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Research Paper

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ABSTRACT

Research shows that the information systems domain is underrepresented in project complexity as it has only eight percent representation within the project complexity landscape. Emphasis is placed mostly on generic project management and engineering project management. This begs the question of how well IS project complexity is understood in literature? The goal of this research is to perform the groundwork for developing new theoretical foundations for information systems (IS) project complexity by enriching previous work. Complexity theory was applied to develop a comprehensive theoretical model for IS project complexity. The IS project complexity (ISPC) model was developed and revealed that 10 elements underpin the complexity of IS projects. The model expands on previous research by including a larger array of IS project complexity elements and their inherent features. The ISPC also goes beyond the project itself, as it considers elements such as the organization's strategy, resource management, and structure.

Keywords

Project management, information systems, project complexity, complexity factors

INTRODUCTION

Information systems (IS) are evident in organizations across the globe as they now drive and underpin strategic initiatives (Kumar & Sushil, 2015). IS projects are implemented to realize strategic initiatives and hence play an intricate role in realizing business success. Widespread deployment in organizations introduces new levels of complexity where new systems must integrate with older systems while maintaining business continuity (Xia and Lee, 2005). Complexity is further compounded as information technology (IT) and business environments exist in a world where change emerges perpetually (Xia & Lee, 2005). These notions of complexity are not unfounded, as complexity science heralded the age of viewing real-world problems from different epistemological and ontological perspectives (Derbyshire, 2016). Significant growth around project complexity is witnessed in the literature to understand how complexity influences the project management domain (Bakhshi, Ireland, & Gorod, 2016; Daniel & Daniel, 2018; Rolstadås & Schiefloe, 2017). Despite the increase in project complexity exposure, the IS project complexity domain is not well represented when compared to engineering, construction, and general project management domains (Bakhshi et al., 2016). IS project complexity is represented by some ageing works, such as McKeen, Guimaraes, and Wetherbe (1994), Ribbers and Schoo (2002), and Xia and Lee (2005). This research aims to perform the groundwork for developing new theoretical foundations for IS project complexity by expanding and enriching previous work. To unpack IS project complexity further, the following research question is addressed:

- What are the latent constructs of IS project complexity?

This will be accomplished through the development of a comprehensive theoretical model for IS project complexity.

This paper is structured as follows. Section one provides further background and motivation for this research. Section two explores the theoretical foundations and literature around project complexity. Section three discusses the research methodology in terms of research design and data collection, as well as research validity and reliability. The theoretical modelling process is presented in section four, while the research results, discussion and implications are presented in section five. Section six concludes the paper.

BACKGROUND AND MOTIVATION FOR STUDY

IS projects are renowned for underperforming and producing questionable results (Joseph, Erasmus, & Marnewick, 2014; Marnewick, Erasmus, & Joseph, 2016; and The Standish Group, 2014). Bakhshi et al. (2016) show that the IS domain is underrepresented in project complexity, as it has only eight percent representation within the project complexity landscape. Emphasis is placed on generic project management and engineering project management. This begs the question of how well IS project complexity is understood in literature?

McKeen et al. (1994) refer to two complexity dimensions in IS systems complexity, viz., task complexity and system complexity. Task complexity focuses on uncertainty in the user's environment and system complexity centers on uncertainty in the developer's environment. Ribbers and Schoo (2002) argue a different three-dimensional view of IS project complexity, viz., variety, variability, and integration. Variety concerns the number of project elements and their interrelationships, while variability addresses the dynamics around changes during a project's lifecycle. The organization between IS project activities and business resources is understood by the integration dimension. The research of McKeen et al. (1994) and Ribbers and Schoo (2002) argue IS project complexity simplistically, with little interrogation of other possible project complexity constructs.

Xia and Lee (2004) and Xia and Lee (2005) expanded on the previous views and designed a four-dimensional IS development project (ISDP) complexity model. The ISDP model takes an organizational and technological perspective regarding structural and dynamic complexity. Structural organizational complexity (SORG) assesses the IS project's affiliation to the organizational environment in terms of resources, managerial support, and project personnel. Structural IT complexity (SIT) specifically articulates IS project complexity constructs, such as software environments, technology suppliers and platforms. Alternatively, dynamic organizational complexity (DORG) and dynamic IT complexity (DIT) speak to IS project change patterns and rates regarding the organizational and technological environment respectively. A number of latent constructs are evident in the literature of McKeen et al. (1994), Ribbers and Schoo (2002), and Xia and Lee (2005). First, McKeen et al. (1994) exhibit the latent construct of uncertainty, as the study's focus centers on uncertainty in the user's and developer's environment. Second, both Ribbers and Schoo (2002) and Xia and Lee (2005) refer to the concept of change management and how change patterns exist from the organizational and technological perspective. Finally, interrelationships is the third latent construct, as Ribbers and Schoo (2002) argue a connection between project activities and business resources, while Xia and Lee (2005) argue a relationship between organizational and IT resources. Table 1 maps the underlying constructs and literature of IS project complexity. Interestingly, Ribbers and Schoo (2002) and Xia and Lee (2005) do not consider uncertainty explicitly for IS projects, although literature argues for its inclusion when determining project complexity (Project Management Institute, 2017). Conversely, there is common ground regarding the implications of IS project complexity interrelationships and change during IS projects.

Construct	McKeen et al. (1994)	Ribbers and Schoo (2002)	Xia and Lee (2005)
Uncertainty	• Task complexity • System complexity		
Interrelationships		• Variety • Integration	• SORG • SIT
Change management		• Variability	• DORG • DIT

Table 1. IS Complexity Model Comparison and Construct Mapping

Current IS project complexity models present an oversimplified view of the latent constructs in IS projects and thus need further interrogation. Moreover, given the IT and IS landscape's rapid progression, these notions of IS project complexity are over a decade old and require revision.

The goal of this research is to develop a theoretical model for IS project complexity through a more holistic perspective. This is achieved by following the logic of complex systems where a phenomenon's constructs are identified comprehensively prior to understanding their applicability and relationships (Gorzeń-Mitka & Okręglicka, 2014; Holland, 1995; Markovsky, 1998).

LITERATURE REVIEW

Theoretical foundations serve as a means to encapsulate and contextualize research problems. As part of this research's endeavor to investigate the latent constructs of IS project complexity comprehensively, the theoretical lens of complexity theory is adopted.

Complexity Theory as a Theoretical Foundation

Complexity theory has proliferated across multiple research domains, as it provides a theoretical lens to illuminate research problems (Aritua, Smith, & Bower, 2009; Cooke-Davies, Cicmil, Crawford, & Richardson, 2007; Zhu & Mostafavi, 2017). Goulielmos (2005, p. 533) asserts that complexity theory facilitates the conversion of "*the chaotic and complicated into something simple and amenable to understanding.*" Kauffman (1995, p. 299) argues that "*we lack a theory of how the elements of our* *public lives link into webs of elements that act on one another and transform one another.*" Complexity theory is a paradigm shift, as it argues that the various elements around us depend on each other to realize a common goal (Battram, 1998). Furthermore, complex problems can be articulated through the application of complexity theory, as it facilitates enlightenment and solution development (Smith & Graetz, 2006).

Complexity theory is witnessed through the following characteristics:

- Analyzability: phenomena are understood by identifying the elements that underlie them. The aim is to enable a simplified understanding of the phenomenon in question (Smith, 2005; Taborsky, 2014). Questions regarding how a phenomenon functions and could function can, therefore, be answered through complexity theory (Dent, 1999; Fitch & Jagolino, 2012).
- Reductionism/Decomposability: complexity theory applies the concept of analyzability and acts as a simplifier through reductionism (Dent, 1999; Phelan, 1999). This occurs by deconstructing phenomena into comprehensible elements and tracing interactions based on patterns and relationships (Fitch & Jagolino, 2012; Taborsky, 2014). A reductionist approach allows complexity theory to "*generate simple outcomes*" that can be interpreted easily at a practical level (Smith, 2005, p. 24).
- Exploratory analysis: a phenomenon's latent relationships and aggregate behavior are hypothesized and explored through analysis and reduction (Phelan, 1999). Aggregated behavior hypotheses facilitate simple explanation of phenomena and provide an overview of the phenomenon in question. Although complexity theory does not provide extensive detail of phenomena, it does provide an accurate explanation and description through exploratory analysis (Fitch & Jagolino, 2012).
- Element interaction through simple rules: a key concept of complexity theory is that interactions within a phenomenon are governed by simple rules (Dent, 1999; Phelan, 1999). Phelan (1999) and Phelan (2001) assert that complexity theory aggregates complex behavior into simple rules which dictate how elements interact, as this provides the basis for understanding relationships and dependencies of phenomena.

The application of the four characteristics above epitomizes the theoretical foundations of complexity theory. Project management is a domain where the relevance and applicability of complexity theory are becoming more evident (Daniel & Daniel, 2018; Padalkar & Gopinath, 2016). In order to build and expand on the constructs of IS project complexity, the constructs of general project complexity must be explored.

Exploring the Underlying Constructs of Project Complexity

The notion of project complexity is a widely debated topic in literature (Baccarini, 1996; Bakhshi et al., 2016; Cooke-Davies et al., 2007; Floricel, Michela, & Piperca, 2016; Geraldi, Maylor, & Williams, 2011; Geraldi & Adlbrecht, 2007; Vidal & Marle, 2008; Vidal, Marle, & Bocquet, 2007; Whitney & Daniels, 2013; Williams, 1999). Geraldi et al. (2011, p. 967) assert the importance of organizations and individuals understanding how to "*deal with complexity*". Seminal work such as Baccarini (1996, p. 201) argues that "*complex projects demand an exceptional level of management, and that the application of conventional systems developed for ordinary projects have been found to be inappropriate for complex projects*".

Bakhshi et al. (2016) draws on the Cynefin framework of Snowden (2002) and contends that projects should be viewed from a hierarchical perspective of either simple, complicated, complex, or chaotic prior to investigating project complexity. Simple projects exhibit limited activities, with clearly and easily articulated relationships (Bakhshi et al., 2016). Complicated projects consist of simple projects, with areas requiring further knowledge and expertise to develop appropriate practices to handle project complications (Snowden & Boone, 2007). Alternatively, complex projects are ambiguous, uncertain, interdependent, and non-linear, with emergent attributes and variable restrictions. Chaotic projects have problems which require innovative techniques, as the variables are not always clearly evident and are mostly hidden, i.e., multiple latent variables exist (Oehmen, Thuesen, Ruiz, & Geraldi, 2015). Bakhshi et al. (2016, p. 1201) argue, however, that projects rarely fit into a specific classification, as they often "*lie somewhere along the spectrum."*

Project complexity literature has revealed multiple views regarding the constructs of the concept. Literature sources from over two decades were assimilated in Table 2 to illustrate the five prevalent constructs in general project complexity. Comparable underlying elements and features were identified, understood, and logically mapped where different terms and categories were used in literature. The technical, organizational, and environmental (TOE) framework of Bosch-Rekveldt, Jongkind, Mooi, Bakker and Verbraeck (2011) served as the basis for classifying project complexity constructs. To ensure that a wide spectrum of project complexity was investigated, two constructs were added to the analysis of project complexity, viz., uncertainty and dynamics.

Literature Source	Organizational Complexity	Technical Complexity	Environmental Complexity	Uncertainty	Dynamics
Baccarini (1996)	✓	✓			
Williams (1999)	✓			✓	
Remington and Pollack (2007)	✓	✓	✓	✓	✓
Vidal and Marle (2008)	✓	✓	✓		
Bosch-Rekveldt et al. (2011)	✓	✓	✓		
Geraldi et al. (2011)	✓	✓	✓	✓	✓
Senescu, Aranda-Mena and Haymaker (2013)	✓	✓	✓		
Dunović, Radujković and Škreb (2014)	✓		✓	✓	
Bakhshi et al. (2016)	✓	✓	✓	✓	
Floricel et al. (2016)	✓	✓	✓		

Table 2. Project Complexity Constructs Mapped across Expanded Literature Sources

The following sections discuss the elements and features of each construct.

Organizational Complexity

Although projects are considered standalone initiatives in an isolated context, organizational complexity must be taken into consideration as the organization itself heavily influences the execution of projects (Baccarini, 1996; Bosch-Rekveldt et al., 2011). Table 3 shows that organizational complexity was found to consist of eight elements, each with multiple features.

Construct	Element	Feature	Variable Name
Organizational complexity	Vertical differentiation	Organizational structure	OC_01
	Horizontal differentiation	Organizational units	OC_02
		Task structure	OC_03
	Size	Project duration	OC_04
		Variety of methods and tools	OC_05
		Capital expenditure	OC_06
		Work hours	OC_07
		Project team	OC_08
		Site area	OC_09
		Number of locations	OC_10
	Resources	Project drive	OC_11
		Resource and skills availability	OC_12
		Experience with involved parties	OC_13
		Health, safety, security and environment (HSSE) awareness	OC_14
		Interfaces between different disciplines	OC_15
		Number of financial resources	OC_16
		Contract types	OC_17
	Project team	Number of different nationalities	OC_18
		Number of different languages	OC_19
		Cooperation with joint-venture partner	OC_20
		Overlapping office hours	OC_21
	Trust	Trust in project team	OC_22
		Trust in contractor	OC_23
	Risk	Organizational risks	OC_24
	Interdependencies	Environmental dependencies	OC_25
		Resource sharing	OC_26
		Schedule dependencies	OC_27
		Interconnectivity and feedback loops in task and project networks	OC_28

		Dependencies between actors	OC_29
		Information systems dependencies	OC_30
		Objective dependencies	OC_31
		Process interdependencies	OC_32
		Stakeholder interrelations	OC_33
		Team cooperation and communication	OC_34

Table 3. Underlying Organizational Complexity Elements and Features

The element of vertical differentiation focuses on the depth of the organizational structure employed (Baccarini, 1996). Baccarini (1996) refers to the next element as horizontal differentiation, where the organizational units and task structure are emphasized. There is a relationship between the two, as the task structure is dependent on the unit's function. The concept of size is presented as the third element and refers to the tangible quantity and scale of a project. This would include features such as project duration, cost, tools and methods, as well as team size (Bosch-Rekveldt et al., 2011; Vidal & Marle, 2008; Xia & Lee, 2004). Resources serve a key role in any project. Strategic intent and support influence the allocation of capital and skills directly, while facilitating alignment between resources (Baccarini, 1996; Cui, Ye, Teo and Li, 2015; Floricel et al., 2016). Although the project team size influences project complexity, the project team element targets the intricacies of the team itself. Geographically dispersed teams have become commonplace and bring along challenges such as language, cultural variations, and overlapping operating hours (Bosch-Rekveldt et al., 2011; Floricel et al., 2016; Geraldi et al., 2011).
Trust is an underestimated social construct which plays a key role in projects (Killen & Kjaer, 2012; Smyth, Gustafsson, & Ganskau, 2010). A strong level of trust should exist among all team members and contractors to ensure the project runs as smoothly as possible. The risk element is inevitable, as organizational risks feed directly into projects (Bosch-Rekveldt et al., 2011). The final element concerns project interdependencies, as it explicitly notes that no element exists in isolation as they are dependent on each other to a certain degree (Brady & Davies, 2014; Padalkar & Gopinath, 2016; Senescu et al., 2013; Vidal, Marle & Bocquet, 2011).

Technical Complexity

Technical complexity was defined initially as technological complexity but was later reclassified, as it places more emphasis on technical project complexity elements rather than technological elements only (Baccarini, 1996; Bosch-Rekveldt et al., 2011; Floricel et al., 2016). Six underlying elements are present in technical complexity, as per Table 4.

Construct	Element	Feature	Variable Name
Technical complexity	Differentiation	Number and diversity of inputs and/or outputs	TC_01
	Goals	Number of goals	TC_02
		Goal alignment	TC_03
		Clarity of goals	TC_04
	Scope	Scale of scope	TC_05
		Quality requirements	TC_06
	Tasks	Number of tasks	TC_07

		Variety of tasks	TC_08
		Conflicting norms and standards	TC_09
	Experience	Newness of technology	TC_10
		Experience with technology	TC_11
	Risk	Technical risks	TC_12

Table 4. Underlying Technical Complexity Elements and Features

From a technical perspective, projects are process-driven and thus include the input/output differentiation element. Inputs and outputs are required throughout a project, as there are procedural constraints to abide by (Baccarini, 1996). The second element takes an in-depth look at how the project goals and objectives are defined to ensure they are not unrealistic and are aligned to strategic goals (Patanakul, Pinto, & Pinto, 2016; Tatikonda & Rosenthal, 2000). The project scope element focuses on the requirements of the engineering process and in understanding the scale of the project to ensure quality outcomes are delivered (Bosch-Rekveldt et al., 2011; Mirza, Pourzolfaghar and Shahnazari, 2013). Tasks underpin the execution of any project and this element speaks to the number and variety tasks as well as project management standards and policies that impact complexity (Baccarini, 1996; Senescu et al., 2013). Technological experience is a separate entity compared to the initial definition of technical complexity. The element concerns the newness of technology and experience with technology (Bosch-Rekveldt et al., 2011; Thomé, Scavarda, Scavarda, & Thomé, 2016). Like organizational risks, technical risks exist, with emphasis on technological risks (Schwalbe, 2013).

Environmental Complexity

Projects are subjected to volatile internal and external environments which have a direct and indirect impact on complexity. This construct has four underlying elements as shown in Table 5.

Construct	Element	Feature	Variable Name
Environmental complexity	Stakeholders	Number of stakeholders	EC_01
		Variety of stakeholder perspectives	EC_02
		Political influence	EC_03
		Internal support	EC_04
		Required local content	EC_05
	Location	Interference with existing site	EC_06
		Weather conditions	EC_07
		Remoteness of location	EC_08
		Experience in country	EC_09
	Market conditions	Internal strategic pressure	EC_10
		Stability of project environment	EC_11
		Level of competition	EC_12
	Risk	Environmental risks	EC_13

Table 5. Underlying Environmental Complexity Elements and Features

Stakeholders support and drive a project, which results in multiple internal and external stakeholders being intertwined, as they vary in perspectives and influence (Geraldi et al., 2011; Vidal & Marle, 2008). The physical project location is generally an element which is considered ad-hoc or on-the-fly during project execution, but project site interference and remoteness are real complexity concerns (Hanna, Vanclay, Langdon, & Arts, 2016; Nguyen, Nguyen, Le-Hoai, & Dang, 2015). Bosch-Rekveldt et al. (2011) and Dunović et al. (2014) contend that projects exist within a market domain and are influenced by features, such as strategic pressure, competition, and market experience. Each of these elements exhibits risks which need to be considered; hence, the inclusion of environmental risks as well (Thomé et al., 2016).

Uncertainty

Ignoring the possibility of uncertainty is foolish because certainty is unlikely in project management (Williams, 1999). Project Management Institute (2017) argues that all projects are unique, as there are multiple uncertainties during their lifecycles. Although uncertainty could pertain to the constructs and elements above, the literature focuses on six uncertainty elements (Table 6).

Construct	Element	Feature	Variable Name
Uncertainty	Triple constraint	Uncertainties in scope	U_01
		Uncertainties in cost	U_02
		Uncertainties in time	U_03
	Activity	Uncertainty in methods	U_04
		Task uncertainty	U_05
	Goals	Uncertainty of goals and objectives	U_06
	Technology	Technological maturity and novelty	U_07
	Stakeholders	Undisclosed participants	U_08
		Competency	U_09
	Information	Incomplete information	U_10

Table 6. Underlying Project Complexity Uncertainty Elements and Features

The triple constraint of time, cost, and scope are debated ad nauseam in literature, as this element is considered a key area affecting overall project success (Remington & Pollack, 2007; Thomé et al., 2016). There are continuous calls for good project planning practices to mitigate activity uncertainty, yet, this continues to occur as project method confusion arises and leads to task ambiguity (Conforto, Amaral, da Silva, Di Felippo, & Kamikawachi, 2016; Tatikonda & Rosenthal, 2000). Uncertainty also relates to the element of project goals and objectives, where clarity is called for (Dunović et al., 2014; Geraldi et al., 2011). Technological uncertainty is a somewhat different element, as technology progresses at an exponential rate, thus placing reliance on the experience of the project team. Competency and undisclosed participants are addressed in the stakeholder uncertainty element, as the emphasis is placed on knowledge and skill availability (Geraldi et al., 2011; Marnewick et al., 2016; Maylor, Vidgen, & Carver, 2008). The final element centers on information incompleteness, where incorrect or poor information is used during a project (Geraldi et al., 2011; Maylor et al., 2008).

Although uncertainty exists, agile practices have become more evident in project management to mitigate the threat of uncertainty, given its more adaptive approach (Whitney & Daniels, 2013).

Dynamics

Change management is the core of the dynamics construct, as key aspects pertaining to change management are included (Table 7). The process of implementing and managing change is pivotal (Whyte, Stasis, & Lindkvist, 2016). The number, frequency, and impact of changes as well as change over time are emphasized, as they are key to measuring and monitoring project changes (Geraldi et al., 2011; Geraldi & Adlbrecht, 2007; Muller, Geraldi, & Turner, 2012). Scope of changes rounds up the change management element, as it provides a qualitative view of project change (Brady & Davies, 2014; Xia & Lee, 2004). The dynamics around change are more apparent in agile environments where continuous assessment and delivery redefine how change is managed (Schön, Thomaschewski, & Escalona, 2017).

Construct	Element	Feature	Variable Name
Dynamics	Change management	Change process	D_01
		Number of changes	D_02
		Scope of changes	D_03
		Frequency of changes	D_04
		Impact of changes	D_05
		Change over time	D_06

Table 7. Underlying Project Complexity Elements and Features of Dynamics

Knowledge around project complexity reveals varying views, as literature discusses multiple constructs and variables surrounding the concept (Bakhshi et al., 2016; Bosch-Rekveldt et al., 2011). The current epistemological stance of project complexity shows arguably that current literature is arbitrary and vague regarding what constitutes IS project complexity. After surveying 420 project complexity research papers from 1990 – 2015, Bakhshi et al. (2016) revealed that only eight percent of papers focus on the IS project complexity domain. IS project complexity research, therefore, lacks depth and requires further knowledge building. The reality is that the dated IS project complexity models of McKeen et al. (1994), Ribbers and Schoo (2002), and Xia and Lee (2005) require revision and expansion, especially given the rapidly changing environment of IT and IS. The following research question is formulated:

- What are the latent constructs of IS project complexity?

In the IS project complexity context, complexity theory argues that a holistic view must be taken and all possible project complexity constructs must be explored to determine their applicability within this domain. Furthermore, exploring a wide range of constructs assists with reducing and interpreting them at a practical level in the IS project complexity space. This research subsequently adopts and investigates the five constructs of organizational complexity, technical complexity, environmental complexity, uncertainty, and dynamics within the IS project context. Each construct's features are analyzed to determine the latent constructs of IS project complexity.

RESEARCH METHODOLOGY

Research Design

The post-positivist theoretical lens was adopted for this research, as it allows the researcher to investigate and approximate reality and truth by identifying latent laws pertaining to the phenomenon (Serrador & Turner, 2015). Subjective opinion informs results regardless of data collection mechanism, and post-positivism facilitates this as it acknowledges that although the perfect truth cannot be achieved, the results are useful for knowledge generation.

Data Collection

Post-positivists apply quantitative data collection methods predominantly, such as experiments and surveys, as this enables the statistical analysis of relationships among data (Joslin & Müller, 2015; Tashakkori & Teddlie, 2009). This research collected data using a survey in the form of a questionnaire. Questionnaires allow respondents to provide their subjective opinion which can be analyzed statistically and modelled by the researcher. The questionnaire included four sections: (i) biographical information, (ii) project information, (iii) project success, and (iv) project complexity. The project complexity section was developed based on the constructs and features presented in Tables 3 to 7. Respondents were asked to indicate their view of the complexity of the project with regards to each feature, using the following Likert scale: (1) simple, (2) relatively simple, (3) fairly complex, (4) complex, and (5) very complex.

Non-probability sampling in the form of snowball sampling was applied in this research. A total of 617 responses were gathered. The questionnaire was posted on SurveyMonkey, and the link was emailed to various parties for distribution, using the snowball technique. IS project leadership was considered the unit of analysis, where the sample included, *inter alia,* project managers, portfolio managers, program managers, project team leaders, IT managers, and business analysts. No preference was given to the industry in which the sample existed, as the aim was to provide varying perspectives of IS projects in multiple industries. These perspectives could be articulated and quantified to provide a holistic understanding of IS project complexity. Table 8 provides an overview of the demographic results.

Characteristic	**N**	**%**	**Characteristic**	**N**	**%**
Position			*Industry*		
Assistant project manager	25	4.1	Agriculture	2	0.3
Project coordinator	23	3.7	Energy	23	3.7
Project manager	115	18.6	Building & Construction	18	2.9
Senior project manager	80	13.0	Healthcare	22	3.6
Project leader	40	6.5	Wholesale & Retail	23	3.7
Program manager	37	6.0	Logistic Services	31	5.0
Portfolio manager	27	4.4	Financial Services	220	35.7
Project implementation manager	14	2.3	Facility & Real Estate Services	11	1.8
IT manager	59	9.6	Legal Services	5	0.8
Business analyst	66	10.7	HR Services	12	1.9
Project management consultant	10	1.6	ICT & Communication Services	126	20.4
Iteration manager	21	3.4	Public Administration	75	12.2

Other	98	15.9	Education & Training	45	7.3
Total	615	99.7	Total	613	99.4
Missing	2	0.3	Missing	4	0.6
Domain			*Project type*		
General management	43	7.0	Infrastructure	89	14.4
Commercial management	12	1.9	Customization	70	11.3
Financial management	45	7.3	Integration	69	11.2
IT management	210	34.0	System Implementation - Full	277	44.9
P3 Management	135	21.9	System Implementation - Upgrade	102	16.5
Business development	32	5.2	Total	607	98.4
Consulting	81	13.1	Missing	10	1.6
Training / Education	23	3.7			
Other	34	5.5			
Total	615	99.7			
Missing	2	0.3			

Table 8. Respondent Demographics

Validity and Reliability

Content and construct validity were achieved through the application of literature spanning multiple years and covering project complexity from various views. Consulting these sources allowed the researchers to develop a comprehensive take on project complexity constructs and apply them to IS projects.

Reliability was determined using Cronbach's alpha for each project complexity dimension as well as all dimensions aggregated (Table 9). All reliability readings were above the threshold of 0.6, which is deemed acceptable in the literature, as it makes provision for results which are marginally below the common threshold of 0.7 (Badewi, 2016; Chow & Cao, 2008; Hair, Black, Babin, Anderson, & Tatham, 2006).

Complexity dimension	**Cronbach alpha results**
Organizational complexity	0.936
Technical complexity	0.904
Environmental complexity	0.876
Dynamics	0.883
Uncertainty	0.898
Five dimensions aggregated	0.970

Table 9. Reliability Test and Results

INFORMATION SYSTEM PROJECT COMPLEXITY THEORETICAL MODELLING PROCESS

Exploratory Factor Analysis Process

The aim of exploratory factor analysis (EFA) is to identify underlying latent variables inherent in the observed variables. EFA was adopted as it aligns to the notion of exploratory analysis within complexity theory and it enables relationship aggregation through analysis and reduction. The EFA process applied in this paper is based on various other works (Blunch, 2013; Boomsma, 2000; Gaskin, 2016a; Kaplan, 2009). Prior to performing EFA, data preparation must occur.

Data preparation includes data screening, data codification, blank response handling, and data file preparation. Non-essential data was deleted while remaining data was codified in preparation for data file preparation. Questionnaires with completion rates of less than 25% were removed, as they could distort the analysis. Codification involved assigning each feature a variable name. The initial dataset included 617 responses, but was reduced to 558 once incomplete responses were removed. Data file preparation focused on combining all data into a single SPSS file, which was used for EFA.

The EFA process required multiple adequacy, convergent validity, and discriminant validity tests to determine EFA validity. Measuring the Kaiser-Meyer-Olkin (KMO) was the first adequacy test, and the result was 0.917. This was accepted, as there is a consensus that values above 0.9 are excellent (Field, 2009; Gaskin, 2016b; Kaiser, 1974). Furthermore, the KMO was significant at 0.000, which further validates the first adequacy measure (Gaskin, 2016b). Extraction values in the communalities table were assessed as the second adequacy measure. All extraction values were above the threshold of 0.3, as defined by Gaskin (2016b). The third adequacy test assessed the total variance explained. The cumulative result was 57.976%, and is above the minimum acceptable level of 50% (Gaskin, 2016b; Reio & Shuck, 2015). The final test was to assess the non-redundant residuals of the EFA. The result was 3% and less than the threshold of 5% (Gaskin, 2016b).

The pattern matrix (Table 10) was used to assess convergent validity. The factor loadings are required to be above 0.5 and an average loading within the factor of above 0.7 (Ferguson & Cox, 1993; Gaskin, 2016b; Hair et al., 2006). Cronbach's alpha was used to further validate loadings below 0.5 and averages below 0.7 (Gaskin, 2016b). The same Cronbach's alpha criterion (> 0.6) used to determine instrument reliability was applied during the EFA process. Factors 1, 3, 4 and 7 exhibited average loadings lower than 0.7 but were validated by their respective Cronbach alpha values. The remaining factors' Cronbach values are represented in brackets alongside the factor number (Table 10).

Pattern Matrix										
*Observed Variable	Factor (Cronbach alpha)									
	1 (0.880)	2 (0.871)	3 (0.883)	4 (0.771)	5 (0.795)	6 (0.803)	7 (0.746)	8 (0.849)	9 (0.831)	10 (0.685)
OC_01								.779		
OC_02								.835		
OC_08				.511						
OC_09				.989						
OC_10				.639						
OC_11				.479						
OC_12										.736

OC_13										.690
OC_26	.421									
OC_27	.591									
OC_28	.733									
OC_29	.720									
OC_30	.854									
OC_31	.751									
OC_32	.694									
OC_33	.535									
TC_02									.510	
TC_03									.898	
TC_04									.718	
TC_10					.909					
TC_11					.797					
TC_12					.450					
EC_01						.849				
EC_02						.702				
EC_03						.663				
EC_07							.616			
EC_08							.773			
EC_09							.587			
U_01		.742								
U_04		.751								
U_05		.835								
U_06		.731								
U_07		.628								
U_08		.616								
U_10		.620								
D_01			.505							
D_02			.967							
D_03			.772							
D_04			.742							
D_05			.526							
D_06			.485							
Average Loading	.662	.703	.666	.654	.719	.738	0.659	.807	.709	.713

Table 10. EFA Pattern Matrix

Discriminant validity was achieved by eliminating cross-loadings above 0.33 (Ferguson & Cox, 1993; Reio & Shuck, 2015). Discriminant validity was also ensured by assessing the factor correlation table (Table 11). The factor correlation matrix shows common variance among factors, viz., to the extent the factors are related to each other (Field, 2009). Discriminant validity was confirmed, as there were no correlations above 0.7 (Gaskin, 2016b).

Factor Correlation Matrix										
Factor	1	2	3	4	5	6	7	8	9	10
1	**1,000**	,503	,664	,426	,598	,624	,288	,309	,598	,439
2	,503	**1,000**	,544	,435	,392	,432	,287	,283	,478	,294
3	,664	,544	**1,000**	,550	,554	,554	,224	,434	,547	,384
4	,426	,435	,550	**1,000**	,337	,484	,414	,316	,523	,322

5	,598	,392	,554	,337	**1,000**	,374	,254	,196	,512	,372
6	,624	,432	,554	,484	,374	**1,000**	,259	,269	,554	,256
7	,288	,287	,224	,414	,254	,259	**1,000**	,199	,315	,239
8	,309	,283	,434	,316	,196	,269	,199	**1,000**	,300	,257
9	,598	,478	,547	,523	,512	,554	,315	,300	**1,000**	,427
10	,439	,294	,384	,322	,372	,256	,239	,257	,427	**1,000**

Table 11. EFA Factor Correlation Matrix

INFORMATION SYSTEM PROJECT COMPLEXITY MODEL RESULTS AND DISCUSSION

Model Results and Analysis

A total of 5 constructs, 25 elements, and 75 features underpinned project complexity, as per the literature review. The EFA, however, revealed that 10 elements and 41 features specifically underpin IS project complexity. This reduction adheres to the principles and application of complexity theory in the IS project complexity domain. Appendix A indicates which variables were removed from the EFA process, as this will advise irrelevant and, arguably, trivial IS project complexity features. Figure 1 illustrates the IS project complexity (ISPC) theoretical model based on the results of the EFA.

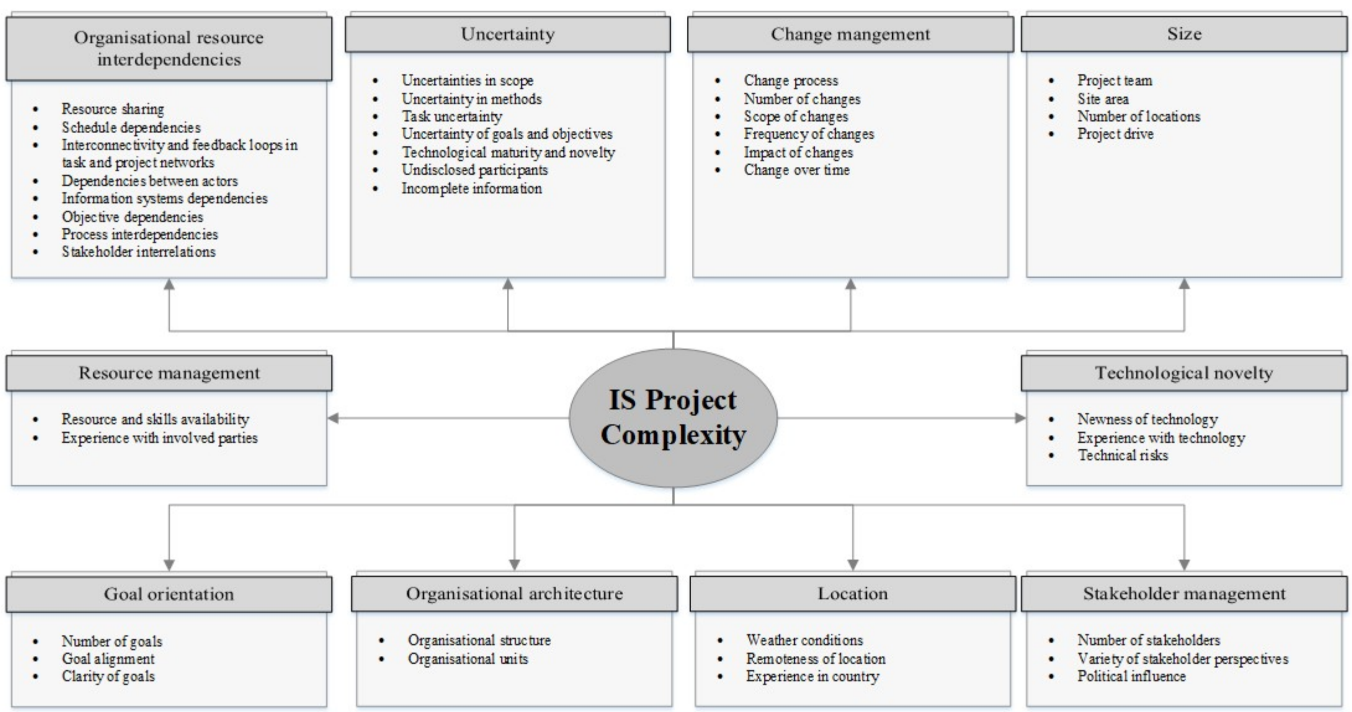

Figure 1. IS Project Complexity Theoretical Model

The naming of each factor was achieved deductively by evaluating the features supporting the factor in question. The factor names were subsequently adopted as the names for the latent constructs of IS project complexity. The ten constructs were classified as follows:

1. Organizational resource interdependencies – this construct consisted specifically of features which are associated with the interdependencies between the internal organization resources required to deliver an IS project. The dependencies primarily centered on the project constraints, activities, processes, and stakeholders of IS projects.
2. Uncertainty – IS project complexity has a strong uncertainty representation as revealed through the uncertainty construct. IS project complexity uncertainties exist with regards to methods, tasks, technology, undisclosed participants, and incomplete information. Interestingly, the ISPC model only considers uncertainties around IS project scope as relevant since time and cost uncertainties were removed during the modelling process.
3. Change management – the features represented in the dynamics construct (Table 7) were assigned directly to the change management construct during the modelling process. This arguably confirms that change management is an important IS project complexity construct to consider. Although not tested directly in this research, change management is important in IS projects which adopted a waterfall or agile methodology, as these projects evolve continuously during their lifespan.
4. Size – measuring and quantifying the size of the IS project team as well as the site area and number of locations is the basis of the size construct. Project teams should be structured and sized accordingly to enable efficient IS project delivery. Furthermore, a project's site area and number of locations influence the management of various project resources. The inclusion of the project drive in this construct implies that IS projects need to understand the project drive in terms of the strategic resources available to facilitate project delivery.
5. Technological novelty – this construct speaks to the technological risks associated with employing new technology in an IS project and experience with old, current, or new technology. The inherent technological nature of IS projects implies that complexities will arise as organizations search for a competitive advantage through the adoption of technology. Poor articulation of technology, whether old, current, or new can lead to expenditure wastage and unrealized business goals.
6. Stakeholder management – IS project complexity in terms of stakeholders is evident in this construct. Understanding the number of stakeholders is important as well as their varied interests and perspectives of how the project will benefit them. These individuals also have varying levels of political power and could use this to influence the management and outcome of IS projects. The ISPC model thus concedes that bureaucratic constraints can influence the delivery of IS projects.
7. Location – IS projects are not restricted to urbanized areas and are thus susceptible to location constraints. Simple considerations such as weather conditions and remoteness of the location contribute to the level of complexity. Furthermore, concerns around the team's experience when working on a geographically dispersed project is another complexity to be aware of.
8. Organizational architecture – this construct focuses on the structure and division of units in the organization. The structure impacts the flow of information and interaction of stakeholders directly during the IS project. Understanding these structures is essential to ensure effective management during the project.
9. Goal orientation – IS projects are governed and informed by the strategic intent of the organizations. This construct argues that complexities arise in terms of the number of goals, goal alignment, and clarity of goals. Project goals must be clear and concise, as this facilitates

alignment between them. Furthermore, ambiguously defined IS projects result in multiple goals which attempt to achieve too much and thus result in poor outcomes.

10. Resource management – the final construct identified is resource management. This speaks specifically to the availability of resources and skills needed to deliver an IS project. Furthermore, the construct also posits that it is important to identify what experience exists in terms of stakeholder interactions. Building a new rapport is more challenging than leveraging existing relationships.

Model Discussion and Comparison to Previous Studies

The ISPC model and the McKeen et al. (1994) view of IS project complexity

Current IS project complexity models have a narrow view regarding the concept. McKeen et al. (1994) focused specifically on user participation and system success, viz., user influence, communication, participation, and satisfaction. The ISPC model represents these more granularly through the features of organizational resource interdependencies, uncertainty, stakeholder management, and resource management. Within organizational resource interdependencies, user participation features include interconnectivity and feedback loops, actor dependencies, and stakeholder interrelations. Uncertainty features include task uncertainty and undisclosed participants. Stakeholder management and resource management are included in their entirety. User interaction is commonly referred to as a key concern for IS projects, as true success can be determined by how these individuals use the project output. The ISPC model expands on the McKeen et al. (1994) model by articulating more features relating to user participation as well as determining latent complexities.

The ISPC model and the Ribbers and Schoo (2002) view of IS project complexity

Ribbers and Schoo (2002) investigated IS project complexity with regard to enterprise resource planning (ERP) solutions. Three dimensions were evident: (i) variety, (ii) variability and (iii) integration. In particular, variety highlighted location and project experience features. The ISPC model embraces these features within technological novelty, location, and resource management. Technological novelty addresses experience regarding technology (new or old) while resource management addresses experience regarding parties involved during the IS project. Location is analogous to location complexity concerns within the variety dimension.

Similarly, comparison between the ISPC model and the variability dimension also exists. Variability concerns resource availability, team competency, project dependencies, as well as goal and scope changes. These concerns are embraced in organizational resource interdependencies, resource management, uncertainty, change management, and goal orientation. Resource management covers resource availability and team competency in resource and skills availability. Project dependencies focus on dependencies between concurrent projects, which is addressed by features schedule dependencies and process interdependencies in organizational resource interdependencies. Goal and scope changes are inherent in IS projects and the ISPC model further endorses this notion through the following inclusions: uncertainty in scope and of goals and objectives (uncertainty); number of changes, scope of changes, and impact of changes (change management); number of goals, goal alignment, and clarity of goals (goal orientation).

Integration dimension addresses the integration of IS and business processes. In particular, the ISPC model covers integration concerns in technological novelty and organizational architecture.

Technological novelty includes technical risks associated with IS design and implementation, while organizational architecture includes the organizational design in terms of structure and business units.

The ISPC model and how it expands on the ISDP model

Xia and Lee (2005) expanded on the models discussed above and developed an information systems development project (ISDP) complexity model. ISDP was more comprehensive, as it included 30 features in total, which arguably provides a more robust view of IS complexity. The final ISDP model consisted of 15 features after extensive analysis. Table 12 compares and maps the final ISDP and ISPC model features. There are direct comparisons between the two models on multiple fronts, implying that the ISPC model is complementary to and an expansion of the ISDP model of Xia and Lee (2005).

There are, however, instances where features of the ISPC model were mapped but were removed to improve model validity. For example, mapping which dwelled on interfaces between different disciplines (OC_15) and the fact that the project team was cross-functional (ISDPC4) were later removed when validating the model. Likewise, other features of the ISPC model were removed, including those which involved multiple external vendors (ISDPC19), contract types (OC_17), cooperation with joint-venture partner (OC_20), and trust in contractor (OC_23). Alternatively, the ISPC model included no representation of features around the system involved in real-time data processing (ISDPC11), and that the project involved multiple software environments (ISDPC16). These discrepancies could, however, be attributed to the exploratory and theoretical nature of the ISPC model and could be addressed in future research. Nevertheless, the ISPC model reveals that there are more features that underpin IS project complexity, as the model includes 41 features compared to ISDP's 15. This implies that the ISPC model has a more comprehensive view of complexity, as there is more awareness surrounding underlying influencing factors.

<table>
<tr><th>ISDP Complexity Model</th><th>ISPC Model</th></tr>
<tr><td>The project team was cross-functional</td><td>Dependencies between actors (ORI)</td></tr>
<tr><td>The project involved multiple external vendors</td><td>Not represented</td></tr>
<tr><td>The project involved coordinating multiple user units</td><td>Organizational units (OA)
Stakeholder interrelations (ORI)
Entire stakeholder management</td></tr>
<tr><td>The system involved real-time data processing</td><td>Not represented</td></tr>
<tr><td>The project involved multiple software environments</td><td>Not represented</td></tr>
<tr><td>The project involved multiple technology platforms</td><td>Information system dependencies (ORI)
Entire technological novelty</td></tr>
<tr><td>The project involved a lot of integration with other systems</td><td>Technological maturity and novelty (UN)</td></tr>
<tr><td>The end-users' organizational structure changed rapidly</td><td rowspan="4">Entire change management
Entire organizational architecture</td></tr>
<tr><td>The end-users' business processes changed rapidly</td></tr>
<tr><td>Implementing the project caused changes in the users' business processes</td></tr>
<tr><td>Implementing the project caused changes in the users' organizational structure</td></tr>
</table>

The end-users' information needs changed rapidly	
IT architecture that the project depended on changed rapidly	Entire change management
IT infrastructure that the project depended on changed rapidly	Entire technological novelty
Software development tools that the project depended on changed rapidly	Uncertainty in methods and technological maturity and novelty (UN)
ORI = Organizational resource interdependencies; OA = Organizational architecture; UN = Uncertainty	

Table 12. Comparing Features of ISDP (Xia & Lee, 2005) and ISPC Models

The ISPC Model Implications and Limitations

Various implications and limitations can be drawn from the ISPC model. From an academic perspective, the model expands on previous research by including a larger array of IS project complexity elements and their inherent features. This further develops the body of knowledge around the subject, as the most recent model has developed arguably over a decade ago. Furthermore, the ISPC model serves as the basis for future research endeavors, where the current data instrument could be adapted and the model could face rigorous analysis, via methods such as structural equation modeling. The pursuit of understanding complex systems in academia could also include IS project complexity as IS forms a critical component of global economic environments.

From a practical and managerial perspective, the model provides insight for IS project managers and IS project participants, as they will have a clear view of various IS project complexities. This not only will enlighten them but also streamline their roles and responsibilities for improved project delivery. IS project success is a perpetual concern and the model could alleviate and assist in the delivery and output of IS projects. The ISPC model is process neutral, thus, it could be used with any project management standard or methodology. Furthermore, the overall project management process would benefit, as the model will address complexity areas which previously could have been ignored. Project planning and risk management could apply the ISPC model to create proactive plans in the event a project complexity hurdle is faced. The ISPC model also goes beyond the project itself, as it considers features such as the organization's strategy, resource management, and structure.

The ISPC model is not without limitations. First, the model is theoretical and lacks further validation through, for example, confirmatory factor analysis or structural equation modeling. Future research should, therefore, explore these methods to affirm or refine the ISPC model's construction. Second, the sample is skewed towards the financial services (35.7%) and ICT and communications services industry (20,4%) , and arguably ignores the complexity of IS projects in other industries where environmental factors differ. Placing emphasis on other industries in future research could create a comparative platform to understand if variances exist. Third, the model only considers how complex each feature is perceived to be and not their importance or relevance. Hypothetically, a very simple feature could be highly relevant for success and vice versa. The data instrument could, therefore, be adapted to include the importance and relevance of each complexity feature.

CONCLUSION

There are multiple views about project complexity, but research surrounding IS project complexity is limited, especially considering the widespread usage of IS in organizations. The ISPC model presented in this paper illustrates how the generic view of project complexity should be molded to cater for the growing IS project environment. Previous research arguably has provided a narrow view of IS project complexity and the areas that must be addressed (McKeen et al., 1994; Ribbers & Schoo, 2002; Xia & Lee, 2005). This research expands on previous studies and portrays a more comprehensive view of IS project complexity. The ISPC model includes 10 constructs that should be understood carefully and respected for IS projects to thrive in any industry.

From a project manager's perspective, the ISPC model provides transparency around what to manage. It is important that the various stakeholders are identified and engaged with, as this directs an IS project accordingly. Creating awareness among stakeholders also facilitates a common understanding and ensures strategic alignment. While uncertainty during an IS project is inevitable, the ISPC model acts as a guiding tool in comprehending and anticipating the uncertainties that can exist during the project. Technology understandably is highlighted as a key complexity element during IS projects. Uncertainty around this can be addressed by establishing proactive structures to educate and train not only project team members but management and users as well. This ensures the IS project output generates value for the organization.

The ISPC model shows that IS project complexity can be mitigated by understanding the organizational environment and the interdependencies between the various resources required to execute the project. Resource management should exist within the constraints of the organization's structures, and the project manager is responsible for communicating the process within the organization and with the relevant stakeholders throughout the IS project's lifecycle. The project manager should also establish a clear and concise change management approach for each IS project, as the context and strategic implications for each project varies.

IS projects often exist in geographically dispersed environments, hence, it is important for the project manager to convey location constraints as well as the size of the IS project being executed. Location conditions cannot be overlooked, and these constraints must be understood in the greater project context. The project team also must be aware of these constraints in the project context to ensure the project realizes the strategic intent it was designed to achieve.

The groundwork for developing a comprehensive and robust IS project complexity model is presented in the ISPC model. IS project complexity can no longer remain behind the scenes, given the perpetual increase in IS project deployment for strategic initiatives.

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APPENDIX A

IS Project Complexity Variables				
Construct	**Element**	**Feature**	**Variable Name**	**Result**
Organizational complexity	Vertical differentiation	Organizational structure	OC_01	Final variable
	Horizontal differentiation	Organizational units	OC_02	Final variable
		Task structure	OC_03	Deleted
	Size	Project duration	OC_04	Deleted
		Variety of methods and tools	OC_05	Deleted
		Capital expenditure	OC_06	Deleted
		Work hours	OC_07	Deleted
		Project team	OC_08	Final variable
		Site area	OC_09	Final variable
		Number of locations	OC_10	Final variable
	Resources	Project drive	OC_11	Final variable
		Resource and skills availability	OC_12	Final variable
		Experience with involved parties	OC_13	Final variable
		Health, safety, security and environment (HSSE) awareness	OC_14	Deleted
		Interfaces between different disciplines	OC_15	Deleted
		Number of financial resources	OC_16	Deleted
		Contract types	OC_17	Deleted
	Project team	Number of different nationalities	OC_18	Deleted
		Number of different languages	OC_19	Deleted
		Cooperation with joint-venture partner	OC_20	Deleted
		Overlapping office hours	OC_21	Deleted
	Trust	Trust in project team	OC_22	Deleted
		Trust in contractor	OC_23	Deleted
	Risk	Organizational risks	OC_24	Deleted
	Interdependencies	Environmental dependencies	OC_25	Deleted

		Resource sharing	OC_26	Final variable
		Schedule dependencies	OC_27	Final variable
		Interconnectivity and feedback loops in task and project networks	OC_28	Final variable
		Dependencies between actors	OC_29	Final variable
		Information systems dependencies	OC_30	Final variable
		Objective dependencies	OC_31	Final variable
		Process interdependencies	OC_32	Final variable
		Stakeholder interrelations	OC_33	Final variable
		Team cooperation and communication	OC_34	Deleted
Technical complexity	Differentiation	Number and diversity of inputs and/or outputs	TC_01	Deleted
	Goals	Number of goals	TC_02	Final variable
		Goal alignment	TC_03	Final variable
		Clarity of goals	TC_04	Final variable
	Scope	Scale of scope	TC_05	Deleted
		Quality requirements	TC_06	Deleted
	Tasks	Number of tasks	TC_07	Deleted
		Variety of tasks	TC_08	Deleted
		Conflicting norms and standards	TC_09	Deleted
	Experience	Newness of technology	TC_10	Final variable
		Experience with technology	TC_11	Final variable
	Risk	Technical risks	TC_12	Final variable
Environmental complexity	Stakeholders	Number of stakeholders	EC_01	Final variable
		Variety of stakeholder perspectives	EC_02	Final variable
		Political influence	EC_03	Final

				variable
		Internal support	EC_04	Deleted
		Required local content	EC_05	Deleted
	Location	Interference with existing site	EC_06	Deleted
		Weather conditions	EC_07	Final variable
		Remoteness of location	EC_08	Final variable
		Experience in country	EC_09	Final variable
	Market conditions	Internal strategic pressure	EC_10	Deleted
		Stability of project environment	EC_11	Deleted
		Level of competition	EC_12	Deleted
	Risk	Environmental risks	EC_13	Deleted
Uncertainty	Triple constraint	Uncertainties in scope	U_01	Final variable
		Uncertainties in cost	U_02	Deleted
		Uncertainties in time	U_03	
	Activity	Uncertainty in methods	U_04	Final variable
		Task uncertainty	U_05	Final variable
	Goals	Uncertainty of goals and objectives	U_06	Final variable
	Technology	Technological maturity and novelty	U_07	Final variable
	Stakeholders	Undisclosed participants	U_08	Final variable
		Competency	U_09	Deleted
	Information	Incomplete information	U_10	Final variable
Dynamics	Change management	Change process	D_01	Final variable
		Number of changes	D_02	Final variable
		Scope of changes	D_03	Final variable
		Frequency of changes	D_04	Final variable
		Impact of changes	D_05	Final

				variable
		Change over time	D_06	Final variable