framework by further (empirical) evaluations, these are currently still topic to further research.

6 Discussion

Based on the conducted interviews, we can derive the following generalizable insights: Although each of the experts seemed familiar with the topic, they all had difficulties in explaining their understanding of complexity. They used manifestations to describe their experiences and perceptions, but were not able to state the overarching aspects of complexity. Thus, we find that that the axiomatic link between the subjective perceptions of complexity hampers a deeper understanding of what conceals underneath the surface in terms of complexity antecedents. Consequently, there is a lack of structured methods for the analysis of objective complexity, although, according to the interviewed expert, these would help to establish a common understanding of complexity by abstracting from subjective perceptions. Furthermore, we find detailed and example-based explanations of complexity with all its terms and descriptions a necessary condition to enable a common understanding between researchers and practitioners.

We, however, also received the feedback (expert 4), that the compilation of such a comprehensive framework from scratch, based on real world data of a particular project would be very time-consuming. Thus, we conclude that the discovered manifestations should be provided as a reference list within the framework, to increase its practicability.

Generally, experienced project managers trust on their gut feelings to handle the complexity in IT projects. Yet, as complexity comprehends various different aspects, we find that it is quite hard for a project manager to consider all aspects of complexity only by gut feeling. In this context, the experts recognized that some of the complexity antecedents which they considered reasonable are usually not considered in project planning. Nevertheless, we find that despite the merits of increased transparency, a framework-introducing research should not be limited to just state the obvious coherences between different complexity aspects. Although the identification and emphasizing of problematic issues is an important first step, the actual added value for practitioners is generated by detecting complexity patterns, revealing recommendations for action and indicating starting points to avoid or reduce complexity.

7 Conclusion

As complexity can be one reason for the failure of IS/IT projects, companies should strive for a clear and unambiguous understanding of IT project complexity. With this in mind, we introduce a concept for the structured assessment of complexity that is particularly relevant to IS/IT projects, as they are considered even more complex than usual projects. In line with the research guidelines provided by Hevner et al. [33], we have followed the DSR approach to develop our concept as an artifact and validate it against literature. We have also improved the artifact by putting it through a design and evaluation cycle [30]. We initially created the framework based on existing literature in the field of complexity. Our two defined dimensions address complexity antecedents and areas where complexity can occur within an IT project. We assigned manifestations of complexity to those dimensions. Based on this validation, our initial framework has been adjusted to subsequently account for 92% of all identified manifestations. Drawing on five semi-structured interviews with experienced project management experts, we evaluate the framework concerning usability and applicability.

Our framework can be equally beneficial for research and practice, as it facilitates comprehension of the concealed aspects of complexity. On one hand, the framework can contribute to future research by analyzing and structuring existing literature to arrive at hypotheses about the causalities of complexity. On the other hand, it can help practitioners understand how complexity can occur within an IT project, as the matrix provides insights into the antecedents of complexity and where it is located within the different areas of an IT project. Additionally, the identification of manifestations from literature can help practitioners to understand the complexity within their IT projects, as the manifestations represent a reference list of aspects that might influence the complexity of a specific application case. Therefore, the framework can be used as an ex-ante evaluation tool to help practitioners identify problems and take adequate mitigating actions prior to a project's implementation, which also includes an adequate allocation of project management capacity. Furthermore, it can be used as a project steering instrument, to help determine appropriate strategies for the better management of complexity during a project, and to counteract the risk of IT project failure.

Nevertheless, the framework is not without limitations. By validating the framework against literature and conducting an expert evaluation, we have ensured its quality and utility in practice. However, the validity of the derived hypotheses concerning the causalities of complexity still need to be empirically tested. We encourage other researchers to empirically test and validate our hypotheses in further research. Overall, our approach provides a framework for assessing complexity with respect to influencing factors, and thus clarifies the construct of IT project complexity. The introduced framework sets a foundation for the development of methods for an active management of complexity. As the quantification of complexity antecedents could support complexity management, it might be interesting to examine the complexity antecedents described in this paper in more detail, considering their quantification and examine what level of complexity is most advantageous. Furthermore, future research should cope with complexity patterns and potential recommendations for complexity mitigation.

Despite its limitations, our study contributes to the current body of prescriptive knowledge regarding complexity assessment by offering a clear and unambiguous structure for complexity. Thus, it provides a first approach to the assessment of IT project complexity, which can be of help to practitioners as well as researchers. Furthermore, it provides a first glance at the causalities of complexity, which have not yet been explored in existing literature.

8 Figures and Tables

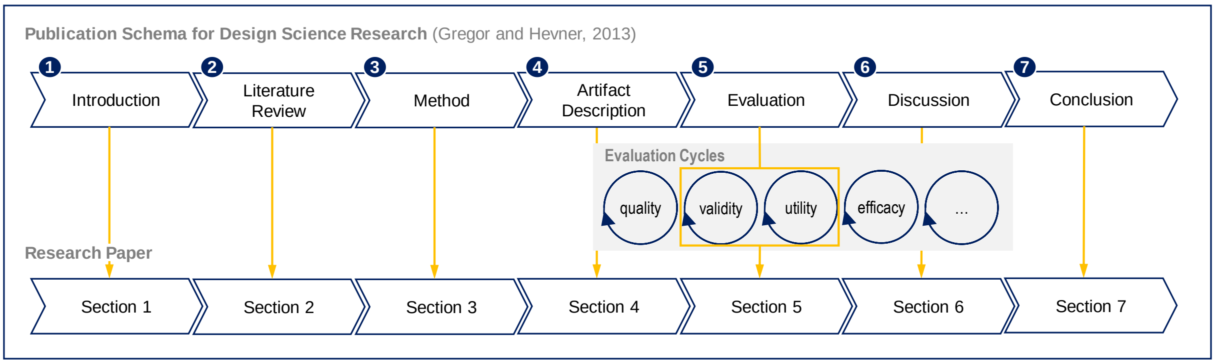

Figure 1. Comparison of research methodology and DSR pattern

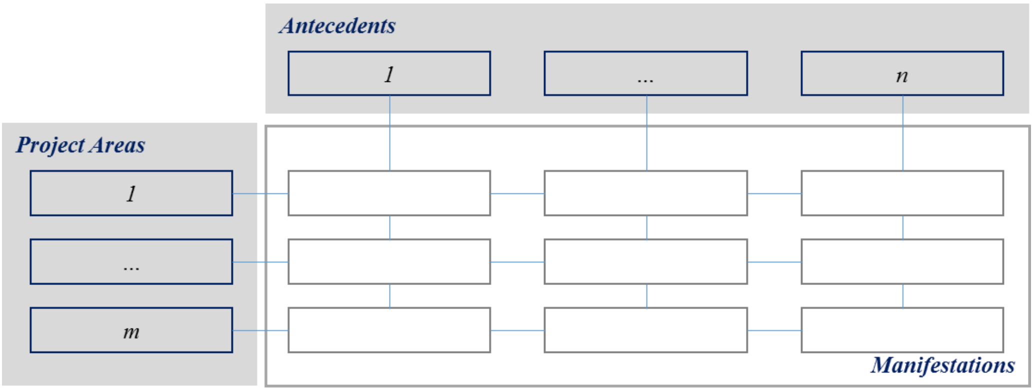

Figure 2. Framework for the assessment of project complexity, including dedicated key terms

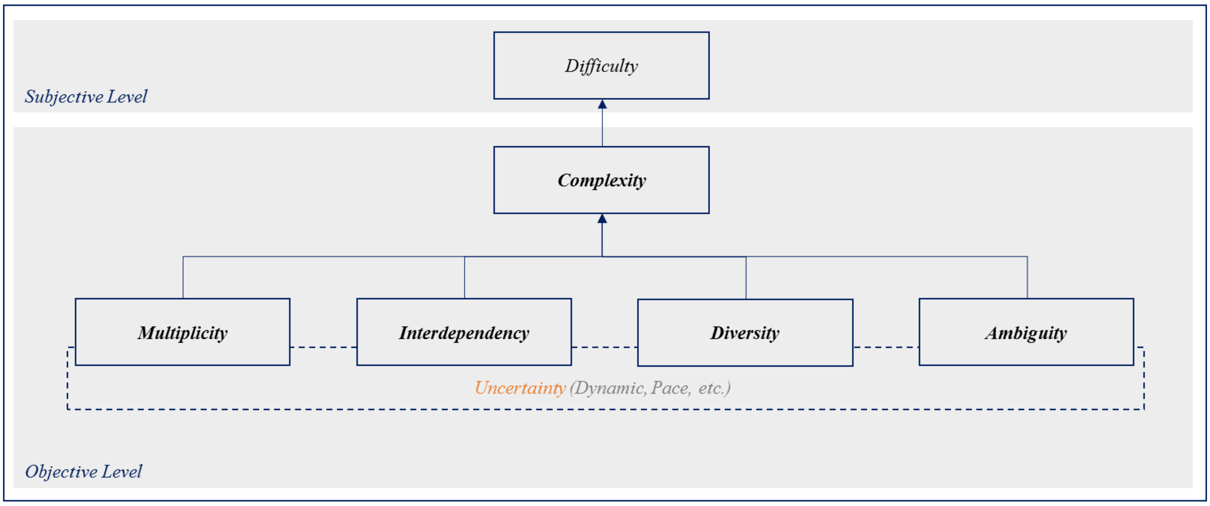

Figure 3 Coherence of complexity characteristics

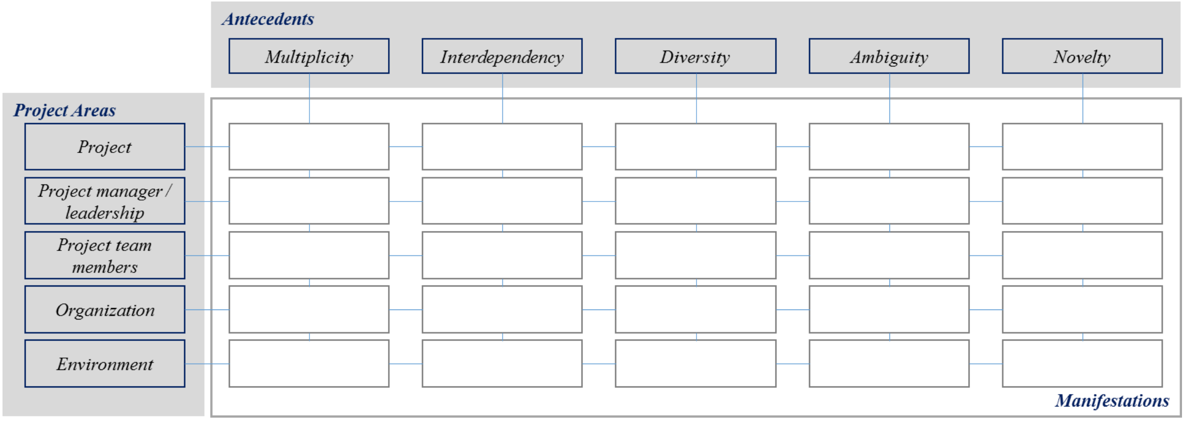

Figure 4. Adjusted framework for the assessment of IT project complexity

Characteristics of complexity	**Distinctness**	**Objectivity**	**Robustness**
Uncertainty	-	✓	-
Difficulty	-	-	✓
Multiplicity	✓	✓	✓
Interdependency	✓	✓	✓
Diversity	✓	✓	✓
Ambiguity	✓	✓	✓

Table 1. Complexity aspects in terms of criteria for complexity antecedents

	Multiplicity	Interdependency	Diversity	Ambiguity
project	**Tasks / transactions** • Number of tasks / actions [3, 10, 26, 36]; • Quantity of organizational subtasks [63]; • High transaction rate [75] • Number of work flow parts [27] • Number of use cases [10] • Number of decisions [36] **Input** • Number of inputs [3, 26] • Number of resources [26, 36] • Computational capacity [36] **Scope / product** • Scope [26, 36] • Breadth of product program [26, 32] • Length of product life cycle [32] • Number of technological elements /infrastructure products, services, requirements / technologies [10, 13, 26, 46] • *Number of embedded software* / information systems [26, 36, 75] • Number of systems to be replaced / data misfit / technical and infrastructural integration [26] **Financial aspects** • Size of financial scale of the project [26, 36, 75] **Output** • Number of outputs / functionalities / product components / deliverables / objectives [3, 10, 26, 36, 52] • Number of possible solutions [26] **Data** • *Amount of real-time data proc*essing [75] • System involves data processing from multiple sites [10, 75]	**Tasks / transactions** • Interrelationship between the activities in schedule [36, 51] • Interdependency between tasks / operations [3, 31] • Interdependency in the workflow [27] • Interdependency of work packages [66] • Interrelations between project phases [36] • Nature of subtask interaction [63] **Input** • Interdependency of inputs [3, 26] • Interdependencies between resources [31, 36] **Scope / product** • Interdependence between scope [26] • Alignment of objectives [36] • Specification interdependence [36, 67] • Interactions of components [10, 11, 11, 52] • Interdependency of technologies / embedded software / systems integration [3, 10, 11, 13, 26, 36] • Interdependency between systems to be replaced / data misfit / technical and infrastructural integration [26] **Financial aspects** • Interdependence of financial scale of the project [26] **Output** • Interdependence of outputs / objectives [26, 36]	**Tasks / transactions** • Diversity of tasks (territory) [3] • Diversity of tasks (technology) [3] • Diversity of tasks (time) [3] • Diversity of parts of the workflow [27] • Variety in the integration of project elements [26] **Input** • Diversity of inputs [3, 26] **Scope / product** • Variety of scope [26] • Variety of goals [31] • Diversity of technologies / embedded software / information systems [26, 36, 46] • Diversity of systems to be replaced / data misfit / technical and infrastructural integration [26] • Variety of technological dependencies [36] • Diversity of products [32] • Degree of customization of the product [26, 36] **Financial aspects** • Diversity of financial scale of the project [26] • Variety of financial resources [36] **Output** • Diversity of outputs [3, 26, 36]	**Tasks / transactions** • Task ambiguity [10, 31] • Level of defined work packages [26] • Number of unknown tasks [26] **Scope / product** • Ambiguity in vision / goals and success criteria [26] • Ambiguity of requirements / goal / scope [26, 31] • Ambiguity of technology [11, 31] **Financial aspects** • Ambiguity of business case [26] • Benefits are intangible [26] **Data** • Ambiguity in availability of relevant project data [26]
Project manager / leadership	**Management** • Length of feedback loops [44] • Number of communication paths [1] • Duration of the project [36]	**Management** • Competing priorities between projects [26] • Interconnectivity and feedback loops in the task [36]	**Management** • Diversity in direct control of project resources [36, 75] • Variety of project management methods and tools [36] **Capabilities** • Diversity of skills needed [36]	**Management** • Ambiguity of performance measurement [26] • Ambiguity of project management methods [26] • Ambiguity of responsibilities [26, 31] • Ambiguity of leadership commitment [26]

	Multiplicity	Interdependency	Diversity	Ambiguity
Project team members	**Structure** • Team size [26, 36] • Number of locations [10, 26] • Amount of person hours required [75] **Capabilities** • Skills of team members [36]	**Structure** • Interdependency between teams [3] • Team cooperation and communication [36, 67] • Interdependency between actors [36]	**Structure** • Diversity of team (locations, time zone, co-location) [3, 26, 31, 36] • Social variety / integration / cultural variety [11, 26, 36] • Variety in culture [36] • Multi-cultural and multi-language [26] **Capabilities** • Variety of skills / cross-functional [26, 75] • Diversity of team (specialist fields) [3] • Variety of knowledge base / multidisciplinary [26, 36] • Variety of empathy and transparency in relationships [26]	**Structure** • Ambiguity in staffing [75] **Capabilities** • Ambiguity of skills of team members (technological, business and project management) [26, 75]
Organization	**Structure** • Number of employees [27] • Number of roles [26] • Number of organizational units / hierarchical levels / teams / groups / departments involved [3, 10, 26, 36] • Number of interfaces in the project organization [36] • Magnitude of organizational subtasks [63] **Processes / technology** • Number of defined processes [26] • Involvement of multiple technology platforms [75] • Number of subsystems [36]	**Structure** • Interdependency between project's elements [3, 67] • Interdependency between subprojects, concurrent projects [26, 44] • Independency between programs [26] • Interdependence between sites, departments and companies [36] **Processes / technology** • *Interdependency with existing processes* [26, 31, 36, 75, 75] • *Interdependency with other systems* [75] • Socio-technical interdependency [31]	**Structure** • Variety of organizational structure [31] • Variety of hierarchical levels within the organization [36] • Variety of organizational interdependencies [36] **Processes / technology** • Number of process types [32] • Variety in process integration [26]	**Structure** • Unclear and ineffective governance structures of the supplier [26] • Ambiguity in the maturity of the organization concerning risk, quality, change management [26] • Nature of organizational subtasks [63] • Ambiguity of top management support [26, 36, 75] • Ambiguity of alignment with institutional configuration [36] **Processes / technology** • Ambiguity with respect to organizational and technological setting [26]
Environment	**Stakeholders** • *Number of customers / user units* [32, 75] • Number of stakeholders [26, 36, 67] • Number of investors [36] • Number of specialties involved (subcontractor, trades) [3, 26, 36, 75] • *Number of external vendors* [75] • Partnership and multi-firm alliances [36]	**Stakeholders** • Interdependency between outsourcing partners [24] • Interdependency of stakeholders [11, 26, 36] **General environment** • Political influence [36] • Dependencies with the environment [36] • Dependency on technology and organization of the environment [36]	**Stakeholders** • Diversity of customers [32] • Variety of geographic location of stakeholders [36, 67] • Variety of interest of stakeholders / status [36, 67] • Variety of stakeholder expectations [10] **General environment** • Level of competition [36] • Diversity of local standards, laws and regulations [36] • Variety of awareness of health, safety, and environment [36] • Variety of weather conditions [36]	**Stakeholders** • Unclear and ineffective governance structures of the client [26] • Unrealistic expectation of stakeholder [26] • Ambiguity of relevant stakeholders [26] • Ambiguity in stakeholders' expectations [26] • *Unclear organizational structure of client* [75]

Table 2 Manifestations of complexity assigned to the initial framework

	Novelty	No antecedent
Project	**Scope / product** • Novelty of project scope [75] • Degree of innovation [36] • Demand of creativity [36] **Technology** • Commercial and technological maturity / novelty [11, 26, 36] • Novelty of technological aspects [10, 26, 75]	**Scope / product** • the project was given a fixed deadline [75] • internal complexity of project elements [10] • lack of robustness of project elements [10] **Input** • availability of resources [36] **Financial aspects** • flexibility of project budget / financial resources [36]
Project manager / leadership	**Capabilities** • Expertise of the project manager concerning leadership, management, authority, technical aspects [36]	
Project team members	**Structure** • No availability of experts [26] • Novelty of project team [26] • **Capabilities** • Experience of the team members [26, 36]	**Structure** • level of trust between actors of the project team [36]
Organization	**Structure** • Novelty of organizational aspects [26] • Novelty of organizational structure [26]	
Environment	**Stakeholders** • Available experience of the stakeholders with management, technology, scope [26] **Environment** • New standards, laws and regulations [36]	**Stakeholders** • intensity of involvement of stakeholders [26] • insufficient support by business users [75] • trust level between stakeholders [36] • conflicts between users involved [75] • significant impact on business if the project failed [75] **Environment** • time to market [36] • significance on the public agenda, public perception [36]

Table 3 Manifestations assigned to project area and antecedent novelty and no antecedent

No.	Current Position	Company	No. of years	Interview Conduct
1	Senior Consultant	Strategy consultancy with focus on European financial sector	8	Telephone
2	Senior Consultant	Strategy consultancy with focus on Swiss financial sector	7	Telephone
3	Junior Partner	Strategy consultancy	7	Telephone
4	IT Project Manager	Global player in the construction industry	7	Video conference
5	Corporate IT Coordinator / Program Manager	Leading supplier of robotics, plants and systems engineering	8	Telephone

Table 4 Summary of details of the interviewees

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