An Exploratory Literature Review and Analysis of Project Complexity Models

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The Information Communications Technology (ICT) industry has been experiencing challenges in project performance for years. Similarly, complexity has been identified as a primary contributor to the challenges in project performance for years. As project complexity is a long-standing issue to ICT performance, an analysis is needed to identify the existing state of research within project complexity and future research necessary to progress the field of research. This study, through literature research, analyzes 19 existing complexity models, including their definitions, factors, and tools of measurement. Findings identify a theoretical definition to project complexity, a general list of 33 factors used to measure complexity and identifies the current research within project complexity to be at a theoretical and conceptual state which has not yet reached a sustained and lasting practical level to the industry. It is proposed that future research into the perception perspective on ICT project complexity may provide novel insights into ICT project complexity.

Keywords: ICT Industry, project complexity, performance, complexity factors.

Introduction

The Information Communications Technology (ICT) industry has had perceived performance issues for years. Performance issues have been identified as early as in 1968 when in The North Atlantic Treaty Organization (NATO) software engineering conference, the so called "software crisis" was addressed (NATO Science Committee, 1969). The crisis was due to the number of software projects failing to be finished on time, on budget, and which did not meet the correct specifications. At that time, based on the NATO conference findings, the proposed causes of failure included the complexity of systems and the suppliers' lack of expertise.

These causes were addressed to be related to the technology and demands of the clients surpassing supplier's available solutions. Due to this demand, suppliers offered solutions which were never tested, and accepted projects which had never been done before on such a large scale. In this state, it was a concern that clients may lose confidence in the industry. The only consensus of the attendees of the conference to these problems was that the solution was unknown. However, guidance was given to continue to improve on current techniques and not to work outside the present state of technology (NATO Science Committee, 1969).

Since 1969, technology has advanced significantly and the methods and theories to deliver ICT projects with it. Rivera and Kashiwagi (2016) identify multiple methodologies such as rapid application development and agile methodology that have been refined over the years to address the challenges encountered in ICT projects. Even with all these advancements within the ICT industry throughout the years, the "software crisis" may not have been resolved. A study

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published by the Standish group (1994) reestablished the issue when it identified that 83.8% of ICT projects failed to be completed on time and on budget, and that projects which were completed by the largest American companies had only 42% of their original features and functions. Recent research of the Standish Group (2016) reported that globally more than 70% of projects failed to be completed on time, on budget and with a satisfactory result.

The ICT industry is a critical element to all industries as it is integrated into all industries from healthcare to construction due to the growing dependencies for technology in day to day activities. For instance, the United States government has experienced ICT performance issues ranging from the Census Bureau (US Department of Commerce, 2011), online healthcare (Costello & Mcclaim, 2013), payroll systems (Chiang, 2013), and Airforce operations (Institute for Defense Analysis, 2011). Other countries such as United Kingdom (Public Administration Committee, 2011), the Netherlands (The House of Representatives of the Netherlands, 2014), Australia (Legislative Assembly of the Northern Territory, 2014) have shown a similar integration into various industries and the impact performance issues on a governmental level. The Standish Group (2016) studied eight of the major sectors including telecom, government, financial, retail, manufacturing, banking, services and healthcare and discovered little differential, with reported performance (on time, on budget, meeting client expectations) of 24 – 34%.

Research has investigated the factors of project performance including Nasir and Sahibuddin (2011), Wateridge (1995) and Fortune and White (2006), all of which concluded that there is no broad consensus among researchers and practitioners in a standard set of factors. However, similar to the NATO conference in 1968, they share a common awareness of the importance of project complexity.

Bullock and Cliff (2004) describe how project complexity is unavoidable with progress and may be caused by the transition from relatively isolated small-scale elements to much larger interconnected systems. The impact of these increasing complex systems has been recurrently identified as growing obstacles. Whittaker (1999) identified that key users misunderstanding the project's complexity to be one of major causes of low project performance. Dijk's (2009) research in project performance ranked the underestimation of complexity as number one of the top five causes of content driven issues. A literature review conducted by Bullock and Cliff (2004) showed the industries acknowledgement of the importance of project complexity, identifying over 26 academic institutions, 12 Global ICT companies and 22 large non-ICT companies that have research centers within the field of project complexity which aim to better understand it's causes and methods to control it.

As research into factors of ICT project complexity continues, it can be seen to be incorporated with the applicable industry solutions to improve ICT project performance (Kashiwagi and Kashiwagi, 2014) including agile project management, the minimization of project size and the Best Value Approach. All three approaches differ in how to improve performance, but all three approaches similarly identified an importance in the reduction of complexity as focuses to their solution.

Research Questions and Methodology

Project complexity has been identified as a leading cause to performance issues as early as 1969. Literature has shown that the ICT industry is still experiencing performance issues due to complexity. The purpose of this paper is to clarify and understand project complexity and identify further research necessary to progress the field of study. The research seeks to answer the following questions:

1. How can project complexity be defined?
2. What factors does the industry use to measure project complexity?
3. What is the current state of project complexity research?

To answer these research questions an exploratory literature study has been performed to identify, understand and analyze the existing complexity models that have been developed.

Research Method

In the literature study for project complexity, “project complexity” + “complexity models” + “complexity factors” were used as the core keywords. The main search engines that were used include Engineering Village, Emerald Insight, Pro Quest and Google Scholar. Engineering Village is comprised of 12 engineering literature and patent databases. In total, the database is comprised of more than 16 million records from over 68 countries and 1,000 publishers. Emerald Insight focuses on research in the practice and management of business. Emerald Insight manages a portfolio of nearly 300 journals, more than 2,500 books and over 450 teaching cases. Pro Quest also focuses on research into business management but extends their database to include dissertations, news, and latest working papers. Google Scholar is a broad search across many disciplines and sources: articles, theses, books, abstracts and court opinions, from academic publishers, professional societies, online repositories, universities and other web sites. Google Scholar ranks search results according to where it was published, who it was written by and how recently it was cited. The selected databases range, saturation and overlap of publications from different sources and fields ensure a sufficient search was performed to identify current research done within the area of project complexity.

Publication Selection

Following the search with the identified keywords, 4 steps or filters were used:

1. The publications had to be available in full text English.
2. Each of the keywords were researched in each of the databases, 500 publications per database for project complexity were reviewed.
3. The publications’ abstracts were reviewed and filtered based on the relation to project complexity models.
4. Publications for project complexity publications were fully reviewed and filtered based on the contribution of a unique project complexity model which included a list of complexity factors.

After the review of 2,000 publications' abstracts [see Table 1], 213 were identified to have abstracts related to project complexity. After the full publications were carefully read and reviewed, 18 publications were identified to contribute with an original piece or whole of a complexity model (directly related). From those publications, 1 more was identified through the references used in those papers. In total, literature identified 19 publications that each presented an original aspect to modeling complexity, of which 18 were taken from academic journals and conferences such as, Kybernetes, Project Management Institute, Wiley Interscience, Elsvier, Sciencedirect, Procedia Engineering, and System of Systems Engineering.

The literature findings for project complexity confirmed that complexity was not solely limited to the ICT industry but as an industry wide issue (see Table 2), of the 19 publications only 1 was specifically limited the study to the ICT industry. Most research publications included projects from multiple different industries and countries. The publications identified did not address an issue with forming and applying their models for multiple industries. In addition to this, no location seemed more common than another in their research into complexity. Due to the lack of research done specifically within the ICT industry, the project complexity research was expanded to all industries for the purpose of identifying an overall general clarification of project complexity.

Table 1: Summary of Literature Search.

Literature Search	Total	Engineering Village	Emerald	ABI/Inform	Google Scholar
Searched	**2000**	500	500	500	500
Related	**213**	57	73	11	55
Directly	**18**	14	1	0	3
Reference	**1**				
Final	**19**				

Table 2: Demographics of Literature Results

Publication Year	Project Complexity
2016 - 2017	5
2011 - 2015	7
2006-2010	4
2001-2005	2
1969-2000	1
Industry	#
General	7
*One or more specific industry cited	12
Construction	8
ICT	5
Other (Organizational, Industrial, Aerospace, Biopharmaceutical, R&D, product development)	5
Location	#
General	10
*Specific Location(s)	9
Asia	4
Europe	6
Americas	3
Australia	2
Africa	0

*Publication could be in one or more of the subcategories

Data Structure

As publications from project complexity literature were identified they were documented in excel, forming a master database, which was used to create an overall factor list. The master database stored two central Excel sheets which comprised the raw data which was easily accessible for all calculations and analysis necessary for the study. An example of the data structure is available in Appendix A: Tables A1 and A2.

Each of the 19 publications relating to project complexity were listed in an Excel sheet (Table A1: Complexity Models) as its own row with the columns of data listing all critical pieces of information gained from the publication including:

1. Demographics of the study such as year of publication, source database, source type, location and industry.
2. Key information of the complexity model including: the research method used to create a complexity model (survey, interview, case study, etc), quantity of participants in the study, number of factors identified by model, definition of complexity, results of the model (tools, relation to performance, etc.), special notes or unique qualities of study.

In a separate Excel sheet (Table A2: Complexity Factors), all project complexity factors found were listed as a separate row and each column a classification of that factor including the reference source, area being measured, and the overall complexity factor it is grouped in.

Analysis and Findings

Defining Project Complexity

There are multiple theories that attempt to define project complexity. However, literature shows that there is no generally accepted definition (Vidal and Marle, 2008). Examples of the wide range of theories include:

1. Baccarini (1987) identified a definition to complexity with an objective and subjective component, listed respectively: (1) Consisting of many varied interrelated parts and (2) Complicated, involved and intricate.
2. Nan Tie and Bolluijt (2014) define complexity as subjective "a measure of the difficulty of delivering a specific project in a specific organization from the perspective of the project manager".
3. Turner and Cochrane (1993) define complexity as something which can be viewed as both subjective or objective "the degree of whether the goals and methods of achieving them are well defined".

Schlindwein and Ison (2004) explore the history and epistemology of complexity, grouping the existing definitions into two components: descriptive and perceived complexity. The descriptive component is an absolute measure that depends on the object itself and is the same measurement regardless of the observer, while the perceived component of complexity is dependent on the observer.

The descriptive component (DC) is centered on the measurement of various aspects of the conditions of the system. For example, Baccarini (1996) focused on the quantity, variation and the interdependence of conditions. Jones and Deckro (1993), Williams (1999), Shenhar and Divir (1993) and Turner and Cochran (1993) incorporate the dynamic and uncertainty of conditions in terms of their predictability, erratic nature and completeness.

The perceived component (PC) has two methods to measuring complexity (PC1 and PC2). The first perceived method (PC1) is very similar to the descriptive component. While the descriptive component is intended to use an objective method to measure the value of the condition, the PC1 uses the observers' perceived value of the condition as the means of measurement. A secondary perceived method (PC2) aims to measure the understanding of the observer. This component similarly uses the perception of the observer however, it differs from PC1 as it is not measuring the value of the conditions but the observer's understanding of that condition.

When analyzing the application of PC1 and DC in research models measuring complexity there seems to be little differential. Both descriptive and perceived components use the observers' perceived value of the condition as the means of measurement while using both descriptive and perceived conditions interchangeably. For instance, Vidal, Marle, and Bocquet (2011a, 2011b), Dao, Kermanshachi, Shane and Anderson (2016), Abdou, Yong, and Othman (2016) use the perception of the observer to measure the value of the conditions but use both descriptive conditions such as cost and duration; and perceived conditions such as team cooperation and level of difficulty in obtaining permits. Theoretically PC2 has been defined, but none of the 19 models have applied the PC2 to modelling complexity.

Literature has shown various differing theoretical definitions to view complexity. Based on the literature, the author defines a new definition which includes both components of Schlindwein and Ison (perceived and descriptive) however, based on the application of these components in existing models, they are regrouped into two new components of 'perception' and 'conditions'. Our definition includes the descriptive component but separates the component of perceived into two subcomponents (PC1 and PC2). The first dimension of 'perception' is based on PC2 which aims to measure the observer's understanding of the project conditions and future project conditions. The second complexity dimension of 'conditions', is based on both the DC and PC1 definitions (Schlindwein and Ison 2004), which aim to measure the value of project conditions through both objective measurements (Baccarini, 1996) and the observers perceived measurement of the conditions (Tie & Bolluijt 2014). For this research the definition's two components are defined as follows:

1. Perception (based on (PC2)): Understanding of project conditions and how to perform the project.
2. Conditions (based on (PC1) and (DC)): Project conditions which are present, whether understood or not understood by the observer.

Project Complexity Factors

Analysis of the 19 complexity models identified a list of complexity factors. In total the analysis identified 604 different factors of complexity. To analyze these factors properly the following two rounds were performed in order to identify "project complexity factors".

The first round was to exclude all duplicates and factors that were not directly related to the project. The factors that relate to the environment or company are excluded in this research. Although these factors may indirectly impact project complexity, it was this research's key focus to narrow the scope in order to provide greater insight into factors directly relating to the project. Each factor was analyzed to identify how it was cited in the literature and tagged it with the area being mentioned in the factor. The areas identified include the supplier, project management, relationship, project scope, stakeholders and technology. The areas used were dictated by the citing of the area in the literature provided with the factor. Some definitions were explained in detail, others were defined by the factor title itself.

In total 580 factors were identified to be unique (24 duplicates), 67 factors were identified that relate to the organization and 54 factors relate to the environment. Table 3 summarizes the distribution of the areas being measured. After this filter 459 factors of complexity were remaining.

Table 3: Frequency of Factors by Area

System Area	% Frequency	# Frequency
Project Scope	26.6%	152
Technology	19.0%	112
Organization	11.6%	67
Stakeholder	11.2%	65
Supplier	10.9%	63
Environment	9.3%	54
Project Management	6.2%	36
Relationship	5.3%	31

The second round required a more in-depth analysis than the first round. To do this, the factors were grouped into larger, broader overall factors. After fully reviewing all remaining factors the analysis identified 33 general project complexity factors, see Table 4.

Table 4: Overview of Factors of Complexity

#	General Project Complexity Factor	Definition
1	Project Team Experience	The project's team past experience and familiarity with the components of the project including stakeholders, company, project team, similar type of project, country, etc.
2	Project Team Capability	The project team's skills, resources, qualifications, training and education.
3	Team cooperation	The cooperation, communication and shared vision amongst team members regarding the implementation of the project.
4	Variety of Team Capability	The diversity of skills, resources, qualifications, training and education within the team.
5	Size of team	The quantity of supplier team members and positions.
6	Team Location	The physical geographical location of the supplier's project team members.
7	Project Management Tool	The utilization of a structured method and tool for project management.
8	Planning and Scheduling	The planning and scheduling of activities, deliverables, and tasks necessary for the completion of the project.
9	Change Order Management	The management of changes to the scope of work of the project.
10	Risk Management	The identification and mitigation of risk on a project.
11	Stakeholder Management	The relationship maintained with stakeholders of the project in the management of their expectations and objectives.
12	Stakeholder Support	The commitment, cooperation, awareness and priority given to the project by stakeholders.
13	Stakeholder Relationship	Appropriate authority and accountability between client and supplier in determining the necessary roles and responsibilities between entities.
14	Amount of work	The largeness of scope in terms of outputs including: man hours, components and deliverables.
15	Interdependence of work	The interaction and interdependence between stakeholders (client and supplier) during the implementation of a project.
16	Clear goal /objective/ requirement	The projects outcome is defined and understood by all stakeholders in meeting the goals, objectives and requirements.
17	Variety of work	The diversity of the different types of components, resources to be manipulated, tasks and actions to be performed on a project.
18	Project Cost	The size of the project budget or capital investment.
19	Project Duration	The length of the project's planned duration to complete the project.
20	Information Uncertainty	The information uncertainty in the project caused by unknown existing and future conditions.
21	Feasibility	A client's creation of scope with unrealistic expectations regarding the quality, necessary resources or outcome of a project.
22	Aligned goals/requirements	The project's alignment with the business goals and interests of the client's organization.
23	Number of stakeholders	The quantity of stakeholders involved in the project including: investors, departments, sub vendors, units, etc.
24	Availability of Stakeholder Resources	Availability of people, material and resources necessary due to sharing.
25	Different Views of stakeholders	The projects stakeholder's different opinions and agendas that may lead to conflict.
26	Stakeholder Knowledge	The project's stakeholder's technical knowledge and/or experience.
27	Location of Stakeholders	The physical geographical location of project stakeholders.
28	Technology Interdependence	The integration between technology, technology including: hardware, software, processes or methods used.
29	Innovative Technology	The newness or novelty of the technology, technology including: hardware, software, processes or methods used.
30	Changing technology	The technology is continuously changing, technology including: hardware, software, processes or methods used.
31	Variety of technology	The diversity of the technology, technology including: hardware, software, processes or methods used.
32	Difficult Technology	The difficulty of the technology, technology including: hardware, software, processes or methods used.
33	Quantity of decisions	The number of decisions to be made regarding the projects plan of implementation or outcome.

State of Project Complexity Research

The existing literature has progressed the field of complexity, establishing a foundation of knowledge upon which lessons learned of what is required to further progress the field can be addressed.

Of the 19 models (see appendix B for full list of complexity models), the identified factors were developed in two stages within each publication. Stage 1 involved the initial identification of factors and stage 2, which was conducted in 11 of the studies, verified the importance of the developed list of factors with a secondary method. Table 5 summarizes the methods of stages 1 and 2 including the number of studies that used each method, the number of studies that reported the quantity of participants/papers, and the total quantity of reported participants/papers.

It is important to note that 1 of the models came from industry publications (Global Alliance for Project Performance Standards (GAPPS), 2005) and 18 came from academic journal and conference publications. It can be observed that the standard for scientific research varies between publications and that publications due to their focus may not have given the full details of their research. For example, Antoniadis, Edum-Fotwe and Thorpe's (2011) model identified 16 factors which were identified to be developed from personal experience as the factors were not clear as to how they were developed which could have been done through a scientific process. However, the factors were verified through multiple case studies.

Table 5: Methods of Factors' Development

Study's Method of Factor Development	# Studies (19 total)	# Studies that Reported Quantity	Total Quantity
Literature Analysis	10	8	> 530 Papers
Workshops	3	1	100 participants
Survey	2	2	91 responses
Expert Panel	2	2	58 participants
Personal Experience	1	-	-
Case study	1	1	17 projects
Validation of Factors			
No verification	8	-	-
Survey	6	4	452 responses
Case study	4	4	32 projects
Workshops	1	1	10 participants

The first stage of developing the factors of the existing models was based on asking or interpreting what factors one or multiple individuals thought were linked to project complexity. The opinion of the individual was collected either by published papers, case study interviews, in person workshops or surveys. Of the 19 models that identified project factors, 8 of these were not supported through a secondary method and only 4 of the 19 models were applied to a collective total of 32 projects. The models are primarily based upon opinion of practitioners as they have been applied on few projects.

Vidal et al. (2011a) also notes that since the participants were not asked to think of how to measure the identified factors, many are too conceptual or unfeasible to measure on the average project due to their difficulty and technical skill required to perform the calculations. Vidal indicates that without a simple definition and user-friendly method to measure each factor it has proven difficult to use them on practical level. There is a need for the development of factors with both a standard definition and feasible method of measurement.

Based on the identified factors, 13 of the 19 models created measurement tools to evaluate the level of complexity of a project. There were three different types of tools created. The tools, descriptions of each and studies that produced the tool are reflected in Table 6. As a summary, the three tools identified include:

1. Prioritized list – List of prioritized factors based upon frequency, group consensus and personal judgement.
2. Measurement tool – A software and/or equation that scores a project based upon a set of predetermined weighted factors of a project.
3. Correlation analysis – Analyzes the importance and relation between specific factors of a project.

Through the existing studies there has been research to support that factors of complexity are correlated (Qureshi, 2015) and hold differing weighting of importance to complexity (Dao et al., 2016; GAPPS, 2005; Abdou et al., 2016). However, literature has not provided a proven standard weighting or correlation of factors that that has shown to be accurate through repeated testing. Inaccurate weighting of the correlation and factor have caused inaccuracy in measuring complexity (Vidal et al., 2011a).

Table 6: Tools to Measure Project Complexity.

Type of Definition	Represented study Definition	Represented Study
Prioritized Lists	List of factors based upon frequency and group consensus. (in the studies)	Vidal et al. (2011a, 2011b); Dao et al. (2016); Bakhshi, Ireland and Gorod (2016); Azim et al. (2010); Bosch-Rekveldt et al. (2010); He, Luo, Wang, Li and Zhao (2012); Xia and Chan (2012); Kermanshachia, Dao, Shane and Anderson (2016)
Measurement tool	Weighting system used to score projects on complexity scale from 0 to 1.	Vidal et al. (2011a, 2011b)
	PCAM tool - calculates a complexity score. Determined by a weighting system that was determined off of participant's survey results.	Dao et al. (2016)
	CIFTER - projects are given points based upon a defined list of factors and weights.	Global Alliance for Project Performance Standards (2015)
Correlation Analysis	Relation between complexity factors	Qureshi and Kang (2015)
	Grouping of related complexity factors	Abdou et al. (2016)
	Contextual complexity, inherent complexity	Tie and Bolluijt (2014)
	Product vs project success, Computed vs perceived complexity	Ribbers and Schoo (2002)

In regard to improving performance, 3 of the measurement tools have shown supporting evidence that there is a relation between performance and complexity however, the method and results may require further support as 2 studies showed correlation with performance based solely on the perception of participants not the actual project results (*). The other study was based on the amount of time required to complete individual tasks, but the study did not consider overall project time or other key factors of success such as cost and customer satisfaction (see Table 7).

Table 7: Models' Relation to performance.

Study	Industry	Definition of Performance	Method of measurement
*Tatikonda and Rosenthal (2000)	Product development	Time, cost, functional performance and objectives	Survey was used to measure complexity factors and performance. Analysis was performed on results.
Antoniadis, Edum-Fotwe, Thorpe (2011)	Construction	Completion of tasks on time	Performance vs complexity was tracked over a period of 10 months for 5 projects. Analysis was compared over relation over time.
*Floricel, Michela, and Piperca (2016)	Biopharmaceutical, information and communication systems, energy and transportation infrastructure	Time, cost, functional requirements	Survey was used to measure complexity factors and performance. Analysis was performed on results.

The existing project complexity models have not provided dominant evidence to claim reduction to project complexity using a standardized model. This gap in literature has made it difficult to identify a complexity model as adding more value or use than another. Research in project complexity appears to still be at a very theoretical and conceptual state and has not yet reached a sustained and lasting practical level to the industry. In addition to this, as research into project complexity is a long-standing issue, it is observed that the industry is having difficulties shifting from the theoretical to the practical state.

Conclusions

The focus of this paper was to further investigate project complexity by answering the research questions of R1, how can project complexity be defined, R2 what factors define ICT project complexity and R3 what is the current state of project complexity research? In response to R1, project complexity was found to have no unified definition. Based on literature a new definition of complexity was proposed with the components of perception and conditions. In response to R2, 604 cited factors of complexity were grouped into 33 overall factors of project complexity. In response to R3, it was found that the research into project complexity appears to be at a very theoretical state and has not yet reached a sustained and lasting practical level to the industry. As research into project complexity is a long-standing issue, it is observed that the industry is having a difficult time moving from the theoretical to practical state.

Reflections

The study attempts to be complete in understanding existing project complexity models, however, there are potential limitations due to the small sample size of defined models that exist and the wide range of applicability of ICT services. The data collected was from various sectors (construction, ICT, healthcare and manufacturing), types of projects (end user management, infrastructure management, application management), countries, and project sizes. In addition to this, the research could have been extended to other research methods such as surveying, interviews, and case studies. However, these limitations were expected when approaching such a long standing and unresolved issue such as project complexity. In order to understand the wide breath of knowledge that has already been performed, the method used was identified as the most optimal. There have already been various studies which have used surveys, case studies, and interviews; a literature search would give access to the largest collection of data with minimal resources required. In addition to this, the literature search has identified that most studies have not shown dominant differentiation in terms of complexity between industries, countries or sectors. The selected methodology was a prime factor in arriving at the main contribution of this paper, which is the identification that the existing research in creating a project complexity model is still in a theoretical state and has not shown sufficient evidence of applicability in terms of performance or repeatability. The findings may be a small sample size (19 models) but due to the consensus and similarities between the models they can be used as a microcosm of the existing complexity models. This can be used in future research to examine if the direction of research being performed to examine complexity is accurate.

With the findings of this research the author feels it necessary to reexamine how complexity is being defined and measured. So far, ICT project complexity models are only studied from a condition (value) perspective. There is a gap in complexity research with respect to the perception (understanding) of the observer. Further research into the effect of the perception perspective on ICT project complexity may provide novel insights to complexity.

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Appendix A: Literature Database Design

Table A1: Data Structure Complexity Models

#	Year	Database	Source Type	Industry	Location	Research Methods
501	2012	Engineering Village	Conference	General	General	Literature analysis Survey
502	2015	Engineering Village	Journal	Textile, IT, Automboile, R&D	Europe, Asia and Middle-America	Literature analysis Survey
505	2016	Engineering Village	Journal	General (ICT included)	China	Literature analysis
507	2016	Engineering Village	Conference	Construction	General	Literature analysis Survey

#	# of Factors	Total Quantity	Definition of Performance	Method of measurement	Type of measurement tool	Represented Study Definition
501	28	> 17 papers N/A respondents			Prioritized Lists	
502	38	> 18 papers 150 PMs			Correlation Analysis	Relation between complexity factors
505	127	420 papers			Prioritized Lists	
507	19	> 22 papers 101 PM respondents			Correlation Analysis	Grouping of related complexity factors

Table A2: Data Structure Complexity Factors

#	Complexity Factor	Complexity Overall Factor	Area
512	Ambiguity of performance criteria	Clear goal /objective/ requirement	Project Scope
505	Availability of people, material and of any resources due to sharing	Availability of Stakeholder Resources	Stakeholder
512	Changes of construction works	Change Order Management	Project Management
511	Clarity of goals	Clear goal /objective/ requirement	Project Scope
505	Clients with unrealistic goals 7 14 6	Feasability	Project Scope
510	Constraints	Feasability	Project Scope
516	Cost	Project Cost	Project Scope
509	Demand of creativity	Innovative Technology	Technology

Appendix B: Complexity Models

#	Reference	Industry	Location	Research Methods
1	He, Luo, Wang, Li and Zhao (2012)	General	General	Literature analysis Survey
2	Qureshi, Sheheryar Mohsin, and ChangWook Kang (2015)	Textile, IT, Automobile, R&D	Europe, Asia and Middle-America	Literature analysis Survey
3	Bakhshi, Ireland and Gorod (1999)	General (ICT included)	China	Literature analysis
4	Saed, Yong, Othman (2016)	Construction	General	Literature analysis Survey
5	Ludovic, Vidal and Franck Marle (2008)	General (ICT included)	Europe	Literature analysis
6	Harvey Maylor (2008)	General (ICT included)	General	workshops
7	Marian Bosch -Rekveldta (2010)	Construction	General	Literature analysis Case study
8	Bo Xia, Albert P.C. Chan (2012)	Construction	General	Expert panel
9	Dao (2016)	Construction	United States	Workshop No verification
10	Antoniadis, Edum-Fotwe, Thorpe (2011)	Construction	Norway	Personal Experience Case study
11	Floricel, Michela, and Piperca (2016)	biopharmaceutical, ICT, energy and transportation infrastructure	North/Latin America Europe Africa Australia	Case study project Survey
12	Nan Tie and Bolluijt (2014)	General	General	Literature analysis Survey
13	Vidal et al. (2011a, 2011b)	Entertainment Industry	General	Expert panel Case study
14	Tatikonda and Rosenthal (2000)	Product development	General	Literature Survey
15	Ribbers and Schoo (2002)	IT	Europe	Literature analysis Case study
16	Global Alliance for Project Performance Standards (GAPPS)	General	Malaysia	Workshops
17	Kermanshachia (2016)	Construction	Europe	Literature Search Workshop
18	Azim (2010)	aerospace	Europe	Survey
19	Geraldi, Maylor, and Williams (2011)	Construction, Information Systems, product development, R&D, organizational projects	General	Literature analysis