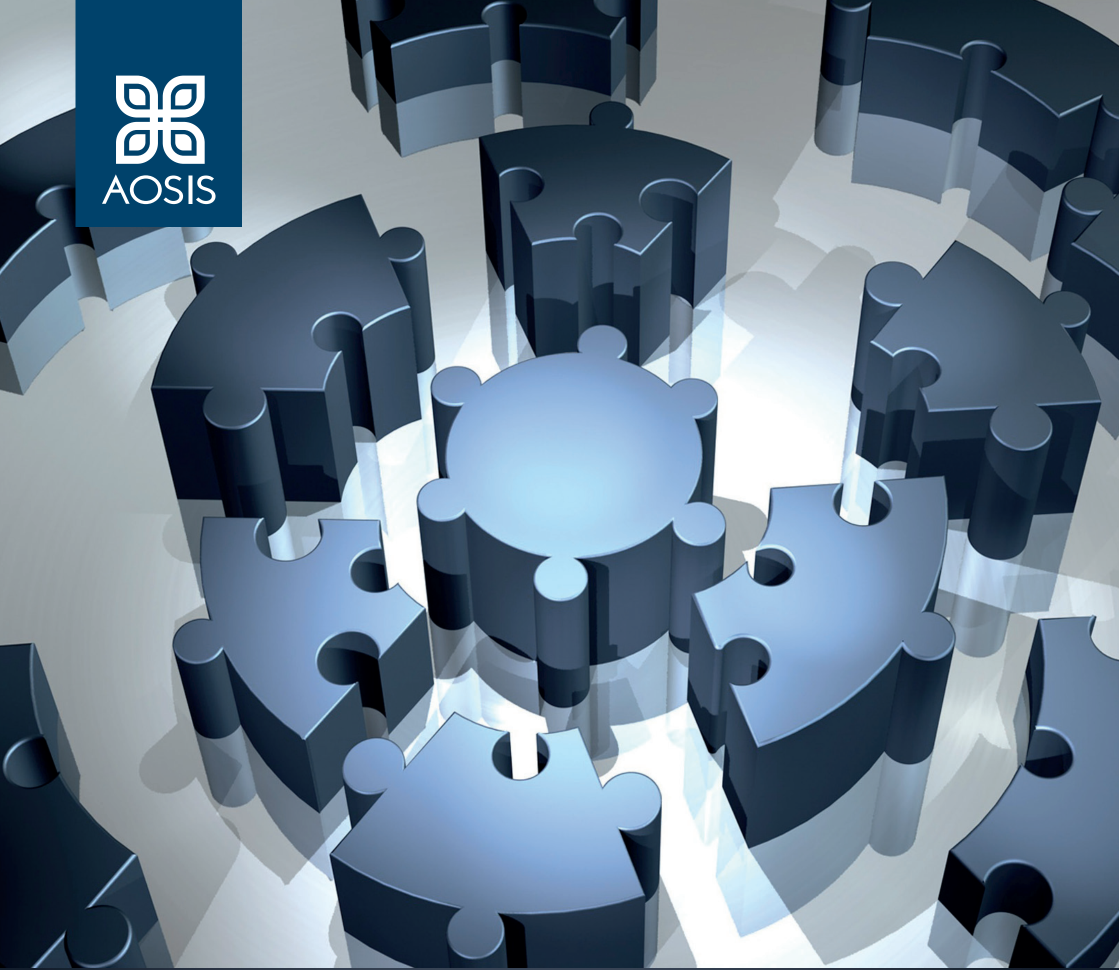

The symbiosis between information system project complexity and information system project success

Carl Marnewick • Wikus Erasmus
Nazeer Joseph

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AOSIS

Head Office
AOSIS (Pty) Ltd
Postnet Suite #110
Private Bag X19
Durbanville 7551
South Africa
Tel: +27 21 975 2602
Fax: +27 21 975 4635
Email: info@aosis.co.za
Website: http://www.aosis.co.za

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AOSIS

Peer Review Declaration
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Research Justification

Project success is widely covered, and the discourse on project complexity is proliferating. The purpose of this book is to merge and investigate the two concepts within the context of information system (IS) projects and understand the symbiosis between success and complexity in these projects. In this original and innovative research, exploratory modelling is employed to identify the aspects that constitute the success and complexity of projects based on the perceptions of IS project participants. This scholarly book aims at deepening the academic discourse on the relationship between the success and complexity of projects and to guide IS project managers towards improved project performance through the complexity lens.

The research methodology stems from the realisation that the complexity of IS projects and their relationship to project success are under-documented. A post-positivistic approach is applied in order to accommodate the subjective interpretation of IS-project participants through a quantitative design. The researchers developed an online survey strategy regarding literature concerning the success and complexity of projects. The views of 617 participants are documented. In the book, descriptive statistics and exploratory factor analysis pave the way for identifying the key success and complexity constructs of IS projects. These constructs are used in structural-equation modelling to build various validated and predictive models.

Knowledge concerning the success and complexity of projects is mostly generic with little exposure to the field of IS project management. The contribution to current knowledge includes how the success of IS projects should be considered as well as what the complexity constructs of IS projects are. The success of IS projects encompasses strategic success, deliverable success, process success and the 'unknowns' of project success. The complexity of IS projects embodies organisational complexity, environmental complexity, technical complexity, dynamics and uncertainty. These constructs of success and complexity are mapped according to their underlying latent relationships to each other.

The intended audience of this book is fellow researchers and project and IS specialists, including information technology managers, executives, project managers, project team members, the project management office (PMO), general managers and executives that initiate and conduct project-related work.

The work presented in this first edition of the book is original and has not been plagiarised or presented before. It is not a revised version of a thesis or research previously published. Comments resulting from the blind peer review process were carefully considered and incorporated accordingly.

Prof. Carl Marnewick, Wikus Erasmus & Nazeer Joseph
Department of Applied Information Systems
University of Johannesburg
South Africa

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Abbreviations appearing in the Text and Notes

EFA	Exploratory Factor Analysis
HSSE	Health, Safety, Security and Environment
ISDP	Information System Development Project
IS	Information System
IT	Information Technology
KMO	Kaiser-Meyer-Olkin
NPD	New Product Development
NTCP	Novelty, Technology, Complexity and Pace
PCM	Project Complexity Model
PMBOK®	A Guide to the Project Management Body of Knowledge

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Notes on Contributors

Carl Marnewick

Prof. Carl Marnewick's academic career started in 2007 when he joined the University of Johannesburg. He traded his professional career as a senior information technology (IT) project manager for that of an academic career. The career change provided him with the opportunity to emerge himself in the question why IT and/or Information System (IS)-related projects are not always successful and do not provide the intended benefits that were originally anticipated. This is currently a problem internationally as valuable resources are wasted on projects and programmes that do not add value to the strategic objectives of the organisation. It is an international problem where there is a gap between theory and practice and he is in the ideal position to address this problem.

The focus of his research is the overarching topic, and his particular interest is the strategic alignment of projects to the vision of the organisations. This alignment is from the initiation of a project to the realisation of benefits. He developed a framework (Vision-to-Project i.e. V2P) that ensures that projects within an organisation are linked to the vision. Within this framework, a natural outflow of research is the realisation of benefits to the organisation through the implementation of IT and/or IS systems. Benefits realisation is part of a complex system and his research to date has identified the following impediments in the realisation of benefits, (1) IT project success rates as well as IT project management maturity levels did not improve over the last decade and these results are in line with similar international research, (2) IT project managers are not necessarily following best practices and industry standards, (3) governance and auditing structures are not in place and (4) IT project managers' training and required skills are not aligned. If these four aspects are addressed through research and practice, then benefits realisation can occur.

His research has given him national and international presence. He is currently a regular reviewer for national and international journals. He was actively involved in the development of new international project management standards ISO21500 and ISO21503 (portfolio management). Project Management SA awarded him the Excellence in Research Award as recognition for his active contribution to the local and global body of knowledge by conducting and publishing scientific research in portfolio, programme and project management.

He is currently heading the Information Technology Project Management Knowledge and Wisdom Research Cluster. This research cluster focuses on research in IT project management and includes, amongst others, governance, auditing and assurance, complexity, IT project success, benefits management and sustainability. Email: cmarnewick@uj.ac.za

Wikus Erasmus

Wikus Erasmus has been researching and lecturing at the University of Johannesburg since 2010 in the Department of Applied Information Systems. He has attained a master's degree in Business Management with his undergraduate studies in Informatics. He is registered as a PhD candidate.

He did a tour of duty as a project manager in the construction and information technology industry where he primarily focused on IT infrastructure implementations. These were for major South African corporate clients, including financial institutions and retail holding groups.

His experience as a project manager in the IT industry has guided him to focus on various issues of importance to project management. These include the governance of projects, programmes and portfolios, the strategic alignment of projects and the success of IT projects. He has published various papers that addressed poor communication and poor risk management practices in IT projects. He also experienced the importance of stakeholder relations, even when challenged, in the successful completion of a project.

He is of the opinion that proper governance frameworks should be implemented if greater project success rates are to be observed as these would improve the strategic alignment of projects. This improved strategic alignment would ensure that projects that contribute to organisational goals will be attempted. The process needs to be overseen with concurrent project auditing and a final project audit to impart organisation to the organisation. These verification methods are yet other areas that he has found lacking in the practice of project management. Email: werasmus@uj.ac.za

Nazeer Joseph

Nazeer Joseph (BCom, BCom Hons, MCom) is a native of Johannesburg who, while working on his master's degree, joined the University of Johannesburg (UJ) as a part-time lecturer for the Department of Applied Information Systems. The output of his master's degree was a predictive model for determining IT project success. His master's degree, which he achieved cum laude, signifies his contribution to the IT project management body of knowledge. On completion of his MCom, he joined UJ on a full-time basis. He chose to pursue an academic career once he completed his MCom and realised that the field of IT project management requires extensive attention in order to improve IT project success. The poor performance of IT projects is a global phenomenon and must be addressed to ensure these projects deliver the expected benefits to realise organisational goals and objectives.

His research touches on a number of areas in the IT project management domain, (1) IT project management processes, (2) Agile IT project management, (3) IT project performance, (4) IT project management competencies and (5) IT project management sustainability. He is currently working on his PhD in IT management with the primary focus on IT project management processes. A key aspect why IT projects fail is that current project management processes are inadequate for IT projects. The aim of his PhD is to investigate why current processes are inadequate and what can be done to improve these processes and subsequently IT project performance.

As a junior lecturer and researcher at UJ, he has established himself as performer and contributor to the IT project management body of knowledge. He publishes in international journals, participates in conferences and strives to continuously contribute as a journal reviewer. His master's research was the only master's degree presented at the 2014 PMI Research and Education Conference.

In an effort to improve the state of IT project performance, he works within a research cluster which has established close ties with South African organisations to assist them with addressing this problematic phenomenon. Email: njoseph@uj.ac.za

Chapter 1

Introduction

Project success is one of the enigmas within the project management discipline. No one is sure how to define project success, what contributes to projects succeeding or failing or how to measure the success of projects. This is even worse when it comes to Information System (IS) projects. The deliverables of IS projects are seldom seen apart from some application that users and customers use as part of their daily routine. The only time that the deliverable of an IS project is visible and tangible is when the focus of the IS project is to replace or upgrade hardware.

Investment in information technology

Vast amounts of money are spent annually on Information Technology (IT). The rationale is that organisations cannot function without IT and therefore it warrants the large amounts of money that are invested in IT. A report by Lovelock et al. (2017) indicated that IT spending is rising on an annual basis and

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TABLE 1.1: Information technology spending world.

Spending (Billions of dollars)	Years						
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Data centre systems	166	171	170	175	176	178	181
Enterprise software	310	314	333	355	380	407	436
Devices	649	646	588	589	589	593	593
IT services	897	866	900	938	981	1029	1081
Communications services	1541	1399	1384	1408	1426	1441	1462
Total	**3564**	**3395**	**3375**	**3464**	**3553**	**3648**	**3752**

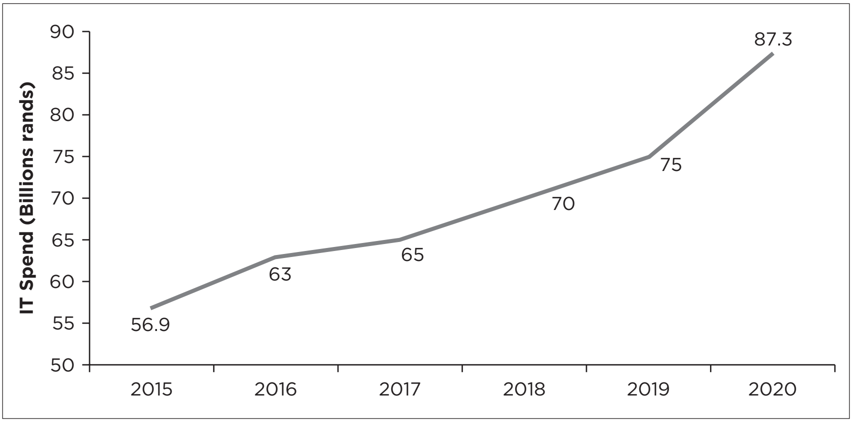
Source: Lovelock et al. 2017.

will continue to rise for the foreseeable future. Annual growth is predicted to be around 2.7%. The prediction is illustrated in Table 1.1.

It is evident from the amounts in Table 1.1 that companies as well as governments spend a lot of money on IT-related services. The annual increase of 2.7% also indicates that IT is a continuous investment. This continuous investment in IT is also evident from a South African perspective where it is expected that South Africa will spend $10.5 billion in 2017. This is 0.3% of the worldwide spend on IT. Research indicated that South African companies spend billions of rands on IT services as illustrated in Figure 1.1.

The South African spend on IT services is 0.5% of the worldwide spend on IT services. That is an amount of $5bn. IT services normally include, (1) IS consulting, (2) system integration, (3) maintenance, support and upgrades, (4) full outsourcing and (5) hosting. The remainder is spent on devices, enterprise software and communication services. Given this amount of money that is spent on IT, the question is raised whether this adds any value to organisations, irrespective of whether they are public or government entities. The amount that is annually spent on IT is a mere 0.7% of South Africa's gross domestic product.

One of the control objectives within COBIT 5 (EDM02) states that organisational leaders should receive the optimal value from



Source: Lovelock et al. 2017.
FIGURE 1.1: Information technology services spending – South Africa.

their investments in IT services and IT assets (IT Governance Institute 2012). Even from a governance perspective, IT investment should make logical sense and contribute to the overall benefit of the organisation. IT investments are generally implemented through programmes or projects that create benefits and ultimately business value (Curley, Kenneally & Carcary 2016).

■ Value of IT

IT provides value to entire organisations because they reach out to the world through IT. IT is not perceived as a stand-alone entity or division because it is integrated within the organisation, and organisations cannot perform without IT. When IT does not deliver value, then the chances are that the organisation will also not reach its optimum performance.

The questions that organisations need to answer are: Firstly, What value is IT to the organisation? and secondly, How can this value be measured? The value of IT can be determined through the following equation:

Value of IT = Benefits – Costs

Given this equation, organisations should determine the benefits that they receive from IT and also how much it costs to implement, maintain and upgrade IT.

Determining the costs of IT is relatively easy, but organisational leaders should not just take the direct costs into account but also the hidden or overlooked costs. Hidden costs include, but are not limited to, recruiting, training, office space, software enhancements (upgrades), software maintenance (bug fixes), hardware upgrades, hardware maintenance and scheduled outages. Ascertaining the benefits of IT is not easy. The easiest way might be to shut down the entire IT department for a day or two and determine the impact on the organisation based on lost sales and opportunities or the negative impact on the brand of the organisation.

Irrespective of what metrics are used to determine the benefits of IT, a general way to determine the benefits is to use financial calculations such as Return on Investment, Payback Period or Net Present Value. The results from these financial calculations normally indicate whether an investment in IT is a safe and profitable investment. The benefits of IT are also intangible and these are the challenge that organisational leaders face. How do organisations quantify the intangible benefits of IT?

Harris, Herron and Iwanicki (2008) provided a framework that can be used to determine the value of IT. The value of IT is determined over a period of time and is based on the investment in IT and also the benefits of IT to business. A simplified version of the framework is illustrated in Figure 1.2.

The value of IT to business is determined by the degree whereby processes are influenced and changed, how sales have improved and whether there is a growth in revenue at the end

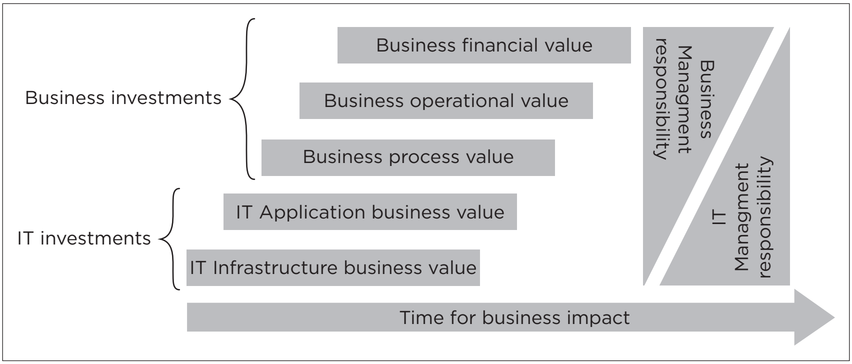


FIGURE 1.2: Information technology value framework.

of the day. Figure 1.2 actually highlights that everyone in the organisations are responsible for determining the value of IT. The IT department provides IT as an enabler for business and it is up to business to determine to what extent they want to embrace IT.

IT investments are normally realised through projects and the more successful the projects, the more value is created from the IT investments. The following sections briefly discuss the success rates of IS projects and highlight that organisations do not obtain value from IT projects and therefore also not from IS.

Information technology is the cumulative word that is used to describe everything and anything that has vaguely to do with computers. IT consists of three components, of which the first is computer science. This discipline focuses on topics such as discrete structures, human-computer interaction, programming fundamentals, graphics and visual computing, algorithms and complexity and programming languages amongst others. The second layer or component is information technology. This discipline focuses on the selection, creation, application, integration and administration of computing technologies. Computing technologies include networking, databases, web systems and information security. Information systems is the third layer and focuses in general on the improvement of organisational processes and the design and management of enterprise architecture. Topics within the IS field focus on data and information management, enterprise architecture, IT infrastructure, IS project management, systems analysis and design as well as IS strategy.

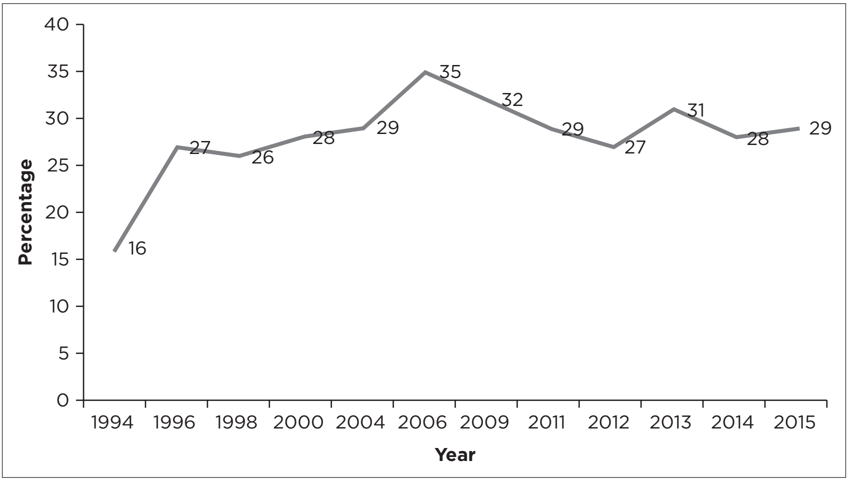
This study focuses specifically on the third layer, that is, the IS layer and more specifically on IS project management.

IS project success rates

IS projects are the vehicles that organisational leaders use to implement the IT strategy. The logical conclusion is that when IS projects fail or are perceived as not delivering on all the benefits, then the IT strategy is not fully implemented. This then creates an imbalance where the IT strategy does not fully contribute to the organisational strategies.

Information system project success has been studied over the last couple of decades by academics and practitioners alike. The reason for this almost frenetic research is that there is enough evidence to indicate that IS projects are still failing at an alarming rate. This was the case two decades ago, and it is still the case in the late 2010s. Research is performed internationally by the Standish group which produces the Chaos Chronicles, and in South Africa the research on IS project success rates is called the Prosperus reports (Labuschagne & Marnewick 2009; Marnewick 2013; Sonnekus & Labuschagne 2003). Results from the international research are shown in Figure 1.3.

The results indicate clearly that something drastically is wrong as the rate to successfully implement an IS project is on average 28%. This implies that 70% of IS projects either do not add value or add limited value to organisations. Of even greater concern is the fact that the success rates have stagnated at around 30% for the last decade, implying three things:



Source: Labuschagne and Marnewick (2009); Marnewick (2013); Sonnekus and Labuschagne (2003).
FIGURE 1.3: International information system project success rates.

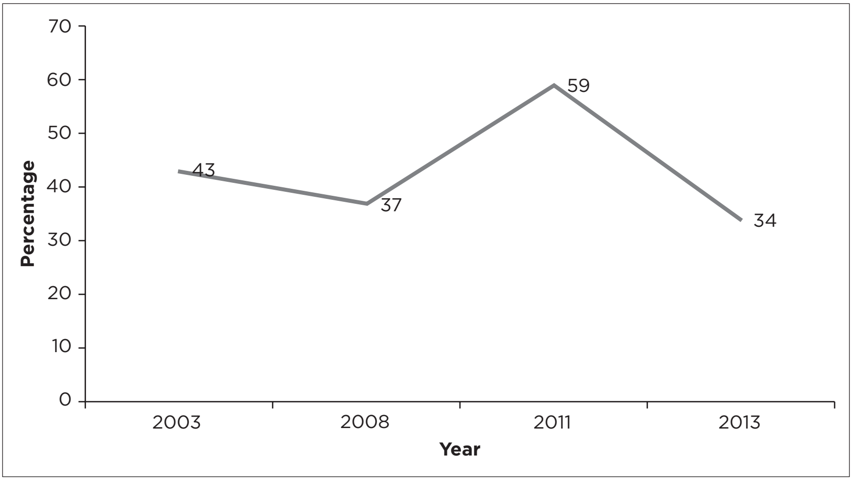
1. IT departments and professionals actually do not care about these results.
2. We do not understand the complexity of IS projects.
3. We are measuring the success of IT projects incorrectly.

IS projects success rates within South Africa do not look much better as indicated in Figure 1.4.

Although the South African success rates look better than the international success rates, South African companies are in the same boat as international companies where a mere third of IS projects are perceived as successful.

When these results are translated into monetary value, a gloomy picture is created as indicated in Table 1.2. The results indicate that $17 820bn are wasted on IS projects that either do not deliver or deliver little value to a company.

The South African perspective is just as bleak as indicated in Table 1.3. On average, 57 cents are wasted for every one rand spent on IT.



Source: Labuschagne and Marnewick (2009); Marnewick (2013); Sonnekus and Labuschagne (2003).
FIGURE 1.4: South African information system project success rates.

TABLE 1.2: Information technology waste – worldwide.

Year	Billions of dollars	
	Spending	**Waste**
2014	3564	2566
2015	3395	2444
2016	3375	2430
2017	3464	2494
2018	3553	2558
2019	3648	2627
2020	3752	2701
Total	**24 751**	**17 820**

The results depicted in this section clearly indicate that companies need to address the success rates of IS projects as a matter of urgency. Information technology cannot continue to be seen as a black hole into which money disappears and little or no value is created for the company and all the relevant stakeholders.

TABLE 1.3: Information technology waste – South Africa.

Year	Billions of rands	
	Spending	Waste
2015	56.9	32.4
2016	63	35.9
2017	65	37.1
2018	70	39.9
2019	75	42.8
2020	87.3	49.8
Total	**417.2**	**237.8**

■ Strategic alignment of IT

Projects are generally perceived as the vehicles to implement strategies (Cooke-Davies 2016; Martinsuo, Gemünden & Huemann 2012; Marnewick & Labuschagne 2010). These strategies can be organisational strategies or they can be strategies specific to a division within the organisation. IT strategies are also implemented through projects.

IT strategies are derived from the organisational strategies and are therefore aligned with the organisational strategies (Marnewick & Labuschagne 2011). This implies that when the organisational strategies change, the IT strategies should also change and be realigned with the organisational strategies. Within the COBIT governance framework, EDM01 (Ensure Governance Framework Setting and Maintenance) focuses on the alignment of the IT strategy with the organisational strategy (IT Governance Institute 2012). EDM01 measures three specific concepts related to the IT strategic alignment:

- The percentage of organisational strategies supported by IT strategies.
- The level of stakeholder satisfaction with the intended IT portfolio. The IT portfolio consists of various programmes and projects that will implement the IT strategy and ultimately the organisational strategy.

- The percentage of IT-value drivers that are mapped to the organisational value drivers.

Given the notion that projects are the vehicles to implement the IT strategies, organisational leaders should then be seriously concerned. The IS project success results clearly highlight the notion that IT strategies cannot be fully implemented because of the large number of IS projects that are failing. It is evident that only a small percentage of the IT strategy is implemented which in turn implies that IT strategies are not necessarily supporting the organisational strategies. This raises the question whether IT adds value to the organisation at large as suggested by EDM02.

This non-delivery of IT strategies creates a governance concern. The question that needs to be answered is what the real value is that IT brings to the organisation at large. There is no doubt that organisations cannot function without IT, but the question is whether IT is of strategic value or operational value. The results suggest that IT is more of operational value than strategic value.

Types of IS projects

There is no one-size-fits-all solution when it comes to the implementation of IS projects. IS projects come in different flavours and IS project managers should take cognisance of these different types of projects.

Infrastructure

The implementation of IT infrastructure is one of the least complex projects to realise. These types of projects focus on the implementation of hardware such as networking equipment or the installation of desktops and printers. What makes these types of projects less complex is the simplicity and predictability to implement. For example, when an organisation needs to relocate offices, new network points need to be installed. The project schedule is easily created, as the project manager will know more or less how long it takes to install a network point and that the time needed is merely multiplied by the number of network points. The same logic applies when printers or desktop workstations need to be installed.

Customisation

Customisation of software is a little bit more complex than the implementation of infrastructure. Software products do not necessarily suit the needs of an organisation as is. To cater for the specific needs of an organisation, software needs to be customised or changed. This change is more a cosmetic change to the existing software product than a major change to the internal workings of the software package. Customisations might include the change of financial reports to suit legislation or a change in the look and feel of an order capture screen.

Integration

Integration on the other hand is more complex than customisation. Integration focuses on sending data (information) between two software products. This implies that the software developer needs to understand the data structure of both products and the way that data is stored. Integration focuses on the conversion of data from the one product to the other product and vice versa. Planning for integration is also tricky as it is not always that easy to estimate the duration of any integration.

System implementation (full)

A full system implementation is extremely complex and contains a lot of uncertainties. A full system implementation is typically when organisations decide to replace one system with another system. This might be the case when an Enterprise Resource Planning (ERP) system replaces a legacy system. This type of implementation requires all hands on deck and normally includes infrastructure replacements, customisations and integrations with other systems.

System implementation (upgrade)

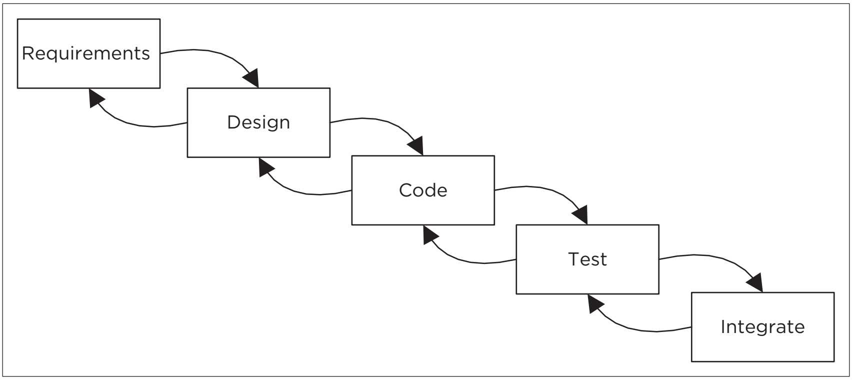
An upgrade is also complex and consists of a level of uncertainty but not to the extent of a full system implementation. The difference between an upgrade and a full implementation is that the basic building blocks are in place. The upgrade focuses on staying current with the latest version of the software. The upgrade might include the upgrade of infrastructure but definitely some customisations and integrations. Customisations and integrations can follow different methods of implementation, that is the traditional Waterfall method or an Agile approach.

Method of implementation

Various methods exist to implement IS projects, but it is not the purpose of this book to discuss all the different methods. The two most important methods are the Waterfall model and Agile and its various variations.

Waterfall model

One of the first structured approaches developed was the Waterfall process. In this model as illustrated in Figure 1.5, the process is executed in an orderly sequence (Leffingwell 2011). Each stage is completed before the next stage starts (Leffingwell 2011). Requirements are agreed, a design is created after which the coding follows and testing is performed. The final step is integration. In practice when implementing complex systems, it is almost impossible to have requirements that do not change



Source: Dorfman and Thayer (2000).
FIGURE 1.5: Waterfall model.

during the implementation life cycle (Dorfman & Thayer 2000). The advantage of the model is that it is a simple process to manage (Sommerville 2001).

An iterative approach is used in the Waterfall model where each successive step provides feedback to a previous step (Royce 1970). However, the Waterfall model is mostly interpreted as a sequential linear process (Boehm 2006).

Agile approach

Agile methodologies were initially authored to manage the development of software development projects, but have been extended because of their popularity and success with handling most types of IS projects. Agile software development is a method of software development that is characterised by an emphasis on, (1) people, (2) communication, (3) working software and (4) responding to change.

The working definition of Agile methodologies can be summarised as a group of software development processes that are iterative, incremental, self-organising and emergent. Hence from a theoretical perspective Agile methodologies can be defined as:

- **Iterative:** The word iterative is derived from iteration which carries with it connotations of repetition. In the case of Agile methodologies it is not just repetition but an attempt to solve a software problem by finding successive approximations to the solution starting from an initial minimal set of requirements.
- **Incremental:** Each subsystem is developed in such a way that it allows more requirements to be gathered and used to develop other subsystems based on previous ones. The approach is to partition the specified system into small subsystems by functionality and add a new functionality with each new release.
- **Self-organising:** This term introduces a relatively foreign notion to the management of scientific processes. The usual approach is to organise teams according to skills and corresponding tasks and let them report to management in a hierarchical structure. In the Agile development setup the 'self-organising' concept gives the team autonomy to organise it to best complete the work items.
- **Emergent:** The word implies three things. Firstly, based on the incremental nature of the development approach the system is allowed to emerge from a series of increments. Secondly, based on the self-organising nature a method of working emerges as the team works. Thirdly, as the system emerges and the method of working emerges a framework of development technologies will also emerge.

It must be noted that for the purpose of this book and study, reference is made to Waterfall projects and Agile projects. Waterfall projects are IS projects that make use of the Waterfall method to deliver the software that forms part of the larger project. Similarly, Agile projects are projects that make use of Agile methods to develop software. These terms are strictly not the correct terms but are used for ease of reading and understanding.

Previous studies uncovered various factors that contribute to IS project success (Marnewick 2013; The Standish Group 2014). Although complexity was defined as a factor, complexity as a construct was never investigated as a factor itself. The purpose of this study is to understand complexity within the IS domain and to determine the relationship between IS project success and complexity. This was achieved through a quantitative approach.

Research methodology

A quantitative approach was used for this study as the primary aim was to determine current IS project success rates as well as the relationship with complexity (Denscombe 2010; Thomas 2003). The rationale for this decision was two-fold. This study builds on previous studies (Labuschagne & Marnewick 2009; Marnewick 2013; Sonnekus & Labuschagne 2003), and IS success rate trends need to be established. This can only be done through a longitudinal study that is embodied within a quantitative approach. The second reason was that it ensured that each respondent was presented with the exact same questions in the same sequence. Moreover, this allowed the researchers to reliably aggregate and compare the responses between different sample subgroups.

Probability sampling was used as this research focused on providing a representative view of the unit of analysis for the purpose of generalisability (Sekaran 2003). Simple random sampling was selected because it not only provides results which are highly generalisable, but also adequately represents the target population. Furthermore, as this form of sampling exhibits low bias, the results obtained would provide an objective view of the research problem.

The instrument used for this study was a questionnaire. The questionnaire was divided into four sections. The first section focused on the biographical information of the respondent. The second part focused on the type of IS project that is under investigation. Two important aspects that form part of an IS project had to be answered. The first aspect speaks to the type of IS project and the second aspect speaks to the type of method that was used to implement the IS project.

The third section of the questionnaire dealt with the notion of IS project success. This section was designed around the model of Bannerman and Thorogood (2012). Each component within a success level was measured based on a Likert scale. Respondents could choose between poor, fair, good, very good and excellent. This was applicable to processes, deliverables, business and strategic success. Actual figures were provided for cost and time that form part of project management success.

The fourth section of the questionnaire focused on the complexity of the project. Five types of complexity had to be assessed based on a Likert scale. Respondents could choose between simple, relatively simple, fairly complex, complex and very complex. Organisational complexity consisted of 34 types of complexity, technical complexity consisted of 12 types, environmental complexity consisted of 13 types, dynamics consisted of 6 types and uncertainty consisted of 10 types. The types of complexity are discussed in detail in Chapter 3.

Book layout

The book is divided into the following chapters for ease of reading and referencing. Chapter 2 focuses on IS project success and what constitutes IS project success. The framework of Bannerman (2008) is used to describe IS project success. Success is not just a yes or no answer but can be measured at various levels that might have an impact on one another. This model or approach provides organisational leaders with a better way to measure and determine IS project success.

The third chapter unpacks the notion of complexity. This is done through the lenses of IS projects. The outcome is that IS projects are complex and that five types of complexity influence IS projects. Each of these five complexity constructs consists of elements that in turn consist of features. This makes the management of IS projects extremely complex.

Chapter 4 analyses the success of IS projects. Each level of the framework is used to determine project success. For each level, the overall success is determined as well as the success for the Waterfall and Agile projects. The results highlight that there is an improvement in overall IS project success and that Agile projects might be more successful than Waterfall projects.

Chapter 5 investigates the results of IS complexity. To simplify the matter, the top five and bottom five elements are provided for each complexity construct. This is also done for all IS projects and specifically for the Agile and Waterfall projects.

Chapter 6 focuses on the relationship or symbiosis between IS project success and complexity. The results indicate that a symbiotic relationship exists between IS project success and complexity. The various complexity constructs are mapped to the levels of IS project success.

Chapter 7 concludes the book. A synopsis is provided to enable organisational leaders and IS project managers to utilise the information and make better decisions, increase IS project success rates and address complexity within IS projects.

Chapter 2

Demystifying project success

Most IS projects fail (Johnson 2014; Marnewick 2013a, 2013b). In fact, almost two thirds of IS projects evaluated since 2003 could not be classified as success stories. Figure 2.1 indicates the lack in progress made by project management professionals in increasing the rate of delivering success.

The South African results approximate the international results, indicating that there are not simply local conditions at play. There must be something at the heart of IS project management that is actively driving these results.

Billions of rands are spent each year on IT services, and investment is set to grow in this area (Lovelock et al. 2017). No wonder organisational leaders are losing confidence in project management methodologies when almost two-thirds of IS projects fail and investment is lost, or the project does not deliver on its promise.

Much has been written on why projects fail (Budzier & Flyvbjerg 2015; Erasmus, Marnewick & Joseph 2014; Joseph

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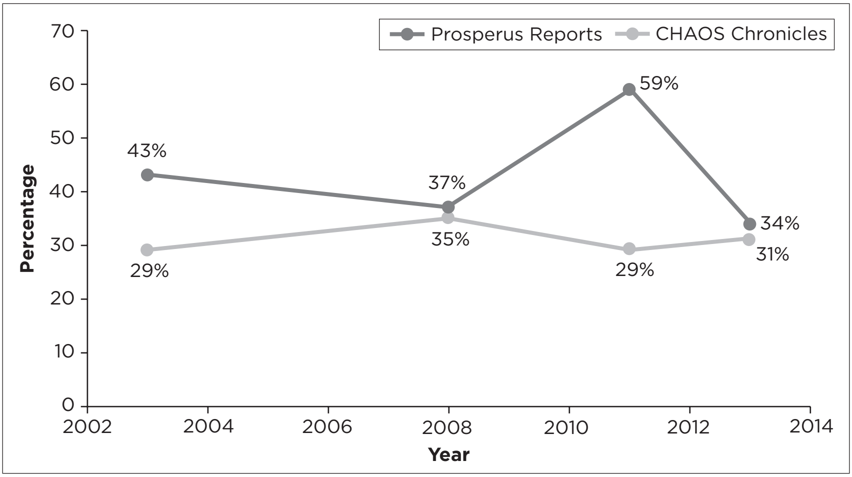


Source: Joseph, Erasmus and Marnewick (2014).
FIGURE 2.1: South African and global information system project success rates.

et al*.* 2014; Marnewick, Erasmus & Joseph 2016a, 2016b; Ngoma & Erasmus 2016). This knowledge has been with project professionals for a very long time. It is known why projects fail. It is known what should be done to ensure projects are delivered successfully (Cooke-Davies 2002). Yet, project managers cannot seem to increase their project delivery success rates. This is the annunciation of Cobb's paradox: If we know why projects fail and how to prevent it, why do we still fail at projects? (Bourne 2011).

The answer could lie in the fact that much research has been done in the technical aspects of project management, while limited studies are done in the so-called 'soft issues' around project management. It may very well be that the identified inhibiters and enablers of project success are only partially responsible for project outcomes and more remain to be uncovered. What may complicate matters even more is the possibility that IS projects do not fit the traditional paradigm of project management as we know it today. Perhaps IS projects are so different that project management should be rethought in its entirety in order to deal with the idiosyncrasies of IS project management.

What is abundantly clear is that should IS project delivery continue on the current trajectory, we may very well not encounter the term 'IS Project Management' in future. Investment decision-makers will look elsewhere to achieve the goals that formal project management methodologies promised.

The evolution of success

One of the formal definitions of a project is that it is a set of predetermined activities that need to be completed incrementally in order to achieve a unique, predefined objective through the use of resources in a specified time frame (Project Management Institute 2013; Schwalbe 2016). At face value, it is a relatively simple task to provide a deliverable in the manner a customer requests.

Tools, techniques and processes that were already available to operations were adapted to compensate for the closed-off time frame in completing these activities. These were harnessed into formal project management methodologies. This was the approach of the 1970s, although projects have been attempted and completed for centuries and millennia before then.

Much of past research was focused on the mechanisms, tools and techniques for managing a project properly. Bodies such as the Project Management Institute and Association for Project Management have developed innumerable toolkits, standards, methodologies and frameworks to assist project practitioners in this endeavour.

But that was not the end of the story. Organisational leaders discovered that even though they had to manage project managers through strict quantifiable metrics, such as the triple constraint, customers were often satisfied with the end product, although they might not have been satisfied in the manner of its delivery. The product became then the priority at the end of the day. The end seemed to justify the means (Davis 2014).

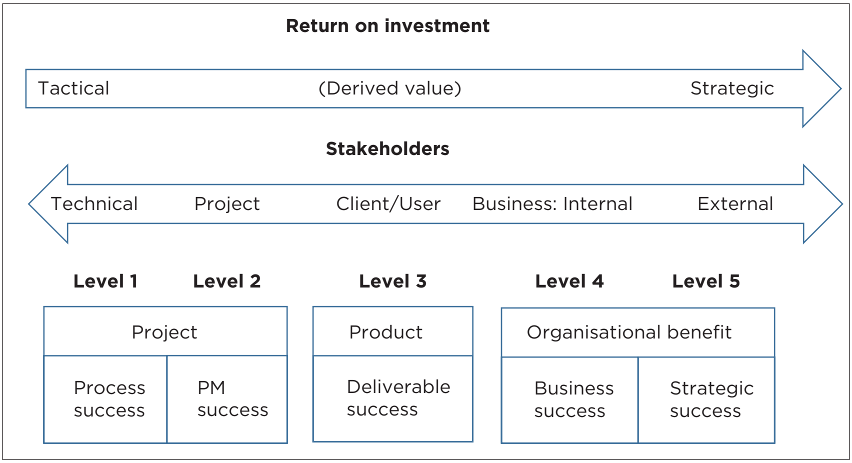
Success varied by industry, yet large amounts were and are invested in project management training and capabilities. As organisations continued to grow, so did the scale and complexity of projects. So much so that megaprojects could not be managed by a single individual but through committees. Megaprojects had strategic significance and as such they were broken down into smaller projects. Programmes emerged. Some oddball projects were encountered that did not seem to fit in with the strategic intent of the organisation. Portfolio management was then required to select and reject projects that would have the greatest benefit in supporting the organisations' strategic objectives. However, complexity grew even more as organisations sought to gain competitive advantage through projects. Market forces dictated that organisations needed to take decisive action in attempting to gain and maintain market share. Project management has now become an important strategy-achieving tool through portfolio management. Any selected project has to contribute to achieving the greater organisational strategic intent.

Ultimate project success is now characterised by strategically effective organisations. But what does that mean to the project manager that is currently experiencing his or her first project that simply cannot be steered to success, regardless of what interventions are put in place? The so-called 'project of death'.

Project outcomes

No discussion on project management success can be held without referring to the seminal work performed by Paul Bannerman. He rightly deduced that project success is achieved on multiple levels and developed a framework to illustrate this concept (Bannerman 2008; Bannerman & Thorogood 2012).

Figure 2.2 lays out the case that project success is defined from various perspectives. In Level 1, project success is defined by the successful implementation of project management tools



Source: Adapted from Bannerman (2008).
FIGURE 2.2: Five levels of project success.

and techniques. Success at this level is determined through the selection of appropriate tools and how effective they were used.

In Level 2, success is measured according to whether the project has met the triple constraint of time, cost and scope. A failure to meet any of these technical constraints would result in total project failure at Level 1 and Level 2.

Customers, clients or users are usually less concerned about whether the projects have used the appropriate technical tools. They may be somewhat concerned how well the project fared with regard to the triple constraint. However, users and customers are mostly concerned about the deliverable the project produces at the end of the day. Consideration such as 'fit for use' or usability are of greater concern at Level 3. Various examples exist where the product produced by a project can successfully be used by the project's customers and has yet failed on Level 1 and Level 2 criteria (Marnewick 2016; Serra & Kunc 2015). If a project meets the customer's specifications, the project can be termed a success on Level 3. Product success would then be achieved.

Project success on Level 4 is determined by realised benefits provided subsequent to project completion. Should the benefits promised in the initial business case actually accrue or realise as a direct result of a completed project, then the project would be a success. Unfortunately, these benefits do not immediately become apparent as soon as the project is completed (Marnewick 2013b). These benefits would only start to become a reality when the product delivered by the project has been fully operationalised and integrated in the organisation. Only after an indeterminate period of time, and after careful observation and measurement, would the direct impact of the deliverable become known.

Ultimately, Level 4 project success is determined by whether or not business goals have been achieved or not through the successful completion of a project. What one has to bear in mind is the fact that certain unintended consequences or benefits may result after the integration of a project product in the organisation. Where it may be difficult to point to a specific project to indicate what impact it had on achieving business goals, it may be simpler to determine where a group of strategically similar projects have had such an impact. This may be done in the form of prudent programme management where control and coordination could be achieved between projects that are aimed at achieving a particular business objective. In organisations where no programme management discipline exists, it will have to make do with strong project management reporting.

Level 5 project success is externally focused in that strategic success is to result because of successful project delivery. These concerns are focused on whether the organisation's position shows improvement with regard to investors, the competition and the market in general. This level of success may be extraordinarily difficult to attribute to any single project. Therefore, portfolio management may be better suited as this is an attempt to aggregate all project outcomes throughout the organisation to determine the strategic success of the project discipline in the organisation. This will obviously only be of any meaning if an effort was made to align all projects to the organisation's strategic intent.

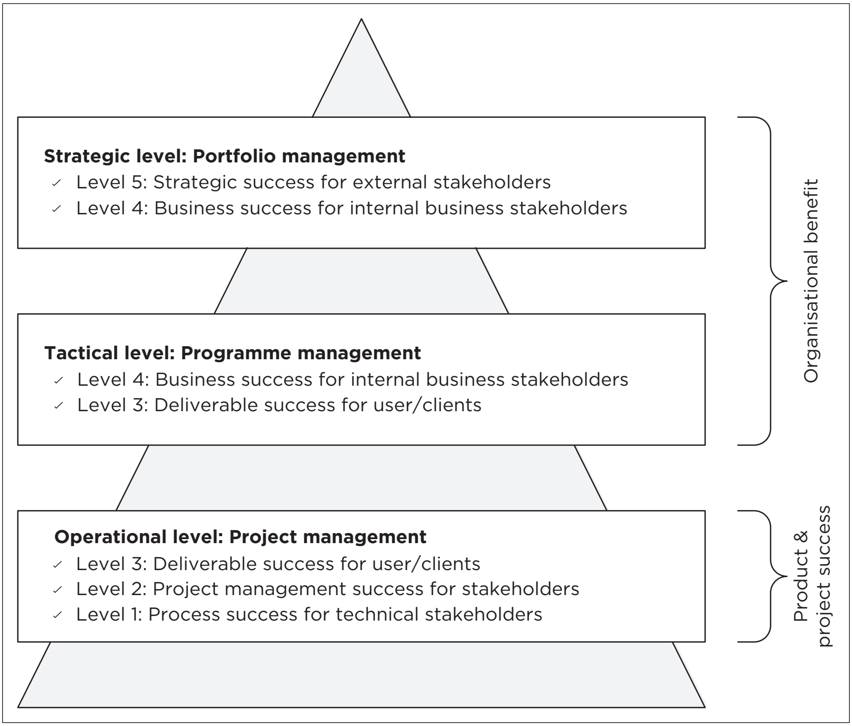


FIGURE 2.3: Project outcome and portfolio, programme and project management.

Mapping these perspectives to the traditional three organisational levels as well as project, programme and portfolio management provides the following view in Figure 2.3.

Some overlap may exist on Level 3 and Level 4. Deliverable success may form part of project or programme management, depending on the structure of the organisation. Level 4 is most often found under portfolio management (Jenner 2016) of the organisation but may also be found under programme management (Serra & Kunc 2015). These adaptations will have to be considered in organisations that do not have a programme management office for lack of need.

Success and failure

When one is set to lose a contest one was almost certain to win through bad judgment and mistakes, one is said to have snatched defeat from the jaws of victory. In project management, there seem to be many avenues to attain success, given the five different available perspectives. Additionally, we know what causes projects to fail and to succeed, yet we continue to reach out feverishly towards defeat.

Bannerman (2008) takes great pains to clarify that the five levels of project success are not related in an aggregated manner. He indicated that process success does not imply project management success. A project that was successfully completed in scope, time and budget does not guarantee that the deliverable will be accepted or useful to the customer. A product regarded as useful by the customer does not imply that business objectives will be met. Achieving business objectives does not imply that the organisation will be strategically successful. Clearly success is dependent on a specific stakeholder's perception.

Does one need to be successful on all five levels before a project can be deemed successful? Luckily this seems not to be the case as it would be a Herculean task. The technical project team member responsible for a specific process on Level 1 can in no way be held responsible for the outcome on strategic success in Level 5. However, is the executive board dependent on these technical processes being completed successfully in order to attain strategic success in the long term? The research determines it need not necessarily be so.

We are left with a conundrum. Vast bodies of literature extoll the virtues of proper project, programme and portfolio management. Each academic work enumerates the seemingly countless processes, procedures, inputs and outputs for each activity. Is it all for nought when the organisational leaders above the project manager's pay grade are unaffected by their successes and failures? Why is there such an emphasis on completing projects successfully when there is little ultimate significance in the high levels of the strategic hierarchy?

It seems that project management shares certain principles with alchemy. The alchemists of yore attempted to transform lead into gold. They never attempted to create gold from nothing. The same may be true in project management. The technical processes on Level 1 needed to produce a '*substance*' that project managers could use to transform into another '*substance*' in Level 2. This new substance takes on the form of a project outcome: success or failure. The individuals in Level 3 need to create this '*project management substance*' and create a product that could be either a success or a failure. The Level 4 alchemist needs to transform this '*product substance*' into some sort of business benefit and that must be transformed again into strategic success in Level 5.

Therefore, two items are required in order to perform 'project management alchemy': substance and alignment, success is not necessarily required. The substance is the output from each level of project success. In order to guide the transformation process to ultimately deliver project management 'gold' in the form of strategic success, some sort of strategic alignment is required.

Without some sort of outcome from the previous levels, it would not be possible to create an outcome that could be ultimately usable in Level 5. And even if a high-quality outcome is delivered at lower levels, if it cannot be taken to ultimately further strategic objectives, the effort is futile.

Evidently, the terms 'success and failure' only have meaning on Level 5 as they relate to ultimate project outcomes. On Level 1 to Level 4, 'success and failure' only serve as a basis for organisational governance to ensure that resources are used appropriately in order to deliver a 'substance' of higher quality that could more easily be transformed in the next level.

Outcome influencers

What would enablers and inhibitors of success be at each level in this 'process' view? The discussion focuses on the three grouping of success as identified by Bannerman (2008):

1. Project success including technical process and project management success.
2. Product success.
3. Organisational benefit including benefits realisation and strategic success.

Project success

The vast body of research focuses its attention on the mechanism and processes of project management and what these contribute to delivering successful projects. The main enablers of success in this section primarily deal with the skills and knowledge of project managers.

Regarding specific technical processes, the main aspects that project managers and their team members need to focus on is in risk management and change control (Marnewick & Erasmus 2014). Of these two, risk management is the knowledge area in the PMBOK® Guide that is the least matured in practice:

- Proper risk management practices increase the quality of project management in that eventualities are planned for in budget, schedule and scope. This would decrease variances in the triple constraint, resulting in a greater chance of project management success.
- When certain parameters of the project are changed, depending on whether specific technical processes are completed correctly, the knock-on effect impacts the triple baseline constraint. Change control must be present as change is a given in the vast majority of projects. The impact of uncontrolled changes is impossible to fully quantify. The effect on the project, however, is devastating.

The skill that most project managers agree is the greatest contributor to success is communication with the project team (Marnewick et al. 2016a, 2016b; Monteiro de Carvalho 2013). This stands to reason as all interaction in a project concerns the flow of accurate information.

Inhibitors to success would include the antecedents of the contributors to project success as discussed. However, when organisational leaders recognise the need for additional training something very counterintuitive happens. Project managers who are sent for certification courses seem to develop a reduced ability to deliver projects successfully once they are certified in a formal project methodology (Joseph et al. 2014). The reasons behind this are unclear, but as it stands, formal certification seems to be an inhibitor of project success.

Another great inhibitor to project success is an organisational culture that does not allow for or value prudent project management practices (Mir & Pinnington 2014; Rosemann & Vom Brocke 2015). This would include undue pressure on project managers to shorten the planning phase of their project in order to get to execution more rapidly. This rush may leave many risks and challenges unidentified, resulting in chaos during execution.

Product success

Product success implies the user and/or customer have their needs met through the project deliverable, regardless of how it came into their hands (Bannerman 2008). The greatest success enabler here is effective communication with stakeholders, more specifically between the project team and the user or customer (Barclay 2015; Davis 2014). This is to ensure that correct client specifications are used in designing the product or service to be delivered. This entails that proper requirements management takes place. Regular customer feedback is required to ensure that all stated needs are met in the deliverable.

Another enabler of product success is the active involvement of an individual that could fulfil a customer relations role that further facilitates communication. This is especially important when project management failure is looming.

An inhibitor to product success is, of course, miscommunication and changing requirements. It will obviously be much more difficult to meet customer requirements should these be in flux. Unreasonable customers may also decide not to accept the product even if all signed-off requirements are met, but the actual product is not what was expected by the customer (Turk, France & Rumpe 2014).

Organisational benefit

The organisational benefits are achieved as a result of successfully completed projects or programmes in the organisation that impart a strategic advantage.

Benefits realisation is a perspective internal to the organisation that could overlap the strategic and tactical organisational levels. This perspective takes a longer view of the effect of projects in the organisation in that benefits can only accrue after a project has been completed. These benefits are not immediately apparent. In order to internalise these benefits, the project deliverable needs to be integrated into the organisation. This would imply that some level of organisational change management must be initiated. This process could be illustrated as in Figure 2.4 (Coombs 2015).

For the implementation of an IS deliverable, operations need to be adapted to accept and effectively utilise the new deliverable. The premise is that business benefits will only accrue once business change has occurred through the use of IT. This seems eminently reasonable in an IS context (Whyte, Lindkvist & Jaradat 2016).

For the implementation of an IS-type deliverable, the following main inhibitors to benefits realisation are identified (Coombs 2015):

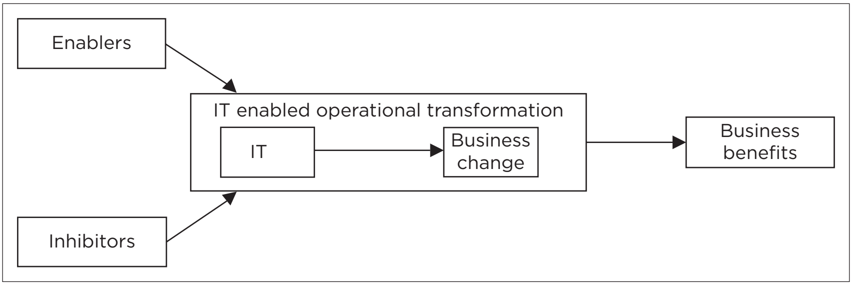


FIGURE 2.4: Information technology enabled operational transformation.

- **Staff not engaging with new ways of thinking:** This speaks directly to the difficulty in changing organisational culture and the individual's resistance to change.
- **Poor design of the new system:** Clearly this links to product success. A poorly designed product or deliverable will not be readily accepted by its intended users. Expected benefits will only accrue once these deficiencies are corrected after the closure of the project.
- **Poor performance of the system:** This is another product-related metric that would inhibit the use of the system and its subsequent realised benefits.

Here we see a much stronger link between levels of project success in Level 3 and Level 4, benefits realisation. The results imply that a poor product deliverable could negatively impact benefits realisation. A poor quality deliverable in Level 3 implies an inhibitor to benefits realisation in Level 4. Enablers of benefits realisation include the following:

- Training in the use of the deliverable. Users cannot immediately accept the new deliverable. Initial acceptance would be dependent on training and ensuring users and customers are used to the new systems. However, this would only account for product success on Level 3. Enhancing the chances of success at Level 4 requires ongoing training for users to use the new system to its fullest potential. A change in organisational culture is required in order to sustain the transformation effort and to prevent users from falling back into old patterns of behaviour that may have necessitated the creation of a new system.

It seems in benefits realisation that inhibitors are more technically oriented, while enablers are more organisationally oriented. It would, therefore, be appropriate that transformation activities take place under the auspices of an organisational entity that is responsible for mapping and tracking benefits. Strategic success on Level 5 has an external perspective where all project activities, from Level 1 to Level 4, culminate in some impact on the market. This is only possible where strategic alignment has taken place where all projects are part of a concerted effort to support strategy (Gerow, Thatcher & Grover 2015).

With this lofty goal in mind, it may stand to reason that project practitioners have very little to do with strategic impact external to the organisation. Instead, very senior members of the board tasked with portfolio management are the key role players that have to ensure that the organisation's strategic intent is achieved through the support of the entire organisation. The delivery of a product through project management methodologies, while essential, is only one small part of the entire exercise (Kaiser, El Arbi & Ahlemann 2015).

An enabler of strategic success from a projects perspective is a concerted strategic alignment initiative that ensures that all projects are selected on their probability of success and envisaged contribution to the organisation. Without such an alignment effort an impact on the market can still be made, however, the degree of impact would be very uncertain. Unexpected benefits or issues may arise more frequently in such a case.

Inhibitors to strategic success may include actions to avoid such as failure to establish a clear strategy and frequently changing strategy. Both these situations require the entire ship that is the organisation to change tack, while all its efforts are focused on achieving and supporting a different strategy.

External market condition will also influence the degree to which the current strategy is effective, if the organisation's chosen strategy has not been developed with this in mind. Inhibitors and enablers for the success of Level 5 are much more dependent on strategic management thinking than purely project management considerations.

Conclusion

How project success and failure is defined depends greatly on individual interpretation. When taking the organisational perspective, perhaps project management success should be viewed on a continuum and not on a binary scale of 'success' and 'failure'. When drilling down into the details of what technical and product success actually imply, lower orders of management need to be aware of what metrics are being used to determine and track how their scarce resources are being utilised.

Ultimately, the organisation exists to provide value to its shareholders. This is most significantly achieved through strategic impacts. However, there is something to be said for laying the foundation for such success. Success on lower levels of project management in no way guarantees success on higher levels. Likewise, failure on lower levels does not guarantee failure on higher levels. There is, however, an implication that success on lower levels contributes in some way to success on higher levels. Failure on lower levels may make success on higher levels more difficult, yet not impossible.

What is important is that an actual deliverable is created that can be used to eventually attempt to achieve strategic success through strategic alignment. In such a way, the organisation can attempt to snatch victory from the jaws of defeat, and not vice versa.

Chapter 3

Complexity of information system projects

Complexity is a concept which is now more prevalent than ever (Derbyshire 2016; Vidal & Marle 2008). Geraldi (2008:4) proclaims that 'mastering complexity is not a new challenge but an old challenge that is being increasingly recognized and accepted.' Project management literature traditionally emphasise the success criteria and success factors that are necessary to understand project performance (Belassi & Tukel 1996; Cooke-Davies 2002; Ika 2009; Pinto & Slevin 1987). Project management research has evolved over the years to include the concept of project complexity (Ahern, Leavy & Byrne 2014; Baccarini 1996; Cooke-Davies et al. 2007). The increased focus on project complexity is the result of attempts to address the fluctuating performance of various projects regardless of industry and type. This chapter aims to elaborate on the concept of project complexity and constructs which constitute project complexity.

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The concept of project complexity

Project complexity involves identifying and understanding the various intricacies embedded in a project. Baccarini (1996:201) introduced project complexity within the context of construction projects and argued that project management is 'associated with management of complexity.' The research of Baccarini (1996) subsequently resulted in the development of a conceptual model of project complexity. Similarly, Xia and Lee (2004) applied the concept of project complexity to IS projects and produced a conceptual model for IS project complexity. Similar literature works have developed models for project complexity to enlighten how projects are understood and perceived. Four key models are identified and discussed in the sections that follow.

Complexity model for new development products

New product development (NPD) projects are commonplace in many industries but suffer poor performance with regard to time and cost (Kim & Wilemon 2003, 2009). Kim and Wilemon (2003) investigated these projects and developed a complexity model for NDP projects. They argue that NDP projects consist of several functions and technologies which add to the level of complexity. Furthermore, the level of complexity faced by functional groups varies during projects which influences the 'complexity curve' of a project (Kim & Wilemon 2003:18). Kim and Wilemon (2003) discovered the following sources of complexity:

- **Technological complexities:** This source focuses on challenges with tasks and uncertainties around technology or a technological approach. Component integration and technological newness underpin the challenges and uncertainties. Component integration addresses the complexity of integrating the various technological parts, systems and subsystems at the software and hardware level. The aim is to integrate all components correctly and ensure the system operates effectively. Alternatively, technological newness looks at how new technology can be used to solve technological issues. If new technology is not understood, the implementation of such technology could be detrimental. This applies to the novel use of existing technology and the introduction of cutting edge technology. Introducing new technology also introduces other complexities such as the requirement of new skills and resources for effective exploitation.

- **Environmental complexities:** The markets in which organisations and product developers operate are dynamic as they follow a rapid pace and are unpredictable at the best of times. These external complexities require organisations to process data and information more efficiently to remain competitive and relevant in their industries. It is therefore of paramount importance to understand market size and growth, market variability (e.g. regulatory changes), challenges in predicting competitors and weakness in adapting to market change.
- **Development complexities:** Complications and complexity around the research and development processes are the core of development complexities. Factors underlying research and development process complexities include, integration of multiple research decisions, predicting effort, money and time required for new product development, component integration, evaluating process requirements for development, identifying and obtaining quality suppliers and management of supply chain relationships.
- **Marketing complexities:** Introducing products into new, untapped markets requires organisations to apply new and novel marketing skills to penetrate the market. This often involves conducting intense market and consumer tests. Risk appetite is an indicator of how organisations will approach entering a new market. Multiple considerations must be taken into account such as customer education regarding the product, introducing new distribution channels, understanding and managing the needs of a new market, establishing pricing policies, developing advertising campaigns, user adaptation and capability level as well as incompatible technologies.
- **Organisational complexities:** The organisational structure plays a defining role in rolling out NPDs. NPDs require interaction

between multiple business units, departments and employees which increases the level of complexity. Education and communication strategies must be thought out as these will ease the management of organisational complexity. Furthermore, effective knowledge management and transfer must exist within the organisation as this enables the application of new tools, techniques and technologies. Another important aspect to organisational complexity is that of forming and managing project teams which include multiple specialists. Team dynamics such as cultural differences, geographical location and competency must also be taken into account.
- **Intra-organisational complexities:** These complexities arise when organisations partner to achieve a common goal and pursue NPD projects. The original notion is that collaboration will not only mitigate other complexity areas but, in turn, generate other new complexities. Similar to organisational complexities, intra-organisational complexities consider aspects such as degree of formality and/or informality, dependency issues, communication and relationship management challenges, measuring a collaborator's contribution and distributing outcomes equitably.

Novelty, Technology, Complexity and Pace model

Shenhar et al. (2016:68) developed the 'Diamond of Innovation' model as a means to tackle project complexity. The model is also referred to as the Novelty, Technology, Complexity and Pace (NTCP) model (Frank, Sadeh & Ashkenasi 2011). The model focuses on project management style selection by assessing the four dimensions of NTCP. The four dimensions are defined as follows (Frank et al. 2011):

- **Novelty:** The newness of the product is the focus of this dimension. Three subdomains underpin the novelty dimension, (1) derivative, (2) platform and (3) breakthrough. Derivative projects have minor improvements over other products, while a new generation of products is developed through platform projects. Innovation projects produce unique and niche products which are significantly differentiated in the marketplace.

- **Technology:** Technology and uncertainty are inseparably linked in this dimension as the use of technology introduces varying levels of uncertainty. The aim is to reduce the level of uncertainty by effectively managing the technology employed in a project. Four types of technological projects exist, (1) low tech, (2) medium tech, (3) high tech and (4) super high tech. The more sophisticated the project, the higher the level of uncertainty and complexity. Alternatively, uncertainty also determines, amongst other things, duration and scheduling of tasks and activities, articulating and defining product requirements, planning precision and risk mitigation strategies.
- **Complexity:** This dimension specifically looks at product scope and the interdependencies between various project components. Complexity directly influences the level of formality by which the project will be managed as well as the processes employed.
- **Pace:** Pace stresses the importance of time goals during a project as this will influence the project structure and the level of management attention. There are four apparent levels of timed goals, (1) regular, (2) fast, (3) time-critical and (4) blitz. They follow a progressive scale on haste and importance.

Project Complexity Model

The Project Complexity Model (PCM) was developed to capture the various dimensions of project complexity (Hass 2009). The aim of the PCM is to provide a framework to identify and analyse complexity elements of a project and facilitate decision making amongst the project team. Hass (2009) argues that specific project management tools, methods and approaches will be determined by which dimensions apply to the project. The complexity dimensions within PCM are as follows:

- **Strategic importance, political implications and multiple stakeholders:** It is clear there are three subdomains within this dimension. Strategic importance is associated with the level of executive support and impact on the mission statement set out within the organisation's strategy. Political implications relate to the internal political landscape of the organisation. Political issues are often bureaucratic issues and red tape which hinder or inhibit the project from being performed as initially planned. If these issues are visible at all levels of management, the project becomes increasingly complex to manage. Stakeholders play an important role during projects and the higher the number of them, the higher the level of project complexity. Multiple stakeholder groups introduce communication and coordination challenges as well as conflicting expectations.

- **Level of organisational change:** The dimension looks at how the project influences and contributes to organisational change. Less complex projects have minimal influences such as impacting one department, business process or IS. Highly complex projects have widespread influences when the entire organisation is impacted including internal business units, multiple business processes, external joint ventures and information systems. Inevitably, the organisation has to transform as a result of a highly complex project.
- **Level of commercial change:** Commercial change pertains to how the organisation adapts and changes the way they interact within their industry, including activities such as advertising, marketing and collaboration. The level of project complexity directly influences how the organisation implements commercial change.
- **Risks, dependencies and external constraints:** Risk increases as the level of complexity increases. High risk projects carry increased risk with regard to the above-mentioned dimensions. Projects are always influenced by internal and external factors. Dependencies assess the relationship between the various factors as well as the impact they have on one another. Project integration efforts are also associated with dependencies as challenging integrations are often caused by large-scale projects where multiple elements must be integrated to realise the project's goals. External constraints relate to regulatory requirements within an industry or sector. Operating within a familiar regulatory environment implies less complexity, whereas highly regulated environments introduce multiple complexities when embarking on a new, novel project such as NPDs.

- **Level of IT complexity:** Information technology is a powerful tool to implement and be used in projects. This dimension determines what technology is used for any project type. Similar to the NPD model, existing and understood technologies traditionally lead to less complex projects. While innovation may be the key, the usage of unproven and immature technology creates complexity where specialist skill sets are required from external vendors.

Information systems development projects complexity model

The previous models have approached project complexity at a generic level. The information system development project (ISDP) complexity model was specifically developed for IS projects as they 'are inherently complex because they deal not only with technological issues but with organizational factors largely beyond the project team's control' (Xia & Lee 2004:70). Xia and Lee (2004) dissect ISDP complexity into four components:

- **Structural organisational complexity:** A number of elements exist within this component. The level of project manager control over resources is the most important element as lack of control implies that the project is driven by other individuals who are not actively and continuously involved in the project. User support is the second element. IS projects preferably need continuous user support and feedback to ensure the output is a solution which the users need. Insufficient staffing is the third element identified for structural organisational complexity. The project cannot meet simple goals such as time and cost if insufficient staff exists. The fourth element focuses on the specialised staff and skills required during IS projects. A deficiency of such staff will have detrimental effects on all IS project types. The final element, insufficient top management support, assesses how much support is garnered from senior management, such as the project sponsor. IS projects cannot be correctly aligned to organisational strategy if top management support is lacklustre or non-existent.

- **Structural IT complexity:** Emphasis is placed on more technical elements within structural IT complexity. Firstly, the involvement of multiple user units influences this complexity component as the different users will have different perspectives and needs. Cross-functional teams are an inevitable prerequisite for IS projects. The second element assesses what level of cross-functionality is apparent as various internal and external team members are required to perform the project. Multiple software environments are the next element within the structural IT complexity component. IS projects often span various software environments that further influence how the project is developed and installed. The next element focuses on multiple technology platforms as IS projects use a wide range of technologies to realise the project's goal. The inclusion of multiple technologies implies that knowledge and skill are required to implement the technologies effectively. This also directly relates to the next element of integration with other systems as compatibility of technology platforms and software environment come to the fore. Enterprise-wide IS projects, for example, require full integration across all systems and platforms to ensure the users' needs are met. The final element addresses the complexity of multiple contractors and vendors. Outsourced interventions during IS projects are commonplace as the contractors and vendors assist with the implementation of the project. Communication and collaboration must be effectively managed to ensure the project delivers as initially proposed.
- **Dynamic organisational complexity:** This complexity component places emphasis on pattern and rate of change during ISDPs. Change in business processes is the first area of assessment as IS projects introduce new ways of performing business tasks and thus re-engineer business processes. Frequency of information change must be managed as the users' information needs change rapidly during IS projects. Patterns regarding information change must be identified and understood to ensure the correct information is relayed to users at all times. Similar to changes in business processes, how the processes are changed from a user's perspective is important to understand given that they are the ones most likely to use the system for day-to-day activities. Certain IS projects also change the structure of the

organisation itself through the change and/or introduction of new business processes and functions. Alternatively, a different view is how a constantly changing organisational structure influences the project itself. Organisations which rapidly change structure during an IS project bring about added complexities to the execution of the project.
- **Dynamic IT complexity:** The IT infrastructure changes throughout its lifetime in an organisation. IT infrastructures can change rapidly given the rapid rate of development within IT. Constant changes in infrastructure add technical complexities to IS projects as it becomes difficult to make decisions when technological uncertainty arises. Furthermore, there must be careful cognisance of the IT architecture as this often dictates and influences structural IT complexities. Software development is a high-paced environment with rapid movement. Programming languages and tools are constantly evolving to enhance IS functionality. Rapid change in languages and tools must be considered at all times as these influence how the project is executed, implemented and tested.

The above-mentioned project complexity models provide an overview of project complexity and its subsequent components. The following section takes an in-depth look at what exactly constitutes project complexity and applies it to IS projects.

Constituents of project complexity

There are various views on project complexity and no clear definition or understanding of what exactly constitutes this phenomenon. This section goes beyond the project complexity models and analyses in depth how multiple publications conceptualise project complexity. Textual analysis was performed through content analysis to identify the underlying components of project complexity (Flick 2014; Martens & Carvalho in press; Pade, Mallinson & Sewry 2008). The following research protocol was applied when conducting the content analysis (Schön, Thomaschewski & Escalona 2017). Key concepts were first identified and articulated to develop search terms, for example 'project complexity, project management complexity, complex project management.' Six databases were targeted as they were identified as the primary databases which cover the key concepts. Forward and backward sampling were used to enhance content availability. Forward snowballing searches literature which has cited the literature in question, while backward snowballing searches the reference list for literature (Badampudi, Wohlin & Petersen 2015; Jalali & Wohlin 2012; Schön et al. 2017). The final step involved manual examination of literature sources to ensure the concepts were well represented and articulated (Asher 2013; Dube & Marnewick 2016; Schön et al. 2017).

Five underlying components were identified from the content analysis, (1) organisational complexity, (2) technical complexity, (3) environmental complexity, (4) uncertainty and (5) dynamics (Baccarini 1996; Bakhshi, Ireland & Gorod 2016; Bosch-Rekveldt et al. 2011; Dunović, Radujković & Škreb 2014; Floricel, Michela & Piperca 2016; Geraldi, Maylor & Williams 2011; Remington & Pollack 2007; Senescu, Aranda-Mena & Haymaker 2013; Vidal & Marle 2008; Williams 1999). An overview of project complexity components is illustrated in Figure 3.1. Each component contributes to the level of project complexity to some degree. The identification of the components is, however, only the first step as more investigation is required to illuminate what exactly these components consist of. The content analysis revealed that each component consists of various elements which, in turn, consist of various features. The following section delves deeper into each component and their applicable elements and features.

Organisational complexity

Projects are generally seen as 'temporary endeavors' (Schwalbe 2013:4) within an isolated context, but this is far from reality as they have a greater role within the organisational context. The organisational context implies that all projects are influenced by organisational aspects which are rarely taken into account during all projects and especially IS projects. This section presents the

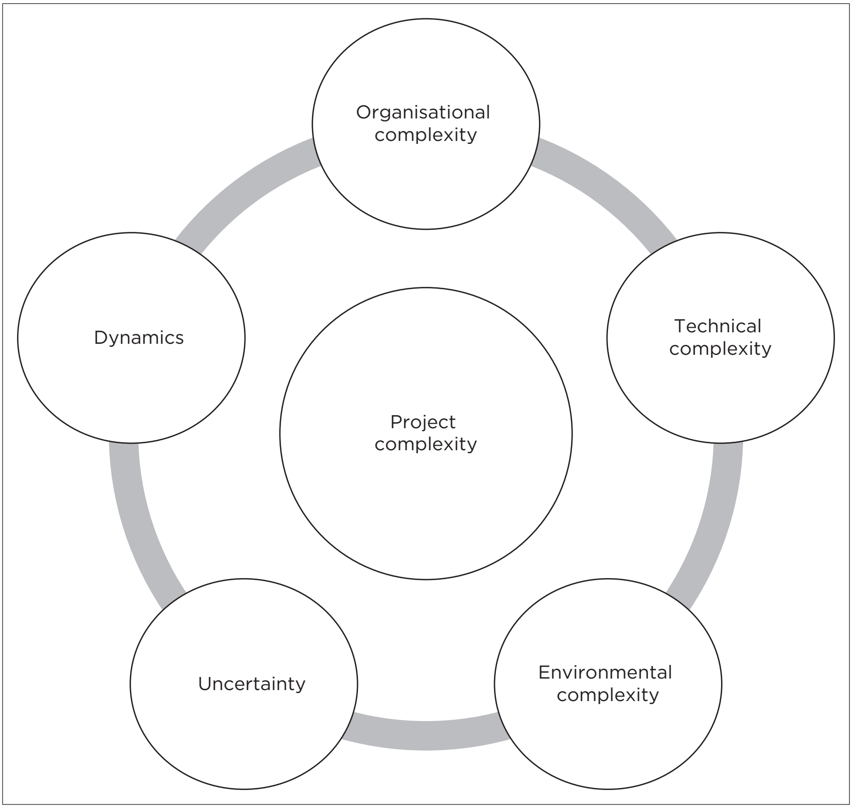

FIGURE 3.1: Overview of the components of project complexity (derived from content analysis).

multiple elements and features which contribute to project complexity:

1. The first element of organisational complexity centres on vertical differentiation (Baccarini 1996). Vertical differentiation deals with the formal structure of the organisation, that is, whether the organisation has, amongst others, a functional, matrix or flat structure. Each structure has varying views on hierarchy as a functional structure has strict levels of command, whereas a flat structure has no

levels of command effectively (Hobday 2000). The varying structures influence project execution particularly as communication and collaboration is different depending on the structure (Geraldi et al. 2011).

2. Horizontal differentiation is the second element within organisational complexity (Baccarini 1996). Two features form the foundation of this element, that is organisational units and task structure. Regardless of structure, each organisation has organisational units which serve a particular purpose. The number of units varies in each organisation and must therefore be taken into account from a project complexity perspective (Dunović et al. 2014). Task structure places focus on how project tasks are divided and distributed to the relevant responsible parties (Lu et al. 2015). This is particularly important during the planning stage of a project, and thus particular attention should be paid to defining tasks as best as possible. Tasks are, however, not set in stone and are prone to change during the project.
3. Organisational complexity's third element is that of size, which consists of multiple features:
    - **Project duration:** This feature relates to the constraint of time (Bosch-Rekveldt et al. 2011). Time is commonly used as a criterion for determining project success. Its representation within project complexity is arguably less vital given the sheer number of other complexity elements and features to consider. Nevertheless, the inclusion of duration is important as all projects have a time goal in which they want to be operational. With regard to IS projects, time is an important feature to consider as these projects are launched to achieve or maintain competitive advantage.
    - **Project method and tool variety:** The project management landscape is awash with various methods and tools. Information system projects, for example, are more commonly adopting the philosophy of Agile as a new approach to deliver projects (Chan & Thong 2009). The Agile landscape, however, is not simple as there are multiple methods which can be chosen and used, for example scrum, extreme programming, rapid application

development and dynamic systems development methods to name a few. Selecting from multiple methods can become difficult especially when there is a lack of understanding and knowledge amongst the project team regarding the details of the method. Methods cannot be adopted based on 'buzzword' status as this negates any potential benefit from adopting the method(s).

- **Capital expenditure:** This feature relates to the constraint of cost (Bosch-Rekveldt et al. 2011). Significant sums of money are spent on IS projects, which implies their strategic importance to many organisations (Joseph & Marnewick 2014). Cost is therefore an important feature as failed projects do occur at the cost of millions and reflect badly on the implementation of other IS projects.
- **Work hours:** Many hours are spent on projects of all types to realise the project and business goals (Thomas & Mengel 2008). The number of work hours is determined by the scale of the project as well as the task structure. Work hours should be meticulously managed during large-scale IS projects particularly as there are a multitude of interdependencies. Moreover, the number of work hours is heavily influenced by IS projects which span geographical regions.
- **Project team:** The size of a project team directly influences project complexity (Bosch-Rekveldt et al. 2011). Large teams include individuals from multiple departments, thus introducing heightened levels of complexity. The management of large teams can become cumbersome for project managers as communication and collaboration breakdowns are highly likely.
- **Site area:** The physical size of the project site(s) is important to identify as this will influence certain aspects of the project (Bosch-Rekveldt et al. 2011). While the initial plans dictate project activities amongst other things, careful attention must be paid to how the physical attributes of the site will influence these activities.
- **Number of locations:** As mentioned previously, geographically dispersed projects are commonplace

within multinational organisations particularly. These dispersed projects affect project complexities such as logistics where travel and access must be considered when executing the project (Padalkar & Gopinath 2016). IS projects often implement systems which span offices across the globe and thus should be fully integrated. Full integration, therefore, requires a robust understanding of the locations where the system must function.

4. The element of resources emphasises tangible and intangible resources required for any given project. The following features must be considered for the fourth element of organisational complexity:
    - **Project drive:** Strategic goals underpin the need and execution of IS projects. Project drive, therefore, pertains to the level of strategic importance and support required for a project (Milis & Mercken 2002). Inadequate support implies that the project will not be aligned to the overall goals of the organisation and thus not deliver the benefits as initially stipulated. The drive of the project must therefore be sound and understood by all parties involved to ensure it realises the greater strategic goal.
    - **Resources and skills availability:** Different projects require different skills and resources even if the projects seem similar on paper (Baccarini 1996). Specific resources with regard to raw materials must be clearly identified and acquired to implement the project correctly. Project complexity is aggravated when projects such as IS projects require very specialised skills which need to be sourced externally. External vendors are often brought in to provide these skills, which add other complexity layers such as project team composition, capital expenditure and work hours.
    - **Experience with parties involved:** Stakeholder management and its importance are documented in project management standards such as the PMBOK® Guide (Project Management Institute 2013). Experience with involved stakeholders and parties creates somewhat of a more predictable landscape during a project as

there is a better understanding of the parties involved (Bosch-Rekveldt et al. 2011). Unknown parties require extra effort from the project manager and team as they will have to engage more to ensure they perform as required.

- **Health, safety, security and environment (HSSE) awareness:** HSSE is traditionally associated with construction projects and not IS projects. HSSE should, however, be applied to all projects as there are national regulations overseeing the implementation of HSSE (Bosch-Rekveldt et al. 2011). Project managers in particular should be aware of all HSSE concerns in a project as this will mitigate any possible litigation arising from regulatory bodies.
- **Interfaces between disciplines:** Cross-disciplinary integration is inevitable in projects as specialists from various fields are required to execute certain tasks (Baccarini 1996). The interfaces or interactions between the various disciplines must be identified and managed accordingly as this influences other areas such as skills availability, works hours, capital expenditure and project duration, to name a few. The more disciplines required for the project, the higher the level of project complexity.
- **Financial resources:** Projects cannot be executed without sufficient availability of financial resources (Killen & Kjaer 2012). Financial resources, however, should be managed in a sustainable manner to ensure they are distributed correctly and not squandered on ineffective tasks and resources. As mentioned before, IS projects require significant expenditure but do not always translate these financial resources into organisational benefits.
- **Contract types:** Resources are procured from various suppliers, whether internal or external. Regardless, contracts are negotiated and signed to ensure the required resources are available for a project. Contractual agreements and arrangements often become intricate and complex and thus add to the complexity of a project (Bosch-Rekveldt et al. 2011).

5. Intricacies relating to the project team are the fifth element within the organisational complexity and consist of the following features:
   - **Different nationalities:** Projects do not need to be geographically dispersed to have the complexity of different nationalities working on the project. The key to different nationalities is that of understanding national cultures and ensuring that they are understood and not offended (Geraldi et al. 2011). Productive project teams understand their boundaries and limitations when working with different nationalities. Furthermore, it is the responsibility of the project manager to manage these cultural relations and mitigate any possible conflicts.
   - **Different languages:** Different nationalities also introduce difficulties associated with language (Bosch-Rekveldt et al. 2011). Language barriers imply that team members and stakeholders cannot understand one another enough to effectively execute the project. Language issues also arise when the main language used for a project is not the first language for some parties involved. It is therefore important that this social aspect is identified early on and possibly before the project initiates as this will ensure the project does not experience difficulties during the project.
   - **Joint-venture cooperation:** Many projects are executed as a joint venture between two or more organisations (Geraldi & Adlbrecht 2007). The roles and responsibilities of each organisation must be clearly articulated before project initiation and planning as they will dictate the way forward for the project. Organisations could perform the same tasks differently as they have varying management styles and structures. Cooperation between the parties involved should therefore be documented and made transparent to all to ensure a common understanding between all parties.
   - **Office hour overlaps:** Overlapping of office hours primarily occurs in projects which are executed in multiple time zones. The project manager and team

must be cognisant that certain tasks and activities can only occur when there is office hour overlap between time zones (Geraldi et al. 2011). On the other hand, there could be instances where overlapping hours could be minimal thus creating a heightened level of complexity. It is therefore imperative that there is a clear understanding amongst those operating within different hours to ensure effective communication occurs during the project.

6. The sixth element focuses on two features of trust, that is trust within the project team and in the contractor (Bosch-Rekveldt et al. 2011). The project team must operate as efficiently as possible to ensure they deliver what is expected by the business. The team would thus work best when trust is apparent between all those involved (Geraldi & Adlbrecht 2007). Moreover, this relates to the feature of experience with involved parties as more experiences can arguably translate to increased trust to perform certain tasks and activities. Similarly, trust must exist with the contractor or outside vendor (Geraldi et al. 2011). Trust in a contractor does not only entail trusting that they play their part but, more importantly, that they provide the required skills and knowledge needed for executing the project. Trust is a social paradigm which is more focused on soft aspects such as people management than on hard aspects such as technical requirements management.
7. Risk is the seventh element within organisational complexity where emphasis is placed on organisational risk specifically (Bosch-Rekveldt et al. 2011). Thamhain (2013) asserts that there are four categories of risk, (1) no impact on project performance, (2) actual impact on project tasks and subsystems, (3) actual impact on project performance and (4) actual impact on project and enterprise performance. Category four of risk therefore implies that the entire organisational performance is at stake if project risk is not addressed. Risk can, however, be mitigated through continuous stakeholder communication and collaboration (Floricel et al. 2016).
8. Projects are fraught with interdependencies which further complicate matters. Interdependencies are thus the eighth and

final element of organisational complexity. Interdependencies consist of the following features:

- **Environmental dependencies:** These span the internal and external operational environment in which the organisation operates (Vidal & Marle 2008). The implication is that both environments must be surveyed and understood as best as possible to ensure the project is not negatively affected by underestimating its environmental dependencies.
- **Resource sharing:** Organisations execute multiple projects at once and thus share resources between them (Vidal, Marle & Bocquet 2011). Furthermore, the same resources are often shared with day-to-day activities which further escalate project complexity. Resources are not infinite and must be managed accordingly between all relevant parties. It is predominantly the project manager's responsibility to ensure that required resources are available when needed and to liaise with other project managers for effective resource management.
- **Schedule dependencies:** Similar to resource sharing, schedule dependencies require the same attention as certain project activities, and tasks are conducted sequentially while other tasks are run in parallel. A lack of schedule dependency understanding inevitably introduces increased complexity which could lead to chaos within a project and subsequent project failure (Baccarini 1996).
- **Interconnectivity and feedback loops in task and project networks:** Communication is at the heart of this feature as the emphasis is on feedback loops between the parties involved (Vidal et al. 2011). There must be a clear level of transparency amongst all stakeholders as this enlightens and reassures what tasks have been performed as well as the status of the task.
- **Dependencies between actors:** All project stakeholders have some form of dependency on one another (Padalkar & Gopinath 2016). Any project which is not cognisant of that will perform poorly and not as intended. It is, however, important that there are not an exorbitant

number of communication and collaboration channels and platforms as this will compromise and distort any work being done.

- **Information systems dependencies:** Various information systems are used as a source of information during a project (Baccarini 1996). The relationship between these systems is important as not all systems provide the same functionality. Furthermore, the technical nature of information systems is important to understand to ensure the most benefit is gained from them. There is arguably a link between this element and skills availability as the use of these information systems often requires specialised skills to extract the maximum benefit.
- **Objective dependencies:** Each project has goals which are linked to greater strategic goals. The relationship between them is important as there should be clear and strict alignment between the project and strategic goals (Vidal et al. 2011). Furthermore, the relationship between the various project goals must be clearly articulated as they work in tandem to realise strategic goals.
- **Process interdependencies:** Project management is a process-based activity where each process serves a function and feeds into another. Alternatively, projects operate within daily business processes, and thus the relationship between project and business processes must be identified and managed accordingly to reduce increased project complexity (Padalkar & Gopinath 2016).
- **Stakeholder interrelations:** Both internal and external stakeholders interact during a project's lifecycle. These interactions and interrelations directly influence the level of project complexity as information and resources are shared between these stakeholders to realise the project's goal (Baccarini 1996).
- **Team cooperation and communication:** There is constant reference to communication and cooperation in multiple project complexity features, especially with regard to the project team (Geraldi & Adlbrecht 2007). Internal feedback

loops amongst team members is critical to ensure the project delivers as expected and project complexity is managed effectively.

Technical complexity

Technical complexity originated from technological complexity where the emphasis was on technology and its intricacies (Baccarini 1996; Brown 2008). Over time, however, technical complexity expanded to include elements and features which place more emphasis on detailed aspects of a project (Bosch-Rekveldt et al. 2011; Floricel et al. 2016). The following elements constitute technical complexity:

1. Differentiation regarding inputs and outputs is the first element of technical complexity (Green 2004). Project processes and activities have various inputs and outputs during the project's lifecycle. The number and diversity of inputs and outputs must be considered under the greater umbrella of project complexity (Baccarini 1996). A large number of inputs and outputs implies that there are multiple interconnected parts which must be managed accordingly in a process-driven environment such as project management. On the other hand, the diversity and scale of the inputs and outputs play a role in the level of importance of each overarching process in which they operate. Project complexity is therefore influenced by the number and diversity of inputs and outputs as they underpin the project management process itself.
2. The second element of technical complexity focuses on project goals (Bosch-Rekveldt et al. 2011). Project goals have been referred to in the project drive and objective dependencies features in organisational complexity and, again, in technical complexity which reiterates the importance of understanding the project goal dynamic. The first feature within project goals is that of the number of goals. The more goals there are to achieve the more complex the project becomes (Gällstedt 2003). This leads directly to

the second feature, goal alignment, where the goals should be aligned to one another and the strategic goals (Geraldi & Adlbrecht 2007). Project goals which contradict one another imply that the project is destined for failure as there is no common ground or vision on what the project must achieve. Goal alignment subsequently leads to the third feature of goal clarity. Goals which are understood and transparent to all the stakeholders are the key to the successful delivery of a project (Shenhar, Levy & Dvir 1997). Conflict and contradicting goals should be avoided at all costs as previously mentioned.

3. Scope is the third element and focuses on scale of scope and quality of requirements (Bosch-Rekveldt et al. 2011; Floricel et al. 2016). The requirements dictate what a project should achieve once they are completed. The scale of scope therefore refers to what requirements must be successfully implemented for the project to deliver business benefits (Vidal & Marle 2008). On the other hand, the quality of requirements is more specific as it looks at whether the documented requirements are well detailed and understood (Floricel et al. 2016). Quality requirements should be correct, unambiguous, complete, consistent, prioritised for importance and/or stability, be verifiable, modifiable and traceable (Marnewick 2013). The omission of any of these attributes implies that the level of project complexity will be raised and that the project will not deliver as initially planned.
4. Technical complexities relating to project tasks is the fourth element to consider. Firstly, the number of tasks plays an influential role as projects with many interconnected tasks are more cumbersome to manage, as discussed in the interdependencies element of organisational complexity (Heaslip 2015). The number of tasks also relates to the number of inputs and outputs as certain tasks act as inputs while others act as outputs. Secondly, the variety of tasks speaks to the varying difficulty and speciality of tasks as not all tasks are equal and some are more specialised than others (Senescu et al. 2013). Thirdly and finally is the feature of conflicting norms and standards (Bosch-Rekveldt et al. 2011). This feature focuses on the misunderstanding of

organisational standards and procedures other than project management ones. Although organisations strive to achieve congruence amongst all standards there are spaces where this is not the case. It is essential to discuss any conflicting standards and decide on the best way forward before the project is adversely affected.

5. Experience within technical complexity refers to technological experience specifically. Experience with regard to new and current technology is the focus of this element. New technology is often punted as performing the same tasks better and more efficiently, but the problem arises when the new technology needs to be implemented as part of the project (Tatikonda & Rosenthal 2000). A barrier to adopting new technology is that of understanding as the project team should understand the technology and how it will influence the entire project if implemented. Experience with technology is therefore important as the more experienced the team is with the technology, the more likely they will be able to implement it correctly (Tatikonda & Rosenthal 2000). Projects which boldly implement new technology often suffer many side effects such as integration issues and lacklustre user acceptance as the technology is not thoroughly investigated and understood.
6. The final element is that of technical risk where the focus is on technological risks (Deutsch 1991). Technological risks include, amongst others, what technology will be used, will the technology integrate correctly, availability of technology and whether technology will be obsolete before project completion (Ahmed 2012:343). Furthermore, the frequency and impact of these risks must be taken into account to ensure the project is not adversely affected.

Environmental complexity

Organisations operate within various industries, and the projects they initiate are influenced by the dynamics of these environments (Bosch-Rekveldt et al. 2011). This project complexity component further illustrates that projects are not entirely isolated endeavours as traditionally believed.

1. The first element focuses on stakeholders specifically and their intricate role in projects. The stakeholder element consists of various features:
    - **Number of stakeholders:** Stakeholder numbers have a positive relationship with the level of project complexity, that is, the more stakeholders there are, the more complex the project becomes (Vidal & Marle 2008). Management of all stakeholders is important to ensure there is consistent understanding by all the participants.
    - **Varying stakeholders' perspectives:** Management of stakeholders must also include an awareness of varying perspectives, that is each stakeholder views the project and its status in a different light (Bosch-Rekveldt et al. 2011). For example, senior management views the project in a strategic light, while operational staff assess the project with regard to how it will influence their daily activities.
    - **Political influence:** This can be viewed from both an internal and an external perspective (Floricel et al. 2016). The internal perspective looks at political influence within the organisation, such as when the project team is pushed by senior management to implement the project as soon as possible for strategic goal realisation. Alternatively, external political influences focus on politics at the national and international level (Vidal & Marle 2008). This is often through regulation and legislation by which the organisation and project must abide.
    - **Internal support:** Projects must benefit from some form of internal support for them to be successfully implemented (Geraldi & Adlbrecht 2007). Senior management in particular, should be heavily involved in and continuously support the project throughout its lifecycle. Lack of support has often

reared its head as a key factor influencing project failure (Hastie & Wojewoda 2015; Joseph, Erasmus & Marnewick 2014).
- **Required local content:** Many nations require organisations to make use of local content and resources as a means to ensure the organisation contributes to economic growth and does not merely exploit national resources.

2. The second element of environmental complexity centres on the location of a project. The first feature deals with interference with an existing site where any possible interference with the project site is identified and understood (Bosch-Rekveldt et al. 2011). Once identified and understood, these interferences can be managed accordingly to avoid adverse impacts on the project. Weather conditions are the second feature within the location element. Projects operate in geographically dispersed regions, and the effect the weather has on the projects must be analysed beforehand as weather can have a detrimental effect during project execution particularly (Sohi et al. 2016). Alongside weather is the remoteness of the location where some project locations are isolated from business hubs and thus require special attention regarding resources and logistics (Nguyen et al. 2015). The final feature focusses on country experience. Similar to experience with involved parties in organisational complexity, organisations which initiate projects in regions of which they have experience are more likely to have fewer hurdles than when introducing a project in a completely new region (Floricel et al. 2016).
3. Market condition is the third element. A more specific political influence of internal strategic pressure is the first feature within market conditions (Bosch-Rekveldt et al. 2011). The project manager and team are prone to increased pressure especially when the project in question is the primary driver of a new strategic direction in the organisation. The stability of the project environment also plays a role and is the second feature to consider. Project environment stability is primarily determined by the organisation's

stability regarding operations (Geraldi et al. 2011). Organisations which are unstable and barely functioning imply that the project has a minimal chance of being executed correctly. The final feature is that of competition level with regard to the organisation's competitors (Senescu et al. 2013). Increased competition requires an organisation to act swiftly by using projects to push out products and services quickly to ensure they remain competitive in their relevant industry.

4. Environmental risk is the final element in environmental complexity. Environmental risk focusses on man-made and natural disaster risks (Floricel et al. 2016; Thomé et al. 2016). On the other hand, risks associated with the elements and features of environmental complexity should also be considered within this element.

Uncertainty

Uncertainty is a concept centred on doubt with regard to the various elements and features of project complexity (Williams 1999). The question, however, is how any level of doubt will be managed to ensure any negative effect is mitigated during a project. The first step is to identify the main elements of uncertainty as this will assist doubt management. Various elements constitute uncertainty in the project complexity context:

1. Uncertainty regarding the traditional project management triple constraint should be evaluated (Bosch-Rekveldt et al. 2011; Geraldi et al. 2011; Thomé et al. 2016). Uncertainty about scope is arguably embedded in the scope element of technical complexity as much emphasis is placed on project requirements. Furthermore, scope creep and poor scope management are commonplace during projects where strategic pressure coerces the project team to take on a project which is unfeasible or unrealistic. The same could be argued for the next two features of cost and time uncertainty where unrealistic budget and schedule expectations are set

for the project which are not met. Alternatively, cost and time uncertainty also comes to the fore when there are outside influences which were not expected such as Brexit (Dhingra & Sampson 2016).

2. The second element of uncertainty concerns project activities. Multiple project methods are available for managing projects and uncertainty regarding these methods inevitably arise (Vidal & Marle 2008). As mentioned previously, this is particularly the case when adopting new methods. On the other hand, it cannot be assumed that all parties understand the method being used when introducing new stakeholders and/or project team members during a project. Method uncertainty leads to the next feature of task uncertainty as project tasks are directly influenced by the method being used (Maylor, Vidgen & Carver 2008). Task and method uncertainty can be mitigated by having adequate support structures and platforms in place to which stakeholders and project team members can refer.
3. Goal uncertainty is the third element which focuses specifically on project goals and objectives (Geraldi et al. 2011; Maylor et al. 2008). This speaks to goal alignment and clarity in technical complexity as uncertainty can be alleviated by ensuring these two features are correctly addressed. The core idea is that all parties are on the same page throughout the project. Furthermore, effective communication and collaboration will underpin transparent understanding amongst all the participants.
4. Technological uncertainty is very specific and speaks to all technological elements and features discussed previously. Technological maturity and novelty are the two features which underpin this uncertainty element. Whitney and Daniels (2013) assert that a key feature of complex IS projects is that of new technology which has not yet been fully developed and tested, that is immature and novel technology. Many projects, however, are deemed failures as the immature and novel technology was not implemented correctly and thus did not deliver expected business benefits. It is therefore essential that novel and immature technology is understood

and that there is a balance between new and old technology for projects pursuing this route (Tatikonda & Rosenthal 2000).

5. Stakeholder uncertainty is the fifth element and refers to undisclosed participants and competency. The overarching nature of projects such as IS projects requires involvement from multiple departments and business units. This could arise when certain participants are not identified and their presence is not disclosed and disclosed until later in the project (Maylor et al. 2008). Omitting participants could lead to incorrect or incomplete information being sourced. The project manager must therefore continuously check if all the required participants have been disclosed during the early stages of the project. Competency is also a key feature which is underestimated (Maylor et al. 2008). Many projects go ahead on the assumption that all stakeholders have the knowledge required for executing the project successfully. This may not necessarily be the case, however, as key individuals could be left out as mentioned previously. Furthermore, competency research argues that although IS project stakeholders deem themselves competent, the mediocre performance of IS projects questions that notion (Marnewick, Erasmus & Joseph 2016). If there are questions around competency, support structures and materials must be in place to mitigate any negative influences.
6. Information uncertainty is the last element to consider and the focus is on incomplete information. Accurate and complete information is an undeniable prerequisite for all projects as this ensures the project is driven correctly (Vidal, Marle & Bocquet 2007). Incomplete information can arise in many forms such as, amongst others, undisclosed participants, conflicting norms and standards, unclear goals, cooperation and communication as well as trust.

Dynamics

Dynamics concerning project complexity refer to the element of change management specifically. The change process is the first feature to consider as it should be as robust and adaptable as possible (Whyte, Stasis & Lindkvist 2016). Poorly defined change processes imply that changes are not instituted correctly or managed effectively thus negating any possible improvements to a project. The number of changes is also important as projects which exhibit multiple changes at once imply the project was poorly planned from the outset (Geraldi & Adlbrecht 2007). A combination of poorly-defined change processes and a high number of changes points to an inevitable outcome for a project. Changes are initiated for various reasons which influence the scope of changes. For example, some changes might be minor while others are widespread and more important (Whyte et al. 2016). Frequent changes are also a red flag during projects as the implication is that there was poor planning and/or previous changes were not carried out correctly thus resulting in high levels of reworking (Muller, Geraldi & Turner 2012). Along with the above-mentioned change management dynamics is that of impact. The impact of changes must be clearly understood and analysed before implementation as some changes are too risky to the outcome of the project and should rather be deferred to future projects or project support activities (Geraldi et al. 2011). The final feature assesses change over time. Change over time is the monitoring and controlling of the above-mentioned features to ensure the project continues in the correct direction (Maylor et al. 2008).

Conclusion

This chapter revealed that project complexity is ironically complex to catalogue and understand. Five complexity constructs were identified based on an extensive literature review, that is organisational complexity, technical complexity, environmental complexity, uncertainty and dynamics. Within each construct there are various elements and features. A total of 75 features across all constructs were identified and discussed. Organisational complexity makes up the bulk of complexity features as this construct has 34 in total. The remaining four constructs were fairly evenly divided, which implies that organisational complexity is the one construct that needs considerable attention.

Chapter 4

Insights into information system project success

This chapter focuses on project success and how the respondents perceived project success within their respective environments. The first section of the chapter focuses on the general information with regard to the type of respondents and the type of projects that organisations implement. This analysis provides us with a general understanding of what the IS project landscape looks like. The second part of the chapter focuses on project success itself and how successful IS projects according to the five levels as per Bannerman and Thorogood (2012) are. Specific attention is given to the difference between Agile and Waterfall as methodologies to implement IS projects.

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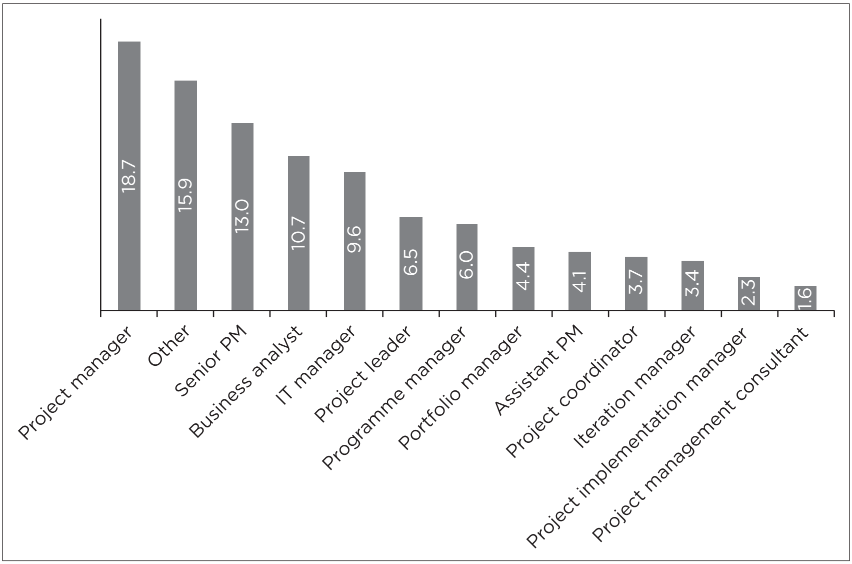

FIGURE 4.1: Job description.

General information

The results in Figure 4.1 illustrate that various job titles exist within the IS project management domain. The majority of the respondents (31.7%) are either project managers or senior project managers. The results also highlight that each and every one of the respondents is involved in IT and specifically within the discipline of project management.

Figure 4.2 indicates that organisations are involved with various types of IS projects covering the full spectrum. The majority of the projects (46%) are concerned with either the full implementation of IS systems or solutions or the upgrade of these systems (17%). This highlights that organisations are permanently in turmoil as they are constantly changing or upgrading the systems. This places enormous pressure on the IT division as well as the users of the various systems.

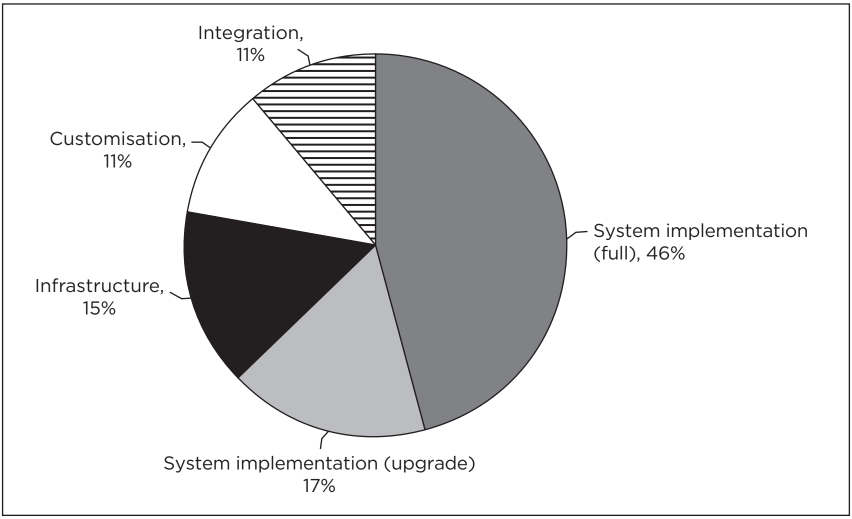

FIGURE 4.2: Type of information system projects.

The results in Figure 4.2 also highlight that customisations and integrations are only about a fifth of the IS projects. It must be noted that these are specific IS projects focusing on customisation and integration. There might be customisations and integrations within the full system implementations as well as the upgrades.

Customisations and integration make use of various development methodologies, and this is displayed in Figure 4.3. The majority of these types of IS projects make use of either the Agile method (41%) or the more traditional Waterfall method (31%). A small percentage (8%) are starting to embrace Lean and DevOps as ways to implement software solutions. A fifth of IS projects incorporate other methodologies to customise and integrate software solutions.

A cross-tabulation between the type of project and the development method resulted in Figure 4.4. An interesting point of observation is that full systems implementation incorporate Agile as a method almost three times more than when an upgrade

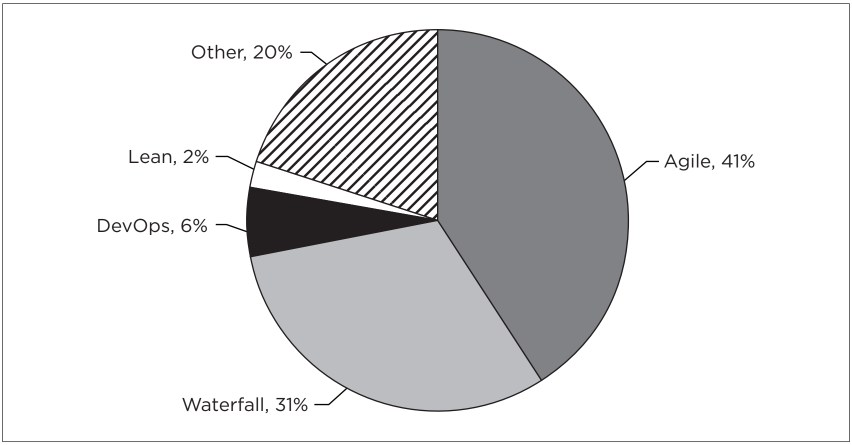

FIGURE 4.3: Development method.

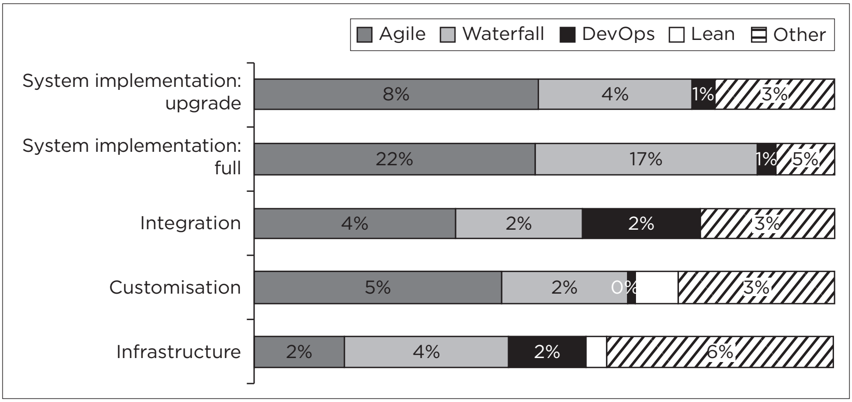

FIGURE 4.4: Crosstab between type of project and development method.

is performed. This might have to do with the fact that full systems implementation is more pressured for delivery than upgrading the system.

The next section focuses on IS project success, and the discussion is based on the five levels of IS project success where the first level focuses on the technical processes of an IS project.

Project success

This section analyses the success of IS projects based on the model of Bannerman (2008). Each level is analysed to determine the level's success. This analysis is done for the overall results but also for IS projects that used Agile and Waterfall as a method within the IS project.

Process success

This level focuses on the various technical and managerial processes that are important at different times throughout the project life cycle (Bannerman 2008). Technical processes in this context refer to conducting the actual work to produce a deliverable, while managerial processes refer to the oversight of the afore-mentioned processes. On average, IS projects are 64% successful in the deployment of either a technical or managerial process. The detailed breakdown is illustrated in Figure 4.5. The results indicate that IS project managers actually spend time and effort on the selection, implementation and integration of technical and managerial processes. In two-thirds of the instances, these processes are aligned with the project's overall processes.

However, two-thirds of IS projects cannot be perceived as successful as they do not incorporate technical and managerial processes into the IT project.

The results in Figure 4.5 compare the Agile and Waterfall methods. Figure 4.6 clearly indicates that IS projects that use Agile as a method are successful in incorporating technical and managerial processes. In 88.25% of the instances, technical and managerial processes are successfully incorporated. In 92% of the cases, Agile processes are aligned with the project and organisational strategies.

The results portrayed in Figure 4.6 are in stark contrast to the results portrayed in Figure 4.5. The results highlight the underlying factor why IS projects continue to fail. The Waterfall

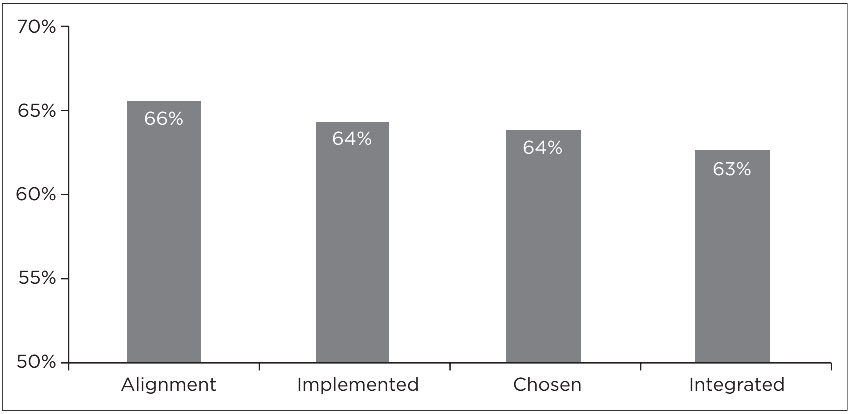

FIGURE 4.5: Process success.

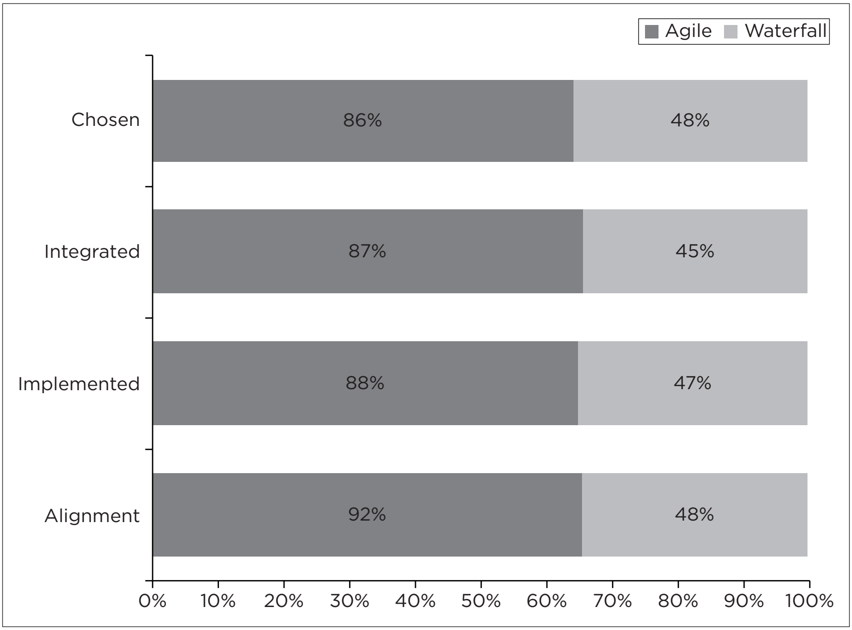

FIGURE 4.6: Process success (Agile vs Waterfall).

processes are not successfully managed and in only 47% of the cases are the processes successfully managed. This is a difference of 41.25% compared to the Agile processes indicating that Agile processes are better managed than the Waterfall processes.

The results of the study indicate that Agile as a method provides an advantage and that the integration, implementation and alignment of Agile processes are more successful than the integration, implementation and alignment of Waterfall processes.

The second level of success is based on the project itself, that is, was the project delivered within the constraints of time, cost and scope?

Project success

The constraints of time, cost and scope are the original project constraints (Marnewick & Labuschagne 2012). The IT industry adopted these constraints from the engineering discipline and IS projects should also be delivered within these constraints. Most of the research that focuses on IS project success rates use the triple constraint as the basis for their analysis.

Figure 4.7 compares the cost and time constraints against the type of IS projects. In four of the instances, IS projects do cost more than what was originally budgeted. The only difference is with integration projects where the actual cost is 133% cheaper than the budgeted cost. When these types of projects are left out of the equation, then IS projects are on average 16% more expensive than originally budgeted. This implies that 16 cents must be added for every one rand that is budgeted.

The time constraint shows the same kind of tendency as that of the cost constraint. The results indicate that IS projects, on average, take almost 2 months longer. The biggest discrepancy occurs with the implementation of full IS systems. These projects take 3 months longer than anticipated.

The results do not paint such a bleak picture. Although IS project managers should strive to deliver the project within

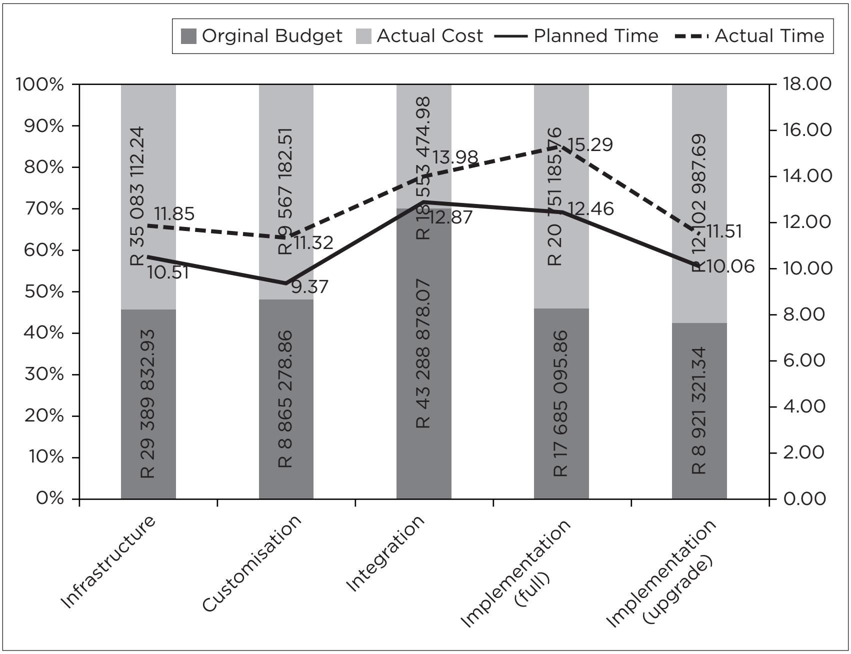

FIGURE 4.7: Cost and time comparison.

the constraints of time and cost, the deviance is not as bad as anticipated. IS projects are delivered 3 months later at an additional cost of 16 cents to a rand.

Table 4.1 presents the comparison between Agile and Waterfall methods. It is interesting to note that Agile projects are 30% more expensive than the original budget. Waterfall projects are, on the contrary, 11% cheaper than originally budgeted. When Agile and Waterfall projects are compared with each other about time, then Waterfall projects take 18% longer than estimated and Agile projects take 12% longer than estimated.

The results presented in Table 4.1 convey a mixed message. According to the literature, Agile projects should be delivered quicker and cheaper than Waterfall projects but this is not the case in this instance. This study itself was of a quantitative

TABLE 4.1: Cost and time comparison: Agile versus Waterfall.

Cost and time	Agile	Waterfall
Original budget	R 5 526 876.09	R 39 398 302.94
Actual cost	R 7 882 681.12	R 35 396 477.77
Original time	9.60	15.22
Actual time	10.91	18.63

nature and no evidence is uncovered why these discrepancies exist. It might be useful to conduct interviews with the various IS project managers to uncover the truth behind these discrepancies.

The third constraint is the scope of the project. In the context of a project, scope is defined as the features and functions that characterise the project's deliverable (Project Management Institute 2013). The majority of IS projects deliver on the scope of the project with 87.5% of these projects delivering on the scope between 60% and 100% of the time. Figure 4.8 shows the comparison between Agile and Waterfall projects. There is no difference between these two methods when it comes to the delivery of the scope. Agile projects deliver in 87.5% of the cases between 61% and 100% of the scope in comparison with Waterfall projects that deliver 89.5% of the scope.

When Agile and Waterfall methodologies are compared with each other with regard to the triple constraint, then there is not much difference between the two methods. Project success is therefore not dependent on the method that was chosen.

The third level of success measures the product itself and focuses on aspects such as meeting the specifications, meeting requirements, meeting client and/or user expectations and the final acceptance of the project deliverable by the user.

Deliverable or product success

The success of the project deliverable or product was measured around seven criteria as illustrated in Figure 4.9. A weighted

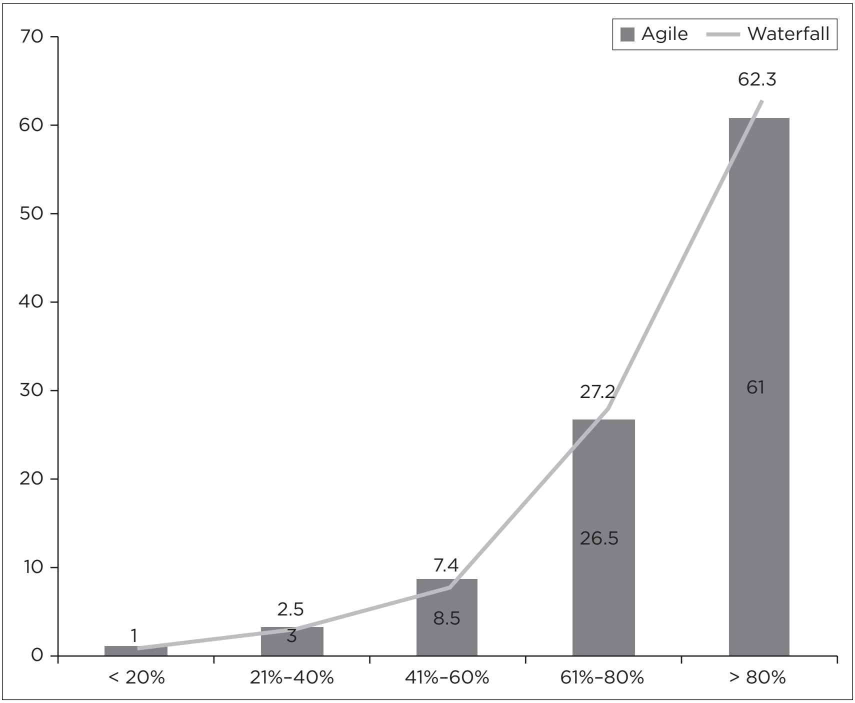

FIGURE 4.8: Scope comparison (Agile vs Waterfall).

average score was calculated for each of the seven criteria. The results show that the deliverable is only perceived as 68% successful when success is determined across all seven criteria. This implies that close to a third of the users are not satisfied with the project deliverable and that they are actually not using it at all.

The results indicate that business analysts are fairly competent in determining the product's specifications (71%) as well as the users' requirements (70%). They still cannot determine in 30% of the instances either the specifications or the requirements. This has a direct result on the remaining five criteria where the product is used and accepted in only 68% of the cases. A third of the users feel that they are not satisfied with the project deliverable and that their expectations were not met.

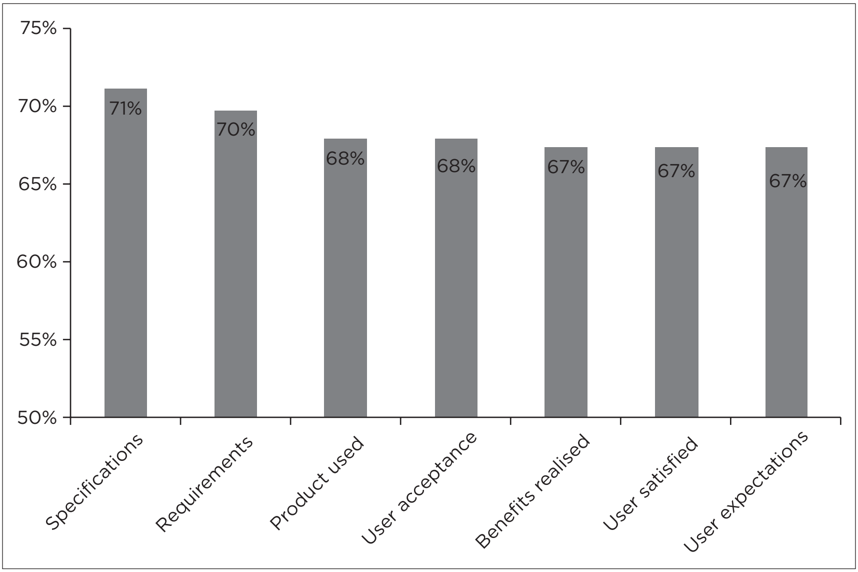

FIGURE 4.9: Deliverable success.

The results in Figure 4.10 are also not as promising as anticipated. On average, Agile projects are only successful 71% of the time in delivering a product that meets all the criteria. One of the principles of the Agile Manifesto focuses on involving the users or customers from the onset. The rationale is that when users or customers are involved from the onset, then the chances are better that they will accept the project deliverable and actually use it. This builds onto the notion that they are involved from the beginning of the project and should provide accurate requirements and specifications.

The concern highlighted by the results is that a quarter of the users are not satisfied with the requirements and specifications of the project deliverable. This means that the Agile principles are not adhered to and that the project team is not trained in the various Agile methodologies.

The average product success for Waterfall projects is 65%, which is 6% lower than that of Agile projects as depicted in Figure 4.10.

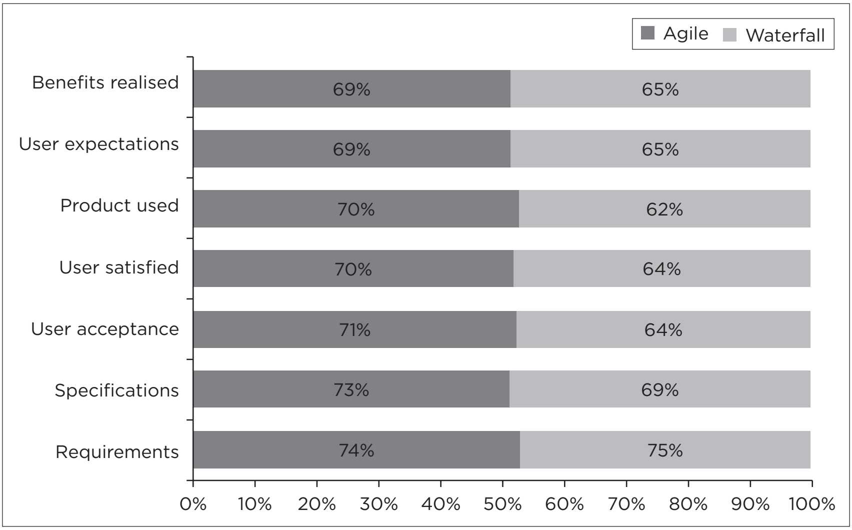

FIGURE 4.10: Deliverable success (Agile vs Waterfall).

The results highlight that in two-thirds of IS projects that follow the Waterfall method, the deliverable does not meet the criteria. This creates a serious concern as this implies that business and strategic success cannot be achieved.

The next section focuses on business success and how the deliverable of an IS project contributes to the overall success of the business. Six criteria contribute to the success of the business.

Business success

Organisational leaders invest in a project to gain some benefits. Criteria that organisational leaders interrogate are whether the project meets the business and project objectives, is the business case validated and are the benefits realised as indicated in the business case?

The results in Figure 4.11 indicate that business success is not that easily achieved. Business success is achieved in 62% of

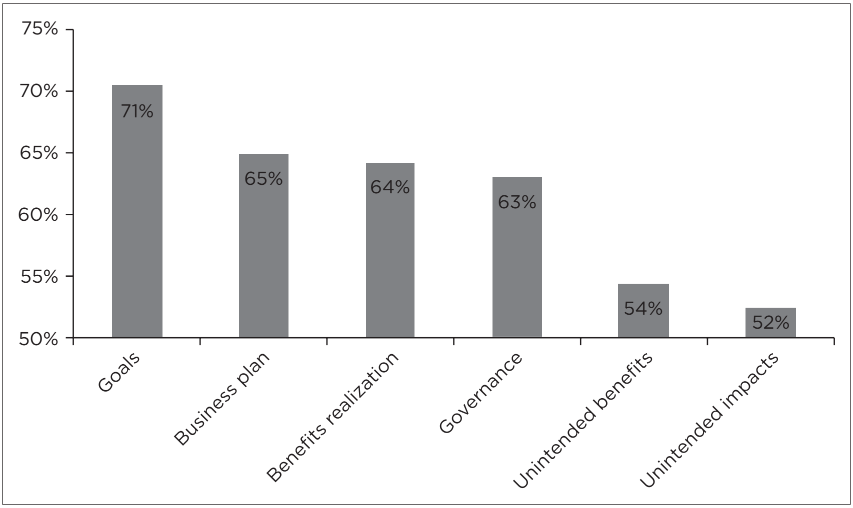

FIGURE 4.11: Business success.

IS projects. The business success rate increases to 66% when the criteria 'Unintended benefits' and 'Unintended impacts' are removed. It is not always that easy for the project manager to plan for these two criteria. The implication is still that a third of all IS projects are not perceived as successful at this level.

In the remainder of the IS projects, IS project managers can align the project with the organisational goal (71%) and this results in the realisation of benefits (64%). This figure is still extremely low given the fact that there is an emphasis on benefits realisation in the last couple of years (Aguilera 2016; Bennington & Baccarini 2004; Marnewick 2016). Adherence to corporate and project governance is also disappointingly low (63%) implying that IS project managers are not always doing the right thing.

When the results are analysed based on the method that was used, then it seems as if there is no difference between whether a project used Agile or Waterfall as a method. The results in Figure 4.12 illustrate that there is no difference between these two methods.

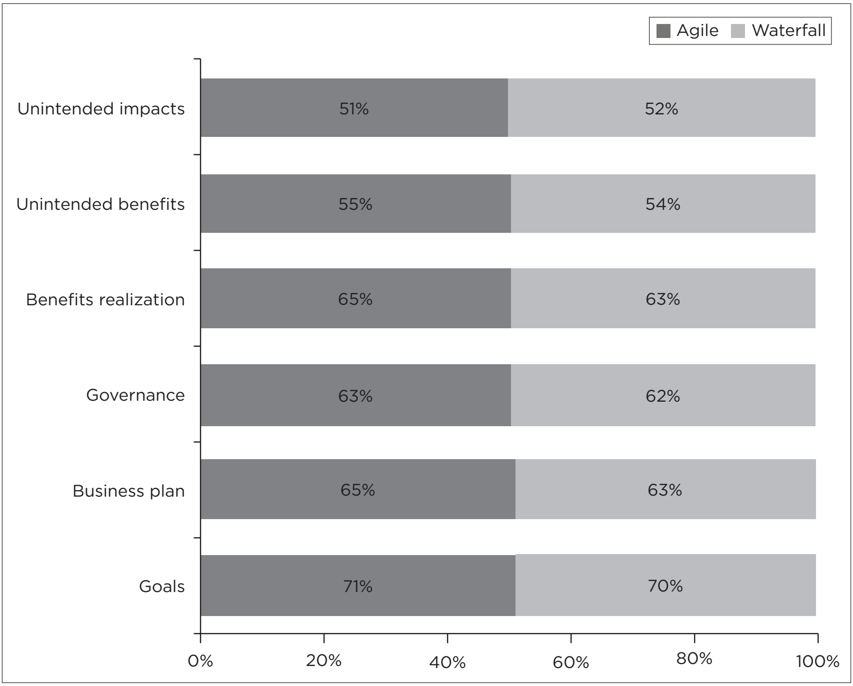

FIGURE 4.12: Business success (Agile vs Waterfall).

Using Agile as a method improves the chances of achieving business success by 1% on average (Agile = 62% vs Waterfall = 61%). The results raise more questions. One of the questions that needs to be answered is whether IS projects actually follow Agile methods or is it merely a lip service?

The last level of IS project success is determined at a strategic level.

Strategic success

Investment in an IS project is perceived as a strategic success when the project's deliverable has a positive impact on the market, competitors, investors and industry at large. The strategic success rate is also not as high as one would hope for. The average success rate is 61% implying that two-fifths of IS projects are failures in achieving strategic success for the organisation at large.

IS projects using an Agile method are far more strategically successful than IS projects that are using Waterfall as a method (Figure 4.14).

IS projects using Agile as a method are on average 41% more successful than IS projects that use Waterfall as a method. The reason is quite obvious. Project deliverables are delivered quicker through Agile opening the opportunity for quicker impact on the environment at large. The results portrayed in Figure 4.14 corroborate the results displayed in Table 4.1. The results highlight that Agile projects are delivered 7.7 months quicker than projects that use Waterfall as a method.

Overall IT project success

People are not necessarily interested in the detail and want to know what the overall success rates are of IS projects. The overall

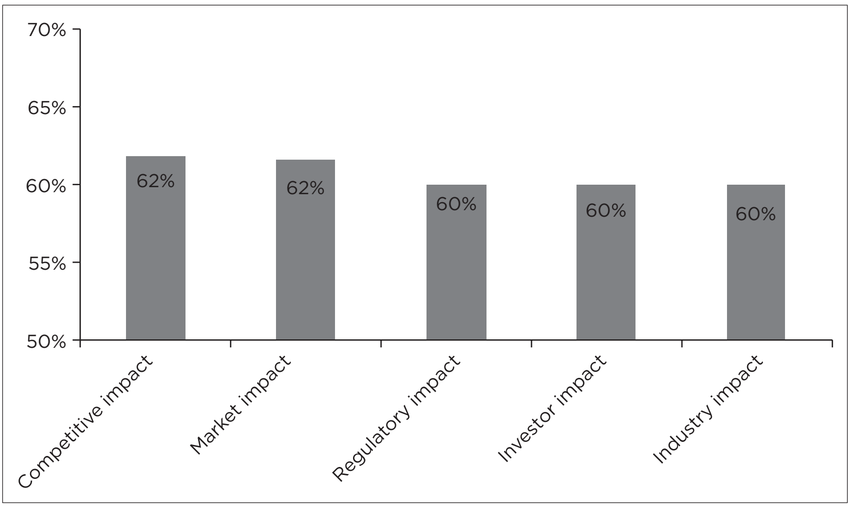

FIGURE 4.13: Strategic success.

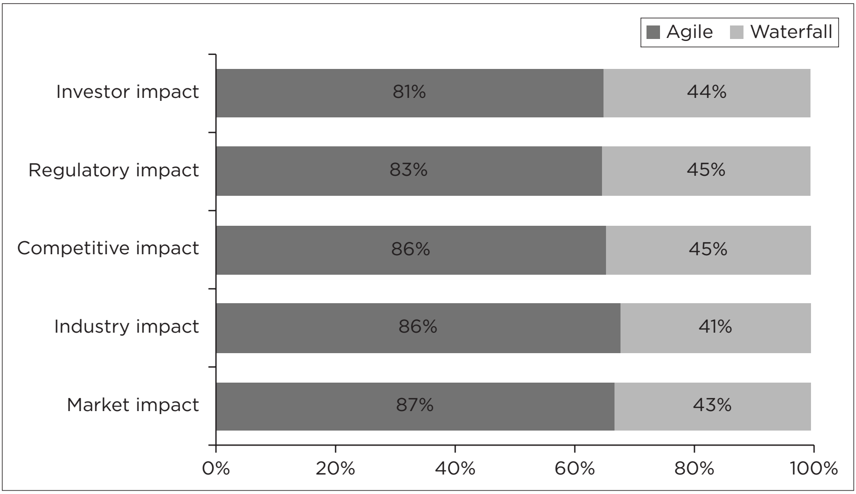

FIGURE 4.14: Strategic success (Agile vs Waterfall).

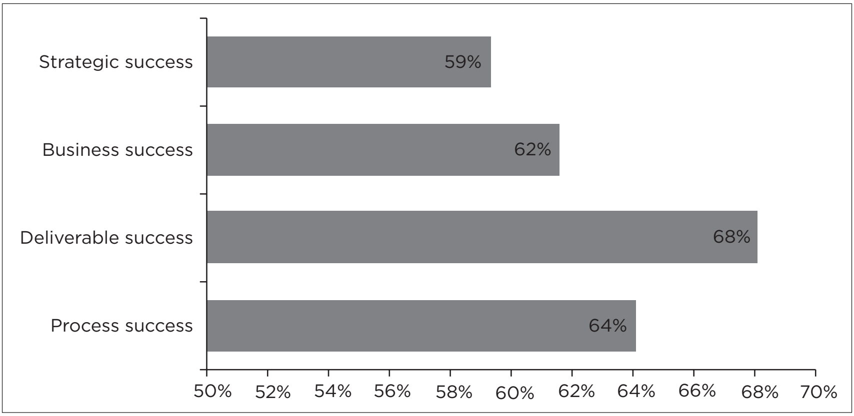

FIGURE 4.15: Overall success.

success rate for IS projects are displayed in Figure 4.15. The project success level is not included as it is difficult to convert time, cost and scope into mere percentages. None of the four levels are above 70%, and the average success rate is 63%.

The success rate of 63% is a dramatic change from the 2013 figure of 34% (Marnewick 2013). It is a positive increase of 29%. This dramatic increase can be attributed to the way that project success was measured in this study. Previous studies focused on the success of an IS project with regard to time, cost and scope. They did not focus on the other levels of success.

The longitudinal analysis of IS project success is displayed in Figure 4.16.

The overall success rates are further analysed based on the method that was used, that is Agile or Waterfall. The comparison is illustrated in Figure 4.17. The two major distinctions between Agile and Waterfall are when process and strategic success are measured. IS projects making use of Agile principles are 88% successful when process success is measured and 85% successful when strategic success is measured. This is in stark contrast with the results of IS projects that made use of the Waterfall method.

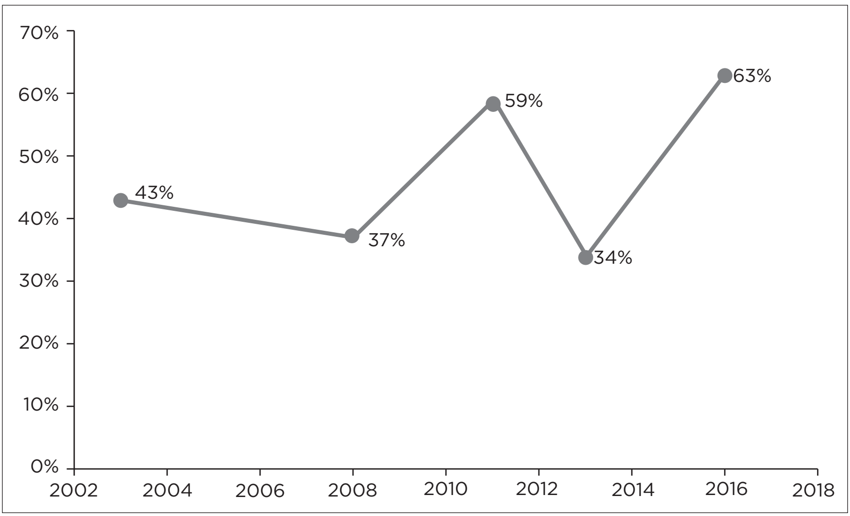

FIGURE 4.16: Longitudinal analysis of information technology project success rate.

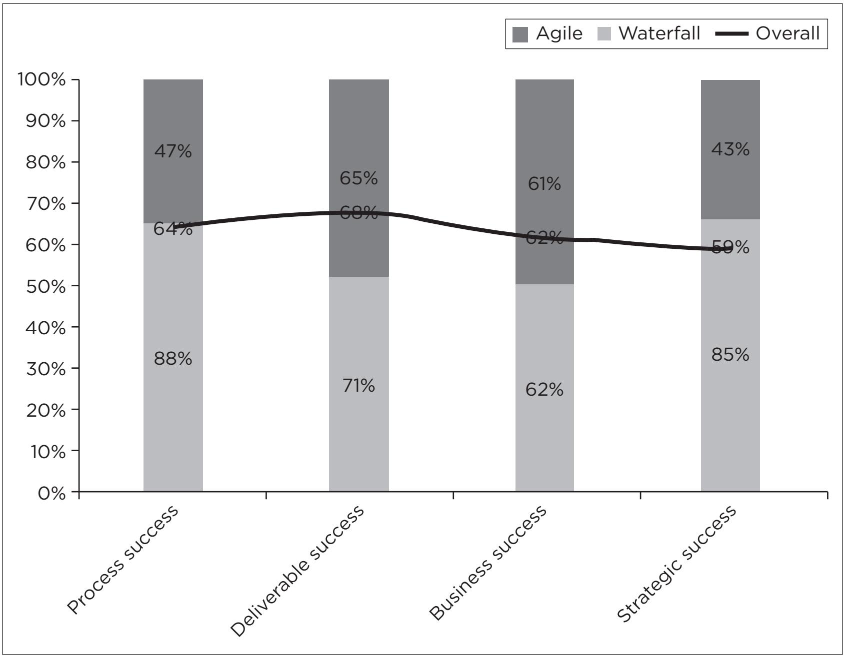

FIGURE 4.17: Overall information technology project success.

TABLE 4.2: Overall information technology project success rates.

Item	%		
	Overall	**Agile**	**Waterfall**
Success average	63	77	54
Overall rule of 9's	16	33	8

The concept of the 'Rule of 9's' appears in the discipline of IT service management (ITSM) (Schiesser 2010). Table 4.2 presents the average IS project success rates, and it is evident that IS projects using the Agile principles are 77% successful versus the 54% of IS projects that used the traditional Waterfall method. The table also illustrates that the success rate of IS projects drops from 63% to a mere 16% when the Rule of 9's is applied. This is also the case with Agile and Waterfall where the success rates drop to 33% and 8% respectively.

Conclusion

IS projects are still not out of the woods although there is an increase in the success rates. The results highlighted two important aspects. IS project success cannot be measured based on the triple constraint and a new way of measuring is needed. The results underline this principle where a strategic approach is needed to measure IS project success. The aim is to deliver a product or service that can be used by the customer and that provide benefits to the organisation. This new way of thinking has seen the increase of IS project success rising to 63%.

Secondly, it seems that incorporating Agile principles do have a positive impact on the success of IS projects. Throughout the analysis, projects that incorporate Agile principles do perform better. This confirms the results of the 2015 Chaos Chronicles where there is a 28% positive difference when Agile principles are applied. The South African results indicate a difference of 23% when Agile principles are applied.

Chapter 5

Insights into information system project complexity

IS project complexity does not have extensive exposure within literature and thus requires further empirical investigation. Chapter 3 revealed that IS project complexity was found to have 75 features in total with 34 associated with organisational complexity, 13 with technical complexity, 12 with environmental complexity, 6 with dynamics and 10 with uncertainty. This chapter aims to provide an initial analysis of IS project complexity constructs and their respective features. Initial analysis provides an overview of which complexity features to be aware of in an IS project environment. Furthermore, analysis on IS project complexity and IS project development method is also employed for further insight.

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Information system project complexity features

Each IS project complexity construct was analysed to identify the top five features.

Organisational complexity

The construct of organisational complexity is directly associated with internal complexities in an organisation and consists of the most complexity features. Table 5.1 displays the top five features within organisational complexity.

Schedule dependencies is the number one feature to consider as it relates to how project tasks and activities are planned and allocated. Furthermore, an IS project must be scheduled within the context of the organisation so that it has minimal impact on day-to-day operations. Skills availability is ranked second and implies that the appropriate skills are available to perform project tasks. IS projects often require extensive technical skills particularly during implementation, as well as soft skills for effective management throughout the project (Marnewick, Erasmus & Joseph 2016). Capital expenditure is ranked third and reiterates the importance of understanding the financial support required to execute the project. Experience is ranked fourth and relates to experience with involved parties. This implies that IS projects perform better if there is some form of previous experience with all involved parties as there is a better level of understanding and collaboration amongst all.

TABLE 5.1: Organisational complexity top five complexity features (Overall).

Ranking	Complexity feature
1	Schedule dependencies
2	Skill availability
3	Capital expenditure
4	Experience
5	Project duration

Finally, project duration is ranked fifth amongst organisational complexity features. The duration of a project is a key factor to consider when embarking on a new project as this is dictated by the strategic importance of the project. As per Table 4.1, it is complex to allocate project duration as IS projects are infamous for their poor performance regarding the time constraint.

Further analysis was performed to determine whether there was any difference in the organisational complexity feature ranking with regard to the IS project development method, that is Agile and Waterfall. Table 5.2 shows the top five rankings for IS projects using Agile as a method.

The top two features are the same as the overall ranking of organisational complexity features. Project duration moved to position three compared to position five. This implies duration is more of a complexity feature for Agile projects. It could be argued that Agile places more emphasis on delivering quick iterations to facilitate a faster project delivery rate. Task structure is ranked fourth, which is somewhat surprising given that Agile places less emphasis on structure and more on deliverables. Conversely, task structure could be more pivotal for Agile projects as the project team must continuously re-evaluate their progress and realign task structures to meet the ever-changing IS project environment. Information system dependencies is the fifth ranked feature. The drive to deliver iterations to realise project goals requires the support of information systems which facilitate an enhanced solution development. It is therefore logical that IS dependencies are considered as a complexity feature.

TABLE 5.2: Organisational complexity top five complexity features (Agile).

Ranking	Complexity feature
1	Schedule dependencies
2	Skill availability
3	Project duration
4	Task structure
5	Information system dependencies

TABLE 5.3: Organisational complexity top five complexity features (Waterfall).

Ranking	Complexity feature
1	Organisational structure
2	Schedule dependencies
3	Resource sharing
4	Skill availability
5	Organisational units

The ranking of organisational complexity features for IS projects using Waterfall as a method is depicted in Table 5.3. Waterfall complexity features are considerably different to the Overall and Agile views.

Firstly, organisational structure is ranked as the highest complexity feature to consider for IS projects which apply the Waterfall method. Given that the Waterfall method is heavily structured approached and sequential in nature, it could be implied that IS projects must be more cognisant of the structure when planning and executing the project. Schedule dependencies come out second, which aligns closely to the Overall and Agile views. It therefore can be concluded that, regardless of the method, scheduling is of utmost importance. Resource sharing is ranked third and is closely associated with the organisational structure as the structure must be understood to ensure resources are shared accordingly. Multiple projects of various types are executed at any single point in time, thus making resource allocation important for Waterfall projects as they require significant upfront planning and task delegation. Skills availability is ranked fourth and is comparable to the Overall and Agile views. Organisational units is ranked fifth for Waterfall projects. Similar to the organisational structure's importance to the Waterfall method, understanding what role each unit plays during a project is important to ensure the project delivers accordingly. IS projects span multiple departments and units thus making them increasingly complex to manage.

The next section analyses the IS project complexity construct of technical complexity and its inherent features.

Technical complexity

Technical complexity assesses strategic and tactical characteristics which directly influence the project. Table 5.4 shows the top five technical complexity features for IS projects.

Risks associated with the technical aspects of an IS project are ranked first. Technical project characteristics are usually considered during the initiation and planning phases but are influenced during a project as well. The implication is that technical characteristics must be part of the continuous risk management as these add to the complexity of managing a project. IS projects thrive on technology and employ new technology wherever possible. Newness of technology is ranked second and confirms that the use of new technology poses risks as increased complexity arises. Chapter 4 notes that 71% and 70% of specifications and requirements are met respectively (refer to Figure 4.9). Scale of scope is ranked third and implies that project scope is an important feature to consider to ensure a project does not become overly complex. Not only must the scope be well defined but also realistic to ensure the project can actually be delivered. The number of tasks is ranked fourth. Project tasks form the basis of any project and the number of them should not be overwhelming and make the project increasingly difficult to execute. The number of tasks is associated with the task structure in organisational complexity as these work in tandem. It could be argued that the number of tasks could be attributed to IS projects deviating from the original time and cost (Table 4.1). Finally, the variety of tasks is ranked fifth for technical complexity features. Variety of tasks speaks to the skills availability of organisational

TABLE 5.4: Technical complexity top five complexity features (Overall).

Ranking	Complexity feature
1	Technical risks
2	Newness of technology
3	Scale of scope
4	Number of tasks
5	Variety of tasks

complexity as many tasks require different skill sets at different proficiency levels. The project can only be delivered if the appropriate skills are available or sought after.

The top five features of technical complexity when Agile is adopted are presented in Table 5.5.

Technical risks and newness of technology are once again ranked first and second for Agile projects respectively. Variety of tasks is ranked third and implies that Agile projects include more task variety during a project. The adaptive and flexible nature of Agile suggests that there will be more task variety as solution development will go through multiple iterations based on user feedback particularly. Diversity of inputs and outputs is ranked fourth and relates to the argument around the variety of tasks as well. Furthermore, inputs and outputs are not predefined for Agile projects implying that there is more inherent diversity which contributes to complexity. Scale of scope is ranked fifth and implies that although Agile projects also rely on well-documented scope, they are more open to scope changes and alterations to ensure the project delivers as intended. Furthermore, Chapter 4 revealed that Agile projects meet specifications and requirements more successfully than Waterfall projects.

The ranking of technical complexity features for IS projects using Waterfall as a method in Table 5.6 is very similar to the Overall view of complexity features albeit in different order.

Technical risks is ranked first for the Overall, Agile and Waterfall views of IS projects which confirms its importance from a complexity perspective. Scale of scope is ranked second highest in Waterfall projects. The Waterfall method is much more

TABLE 5.5: Technical complexity top five complexity features (Agile).

Ranking	Complexity feature
1	Technical risks
2	Newness of technology
3	Variety of tasks
4	Diversity inputs/outputs
5	Scale of scope

TABLE 5.6: Technical complexity top five complexity features (Waterfall).

Ranking	Complexity feature
1	Technical risks
2	Scale of scope
3	Number of tasks
4	Newness of technology
5	Variety of tasks

procedural and thus requires significant time spent on planning and designing an IS project solution. The scope is expected to be more detailed and complete, which makes it a significant technical complexity feature. Alternatively, Figure 4.10 contends that Waterfall projects deliver less on requirements and specifications, which contrasts with its approach of well-defined scope development. The number of tasks is ranked third and is more important for Waterfall projects as the number of tasks is defined early and is not as flexible as Agile projects. Waterfall projects rank newness of technology fourth implying that, although it is an important feature, it does not have the same significance as in the Overall and Agile views. It could be that new technologies are intensively evaluated up front before adoption to decrease possible project complexities. Finally, the variety of tasks is ranked fifth and implies that Waterfall projects consider task variety somewhat less than Agile projects. This does not, however, negate the importance of understanding the various tasks required to execute an IS project.

An analysis of environmental complexity features is performed in the following section.

Environmental complexity

Environmental complexity assesses the internal and external organisational environment in which the project operates. The top five environmental complexity features are shown in Table 5.7.

Stakeholder perspectives can vary during IS projects thus making it difficult to satisfy all stakeholders. Stakeholder perspectives is ranked number one for IS projects in general, which implies it is

TABLE 5.7: Environmental complexity top five complexity features (Overall).

Ranking	Complexity feature
1	Stakeholder perspectives
2	Internal strategic pressure
3	Number of stakeholders
4	Stability of project environment
5	Political influence

increasingly complex to manage stakeholder expectations and to realise stakeholder satisfaction across the board. Constant communication and interaction with all stakeholders are a means to limit the complexity associated with varying perspectives. Internal strategic pressure results from the pressure of senior management expectations regarding the project. This feature is ranked second and implies that IS projects experience higher levels of complexity because of internal strategic pressure. As mentioned, meeting all expectations is difficult and should be done as best possible. The number of stakeholders is ranked third and speaks to the complexity managing multiple internal and external stakeholders involved in a project. Project communication is more difficult than previously believed and is a skill set required to ensure all stakeholders have an equal understanding of the project at hand (Marnewick et al. 2016). IS projects which have a large number of stakeholders increase complexity given the communication challenges. Projects should operate within a stable environment and with minimal negative impacts occurring. The stability of project environment is ranked fourth implying that it is a challenge maintaining a stable environment for the project to thrive and exist freely. The organisational environment has a direct impact on the project environment as any instability would influence how a project is executed. Political influence is ranked fifth and relates to internal politics particularly. Internal politics primarily arise from stakeholders with senior authority, such as executives. There could be cases where executives insist on changing business requirements and scope without fully understanding the intricacies and influences on other complexity constructs and features.

The top ranking environmental complexity features when using Agile as a method, is shown in Table 5.8.

Stakeholder perspectives remain top, which further iterates the importance of stakeholder management. The number of stakeholders is ranked second, one position higher than the Overall view. The implication therefore is that Agile projects are more complex with regard to the management of stakeholders given the top two rankings. Furthermore, this is in line with the Agile Manifesto, which stresses a people rather than a process focus (Beck et al. 2001). Internal strategic pressure is ranked one position lower but still indicates that the organisation at large has a direct influence on IS project management. Although Agile IS projects are more flexible and adaptable, there must still be the semblance of a stable operating environment. Stability of the project environment is ranked the same at position four and further solidifies its importance for Agile projects. Interestingly, Agile projects are more complex with regard to understanding the level of competition in the industry as it is ranked fifth. Agile projects aim to deliver projects rapidly so that business value can be realised as soon as possible. Complexity arises when competing within the organisation's industry as this requires even more focus delivering solutions rapidly to gain or expand market share. This notion is further support by findings in Chapter 4, which confirm that Agile has greater market and industry impact (refer to Figure 4.14).

The environmental complexity features for Waterfall projects are shown in Table 5.9.

TABLE 5.8: Environmental complexity top five complexity features (Agile).

Ranking	Complexity feature
1	Stakeholder perspectives
2	Number of stakeholders
3	Internal strategic pressure
4	Stability project of environment
5	Level of competition

TABLE 5.9: Environmental complexity top five complexity features (Waterfall).

Ranking	Complexity feature
1	Stakeholder perspectives
2	Internal strategic pressure
3	Number of stakeholders
4	Political influence
5	Internal support

Stakeholder perspectives is still ranked number one and confirms that it is a complexity feature which needs the utmost attention. Internal strategic pressure maintains its top three ranking as it is ranked second for Waterfall projects. The number of stakeholders also holds its top three position as it is ranked third. The top three for the Overall, Agile and Waterfall views is particularly focused on stakeholder management, which is more prevalent in modern project success literature (Joseph & Marnewick 2014; Todorović et al. 2015; Williams 2016). Political influence is included for Waterfall projects and is ranked fourth. Internal politics seem to affect the Waterfall project complexity more and must therefore be mitigated and managed as effectively as possible. Finally, internal support is introduced for the Waterfall projects as it is ranked fifth. Waterfall projects arguably suffer from a lack of management support from stakeholders such as project sponsors. This introduces increased complexity as management support is required to ensure the project aligns to the greater organisational goals.

Project complexity includes the construct of dynamics, which is analysed in the next section.

Dynamics

The construct of dynamics focuses specifically on change management practices and characteristics within an IS project. Rather than ranking the top five, Table 5.10 ranks all the features as there are only six features within the dynamics construct.

The number of changes is ranked first overall and implies that the actual quantity of changes is complex to manage.

TABLE 5.10: Dynamics top six complexity features (Overall).

Ranking	Complexity feature
1	Number of changes
2	Impact of changes
3	Change process
4	Scope of changes
5	Change over time
6	Frequency of changes

IS projects inherently have multiple changes throughout the project, but the number of these changes should not be high as multiple changes could imply that the project was not completely understood and thus poorly developed. The impact of changes is ranked second and should not be ignored as small changes can have a large impact either positively or negatively. Complexity increases particularly when negative changes occur which derail the project, especially with regard to time and cost. Complexity around the actual change process is ranked third. Given that change is inevitable, an appropriate and well-designed change process should exist to ensure changes are managed effectively and are predominately positive. Scope of changes is ranked fourth and focuses on the detail around the expected changes. Similar to number and impact of changes, the scope of changes should not be overwhelming as this would suggest poor design. Although there are multiple changes throughout a project, changes should have a fluctuation pattern rather than maintain a continuous high level of changes. Change over time and frequency of changes is ranked fifth and sixth respectively and are comparable to scope of changes. It becomes increasingly complex to manage a project with frequent changes which change significantly over time.

The top six dynamics features when adopting Agile as a method are presented in Table 5.11.

Managing the number of changes is still complex for Agile projects as it is again ranked first. Change process has more emphasis in Agile projects, which is logical given that Agile uses continuous feedback to update and enhance the solution. The change process must therefore be expedited to maintain iterative releases. Scope of changes is ranked one position higher at third and implies that Agile projects face complexities around change scope when delivering the various iterations. The impact of changes is ranked lower at fourth, which arguably is consistent with the fact that Agile minimises change impact through iterative releases. Change frequency is important regardless and is ranked one position higher for Agile at fifth. Interestingly, change over time is considered the least complex for Agile projects, which also corresponds with the notion that iterative releases facilitate change management more effectively.

Dynamic complexity features for IS projects using the Waterfall method, is ranked in Table 5.12.

The impact of changes is ranked top for Waterfall projects which is significantly higher than the Agile project rankings. This implies Waterfall projects face greater challenges when managing change impact. The number of changes maintains its top two ranking for the Overall, Agile and Waterfall views. This confirms that it is important to not have too many changes at any single point in time as this could detract from IS project execution and negatively affect realising the project goals. Complexity around

TABLE 5.11: Dynamics top six complexity features (Agile).

Ranking	Complexity feature
1	Number of changes
2	Change process
3	Scope of changes
4	Impact of changes
5	Frequency of changes
6	Change over time

TABLE 5.12: Dynamics top six complexity features (Waterfall).

Ranking	Complexity feature
1	Impact of changes
2	Number of changes
3	Change process
4	Change over time
5	Scope of changes
6	Frequency of changes

the change process is also apparent for Waterfall projects and thus signifies the importance of having a well-designed change process regardless of the project methodology employed. Waterfall projects consider it more complex to manage change over time as it is ranked fourth. This could be that Waterfall projects mainly address changes towards the end of the project rather than continuously and throughout the project. Interestingly, scope of changes is ranked fifth and is considered not as complex compared to the previously discussed features. Waterfall projects arguably do not worry as much about the scope of changes because they expect to implement multiple changes during the final project stages. Frequency of changes maintains its low ranking at sixth and serves to confirm that complexity around this feature is low as the previous features aim to mitigate frequent changes.

The following section analyses the final project complexity construct of uncertainty.

Uncertainty

Uncertainty assesses the level of doubt and vagueness inherent in IS projects, and the Overall ranking for IS projects is showed in Table 5.13.

Uncertainty regarding time is the most highly ranked complexity feature overall. Time is one of the triple constraints which are often argued as a key success criterion within project management. Complexity around managing time uncertainty therefore makes logical sense. Incomplete information is ranked second and implies that IS projects experience significant

TABLE 5.13: Uncertainty top five complexity features (Overall).

Ranking	Complexity feature
1	Time
2	Incomplete information
3	Cost
4	Competency
5	Scope

complexity regarding poor information dissemination. Incomplete information such as poor requirements and specifications has a detrimental effect on project delivery and subsequent success. Cost is another component of the triple constraints which is argued as important. It is ranked third from an uncertainty perspective. Doubt around cost escalates quickly as it has a knock-on effect on the project as a whole and can easily overshoot planned estimates. Project competency is a strongly debated topic in the IS project realm and brings to question whether IS project managers have the appropriate skills and knowledge to execute projects (Joseph & Marnewick; Marnewick et al. 2016). Competency is ranked fourth and implies that it is increasingly complex to ensure adequate competency exists for the project to be executed correctly. Scope is ranked fifth within the uncertainty construct of the IS project complexity. Scope uncertainty exists predominantly when poor understanding and design exists. Quality requirements is somewhat of a misnomer as literature argues that practitioners do not take a holistic view during the design of a solution and subsequently produce mediocre inputs for development (Fernandez et al. 2015; Tamai & Kamata 2009).

Agile projects' top uncertainty features are shown in Table 5.14. The top three features are identical to the Overall view signifying their importance. Scope is ranked one position higher at fourth, implying Agile environments are slightly more complex regarding the management of scope uncertainties.

Agile's iterative and flexible environment suggests that scope must be managed more carefully, otherwise the project could become disjointed and not deliver as expected. Interestingly, Agile introduces the feature of technological maturity as it is

TABLE 5.14: Uncertainty top five complexity features (Agile).

Ranking	Complexity feature
1	Time
2	Incomplete information
3	Cost
4	Scope
5	Technological maturity

TABLE 5.15: Uncertainty top five complexity features (Waterfall).

Ranking	Complexity feature
1	Time
2	Incomplete information
3	Scope
4	Competency
5	Cost

ranked fifth. Agile arguably prefers using mature technology as this would facilitate the fast-tracking of solutions to the market as the team would have experience with adopted technology. Conversely, it is complex to manage Agile projects which use innovative and untested technology as experience will be lacking.

Table 5.15 shows the top five rankings for uncertainty features for Waterfall projects. Time and incomplete information maintain their top two positions once again.

It is therefore clear that that these two features add to IS project complexity regardless of the methodology employed. Furthermore, time uncertainty is arguably apparent in Table 4.1 where actual time deviates significantly from originally planned time. Scope uncertainty is ranked highest for Waterfall projects, which implies there is considerable doubt regarding upfront scoping activities and that these projects battle with scope issues throughout. Similar to the Overall view, competency is ranked fourth when adopting the Waterfall method. Cost uncertainty is ranked fifth implying that Waterfall projects do not consider cost as a complex feature. This aligns to the findings in Chapter 4, which argue that Waterfall projects' actual cost is less than the original budget (Refer to Table 4.1).

The following section provides a holistic view of complexity features by analysing them across all constructs.

■ Overall complexity view

The previous sections focus on the rankings of features within a single complexity construct. The aim of the section is to elaborate on the previous findings by investigating the top five and bottom five rankings across all five constructs. Table 5.16 provides an overview of the top and bottom five ranked features of all constructs regardless of the method of orientation.

Technical risks ranked top overall implying that IS projects complexity is primarily driven by project technicalities, that is project goals, scope, tasks and technology experience. Schedule dependencies is ranked second, which is logical given that project management is a culmination of tasks required to deliver a successful project. IS projects often face the dilemma of selecting technology to adopt and implement. This is confirmed by the ranking of newness of technology at third. Scope has been argued in previous sections as a contentious issue which plagues IS projects. IS projects face significant complexities regarding the scale of scope as it is ranked fourth. Finishing off the top five is skill availability and speaks directly to one of the most important resources required for delivering a project. The project team particularly requires extensive skills to not only manage an IS project but also implement it. Interestingly, the top five features are predominantly technical complexity features implying that IS projects should focus more on technical aspects than anything else. It could be argued that dealing with technical complexities could have a positive effect on other complexity constructs and features.

The bottom five begins with undisclosed participants. IS project environments do not consider this a complexity feature which requires much attention. It has previously been argued that all stakeholders should be accounted for to ensure the

TABLE 5.16: Top five and bottom five complexity features across all construct.

Ranking	Top 5	Bottom 5
1	TC technical risks	U undisclosed participants
2	OC schedule dependencies	OC HSSE
3	TC newness of technology	OC different languages
4	TC scale of scope	EC remoteness
5	OC skill availability	EC weather conditions

HSSE, health, safety, security and environment; TC, technical complexity; OC, organisational complexity; EC, environmental complexity.

project delivers accordingly. Yet, this feature is ranked as one of the lowest. This could possibly be a fundamental indication why IS projects perform poorly because they merely move forward without comprehensive input from all involved. The second lowest ranked feature is health, safety, security and environment awareness implying that IS project environments omit complexities associated with health and safety. Different languages used in a project is considered the third lowest complexity feature, which is surprising in the South African context given that the diverse nature of the country includes the use of multiple languages. Nevertheless, complexity around language is considered mediocre and does not contribute sufficiently to IS project complexity. The fourth lowest ranking is remoteness regarding the location or site of the project deployment. The implication is that team members and stakeholders do not face any difficulties accessing the project site and logistics are not as complex. Weather conditions was ranked the lowest of all the complexity features and implies that IS projects continue regardless of the weather.

Similar to the individual assessment of complexity features, this section will analyse features when different methodologies are employed. Table 5.17 indicates the top and bottom five feature rankings in an Agile project.

Schedule dependencies is the most highly ranked complexity feature, which confirms that IS projects battle to manage their schedule as the environment continuously changes during the project. Agile projects view technical risks as the second most important and is comparable to the overall view of complexity features. Newness of technology retains its position at third

TABLE 5.17: Top five and bottom five complexity features across all constructs (Agile).

Ranking	Top 5	Bottom 5
1	OC schedule dependencies	U undisclosed participants
2	TC technical risks	OC different nationalities
3	TC newness of technology	EC remoteness
4	OC skill availability	OC different languages
5	D number of changes	EC weather conditions

OC, organisational complexity; TC, technical complexity; EC, environmental complexity; D, dynamics.

and further iterates the importance of technology adoption and implementation. Fourth is skill availability, which arguably confirms that skills development and exploitation is a prerequisite in the IS project realm. Agile projects are known for their iterations based on feedback which lead to evolving changes. The number of changes is ranked fifth and confirms that Agile projects face complexity challenges regarding the management of multiple changes. Even though Agile proclaims adaptation, multiple changes can become cumbersome and adversely impact an IS project.

Undisclosed participants is once again ranked first further implying its lack of complexity. Agile projects rank different nationalities as the second lowest suggesting that organisations have embraced the inclusion of multiple nationalities working together given the modern landscape in which they operate. Remoteness is ranked third while different languages is ranked fourth. Weather conditions continues not to be a complex matter as it is once again ranked last.

Table 5.18 indicates the top and bottom five feature rankings in Waterfall projects.

Waterfall projects rank technical risks as top, which confirm their complex nature to manage. Varying stakeholder perspectives are introduced as a high-ranking complexity feature at position two. It seems increasingly difficult to maintain and manage various perspectives for Waterfall projects, which could be a key attributing feature influencing IS project performance. Scale of scope appears again as it is ranked third. The rigid nature of the Waterfall method could be the reason why scope continues to be a complex issue as the idea is that the scope is defined upfront

TABLE 5.18: Top five and bottom five complexity features across all constructs (Waterfall).

Ranking	Top 5	Bottom 5
1	TC technical risks	U undisclosed participants
2	EC stakeholder perspectives	OC HSSE
3	TC scale of scope	OC different languages
4	TC number of tasks	EC remoteness
5	TC newness of technology	EC weather conditions

OC, organisational complexity; TC, technical complexity; EC, environmental complexity; D, dynamics.

and should not change. The fourth-ranking feature combines some tasks that imply that Waterfall projects are not as adept at task management compared to Agile projects. Although ranked lower than the Overall and Agile views, newness of technology maintains its position in the top five complexity features. IS projects emphasise technology and it is, therefore, logical that new technology complexities inherently exist for IS projects. Technical complexities make up four of the five top ranked features, which is similar to the argument made for the Overall IS project complexity view.

The bottom five features are comparable to the Overall and Agile views, which confirms that they are far simpler to manage than other complexity features.

Conclusion

The aim of this chapter was to indicate which features in an IS project are considered most complex so that practitioners can make adequate provision for managing them. The rankings for the overall and individual views of constructs show that no environment is the same and that each view complexity in a different light. Many features align with the environment they operate in, that is, Agile and Waterfall. The analysis of the top five complexity features does not show one construct as more complex than another construct. What is evident is that features from technical complexity construct occur nine times within the top five features with organisational complexity in the second place. IS project managers should analyse the various complexity constructs and address the features one by one in order to reduce the overall complexity of the project.

The subsequent question is: How does one manage these complexity features to ensure they do not adversely affect project delivery? Ironically, understanding IS project complexity is complex in itself, which is why further analysis is required to illuminate its inherent intricacies.

Chapter 6

Symbiosis between IS project success and complexity

All the constructs related to IS project success and IS project complexity are represented in Appendix A. The various respective elements and features are also included for ease of reference. Moreover, observed variable names were defined as this would act as a cross-referencing tool for the data analysis below.

Conceptualising the symbiosis between information system project success and complexity

Project success and complexity are often viewed in isolation with no real link argued between the two. However, in the real world there is an indefinite association between the two concepts. Chapters 2 and 3 discussed the concepts separately in detail as these formed the foundation of articulating the symbiosis which

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inherently exists. The models represented in this chapter are based on the logical mappings depicted and argued in this section.

The concept of project success has many definitions which have varying perspectives and thus create an element of incongruity in the project management landscape. Chapter 2 presented the five level model of project success to encapsulate the concept from an IS perspective. The concept of project complexity has also resulted in multiple views being developed, which has culminated in a multidimensional perspective of the concept. Chapter 3 subsequently presented a five dimensional view for IS project complexity based on an extensive literature review. The question posed here is how these views relate theoretically and logically prior to further data exploration. A conceptual theoretical model for the symbiosis between IS project success and IS project complexity is presented in Figure 6.1.

Organisational complexity spans the entire five level view of project success as IS projects are executed within the organisational context to facilitate the realisation of the business and strategic goals. An organisation's structural orientation affects everything

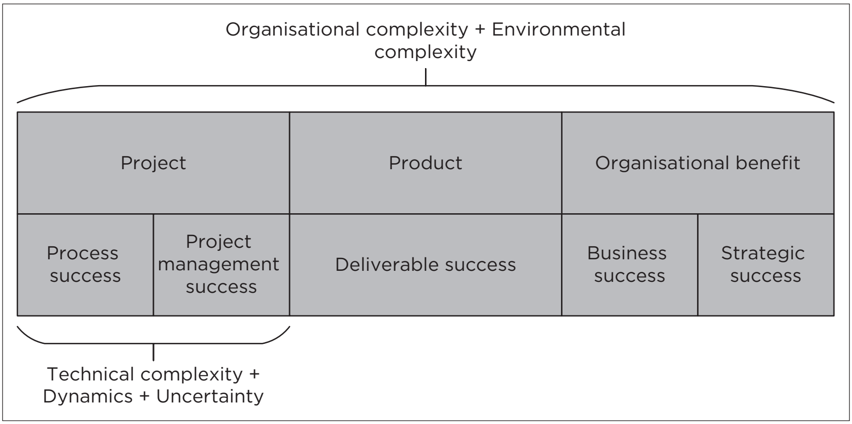

FIGURE 6.1: Symbiosis of information system project success and information system project complexity.

from the project process to long-term strategic success as the organisational structure and business units directly influence how a project is executed. The element of size pertains to attributes of an IS project such as project duration, variety of methods and capital expenditure, for example. Size thus plays a role that influences process and project management success as each attribute pertains to the groundwork that is performed for a project. Resources within organisational complexity elaborate areas which pertain to business and strategic success distinctly, such as project drive. Areas such as resource and skills availability as well as experience with involved parties align to project management and deliverable success as both embrace effective project management execution to deliver valuable product output. The project team and trust elements have implications regarding process and project management success as social dynamics propel and support the execution of an IS project. Interdependencies and risk span the entire five level landscape as each feature influences one or multiple success levels.

Environment complexity comparably covers all five levels of project success as well. Process and project management success are encapsulated by the elements of stakeholders and location. The location element speaks to attributes and intricacies regarding the project site. Process and project management success is dependent on these environmental attributes as they influence the activities required to execute a project. Stakeholders is an element which emphasises stakeholder management, which is key to realising process and project management success. Furthermore, stakeholders aligns to deliverable success as the management of stakeholders such as the end user aims to ensure the project delivers its output goal. Business and strategic success is driven by the need to compete within a competitive global landscape. These two levels of organisational benefit are affected by complexities surrounding environmental stability, strategic pressure and competition level, which are represented in the market conditions element of environmental complexity. Environmental risks span all success levels as risks are inherent regardless the status of each level.

Technical complexity is inherently focused project management as each of the features revolve around project management activities specifically. Inferences exist, therefore, that technical complexity engages with the levels of process and project management success. Differentiation relates to input and output diversity, which is intrinsic of project management as a whole and the processes which support it. Goals is specific to project goals and their alignment to greater strategic initiatives. This is dealt with on the 'ground' level where project activities are executed as each activity is aligned to the greater project goal. The realisation of the project goal is not the main concern during the project management phase as the focus is on delivering the project with assessment done later on. The elements of scope and task once again focus on actual activities and how they are performed, which is project management itself. Experience from a technical complexity view regards the challenges dealing with technology in an IS project. This experience, therefore, relates to project management success as the focus is on how technology is used in the project to realise the project goal. Similar to organisational and environmental risks, technical risks appeal to process and project management risks at the 'ground' level.

Uncertainty incorporates elements and features around doubt and vagueness, which is directly associated with process and project management success. The triple constraints of time, cost and scope are a project management assessment tool and are specific to an individual project. Method and task uncertainty has a process and project management orientation that is particular to hands-on activities. The elements of goals, technology and stakeholders uncertainty are project management specific as they all deal with characteristics of the project itself and not success areas after the project. This, however, does not negate any possible propagating effect to the following project success levels. Information uncertainty and vagueness occur regardless of the various project management processes in place, which is why it relates to process and project management success.

Project experience changes throughout and requires robust change management practices to maintain project momentum. Change management is covered in the dynamics construct and is particular to the project itself, which implies that process and project management success are once again influenced. Change management is particularly important for IS projects as methodologies have different approaches which influence its practice. For example, Agile projects profess adaption and iteration which require robust change management practices and processes.

The discussion above argues the logical mapping of IS project success and complexity to convey symbiosis of the two concepts. The subsequent model development and analysis is based on these mappings to illuminate the symbiosis.

Development and analysis of IS project success models

The third section of the questionnaire requested the respondents to provide their impressions regarding what affects project success on various levels. These five levels were identified from the research performed by Bannerman (2008):

- **Level 1: Process success.** The need to consider technical and managerial aspects in completing the project task.
- **Level 2: Project management success.** The immediate performance of the project with regard to budget, scope and schedule.
- **Level 3: Deliverable success.** The measures of information quality, system quality, service quality, intention to use, actual use, user satisfaction, and net benefits.
- **Level 4: Business success.** The ability of the project to successfully meet the needs or solve a business problem the customer is experiencing.
- **Level 5: Strategic success.** This criterion represents the highest level of benefit achieved by a project, despite the possibility of failures against lower level criteria, as recognised by external stakeholders such as investors, industry peers, competitors, or the general public, dependent upon the nature of the project.

One level is omitted in the discussion that follows, that is Level 2 that focuses on project management success. The questionnaire requested specific data from the respondents which is not conducive for modelling. The other four levels were measured using a 5-point Likert scale. Suffice to say that various other studies have been able to determine the various critical success factors and causes of failure (Marnewick, Erasmus & Joseph 2016).

What follows is a discussion on the Overall factors and model as well as an investigation into the differences between Agile and Waterfall projects.

Overall results

The Overall results closely reflected the research done by Bannerman (2008) in that three of the levels were clearly identified. The following factor loading is the result of factor analysis through statistical software (Figure 6.1).

All the relevant variables associated with the different levels associated with four factors. Factor 1 included all the variables of deliverable success. These were:

- requirements met
- specifications met
- client and/or user specifications met
- client and/or user acceptance
- product and/or system used
- client and/or user satisfied
- client and/or user benefits realised.

These clearly relate to Level 3 of the Bannerman (2008) model and therefore Factor 1 can confidently be labelled as *Deliverable success*. However, there are other variables, not thought of as part of deliverable success in the original model, that are associated with this factor. These are:

- goals and/or objectives
- business plan
- benefits realisation.

These variables are identified as forming part of *Business success* or Level 4. On examination it would seem these three variables bear some relation to product success in the mind of the respondents.

TABLE 6.1: Overall factor loadings with Pattern Matrix.

Observed variable[a]	Factor			
	1	2	3	4
DS_06	0.851			
DS_04	0.842			
DS_03	0.800			
DS_02	0.748			
DS_07	0.728			
DS_05	0.648			
DS_01	0.626			
BS_04	0.574			
BS_01	0.561			
BS_02	0.370			
SS_03		0.756		
SS_04		0.734		
SS_01		0.722		
SS_02		0.690		
SS_05		0.603		
SS_06		0.587		
PS_01			0.772	
PS_03			0.735	
PS_02			0.698	
PS_04			0.654	
BS_05				1.018
BS_06				0.587

Notes: Pattern Matrix: Rotation converged in 7 iterations, Extraction Method: Maximum Likelihood and Rotation Method: Promax with Kaiser Normalisation.
[a], Variable names and associations are presented in Appendix A.

Factor 2 contained all the variables associated with strategic success on Level 5 of Bannerman's model. These are:

- market impact
- industry impact
- competitive impact
- investor impact
- regulator impact
- other impacts.

Therefore, Factor 2 can be labelled as *Strategic success* and correlates strongly with what literature determines.

Factor 3 includes all the variables labelled as part of process success. These are:

- Processes appropriately chosen for the intended purpose.
- Processes aligned with project objective.
- Processes appropriately integrated with one another.
- Processes effectively implemented.

Therefore, Factor 3 correlates strongly with what Bannerman (2008) identified as Level 1 and can be labelled as *Process success*.

Two remaining variables are grouped into Factor 4. These variables are:

- Extent to which the project achieved unintended benefits.
- Extent to which the project achieved unintended consequences.

These variables are associated with business success in literature. However, on their own, it may not be apparent that they belong there. Given the 'unknown' description of both of these variables, perhaps the data can be interpreted differently. This factor is labelled as the *Unknowns* of project success as it refers to impacts and consequences of conducting project work. These impacts are difficult to plan for or to anticipate without extensive due diligence activities.

These factors are all confirmed with Cronbach Alpha values of 0.9 and above (Field 2013). Therefore, the researchers are confident about the validity of the four identified factors. These could be depicted as per Figure 6.2.

The next step is to attempt to determine a model. The purpose of such a model is to ascertain whether there are links between these different factors and whether or not there are correlations between one another. This is done through the process of Structural Equation Modelling (SEM). The following model (Figure 6.3) emerged after numerous iterations.

This model clearly indicates that these different levels have medium to strong relationships to one another, the strongest being between *Process success* and *Deliverable success*. This is an

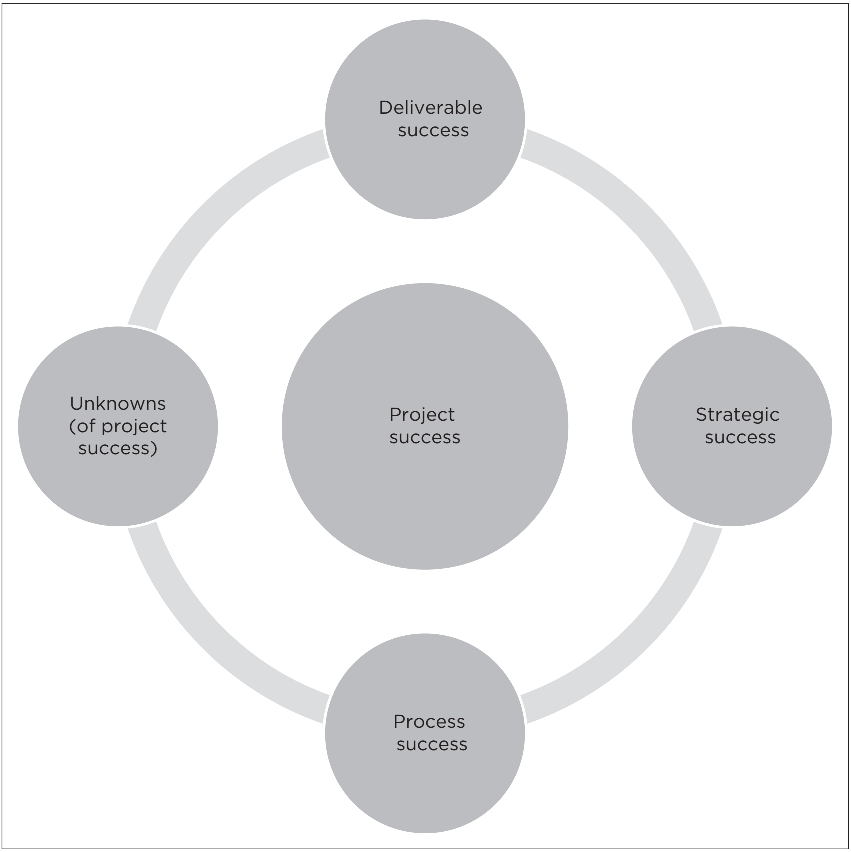

FIGURE 6.2: Project success level factors.

expected result as it would be difficult to imagine that a deliverable can be produced without completing proper processes. Recall that Bannerman (2008) indicated that these levels need not necessarily be related to achieve success on higher levels. While these results do not directly contradict Bannerman (2008), they indicate that there is a relationship nonetheless. The outcome on lower levels would seem to have an impact on the outcome on higher levels.

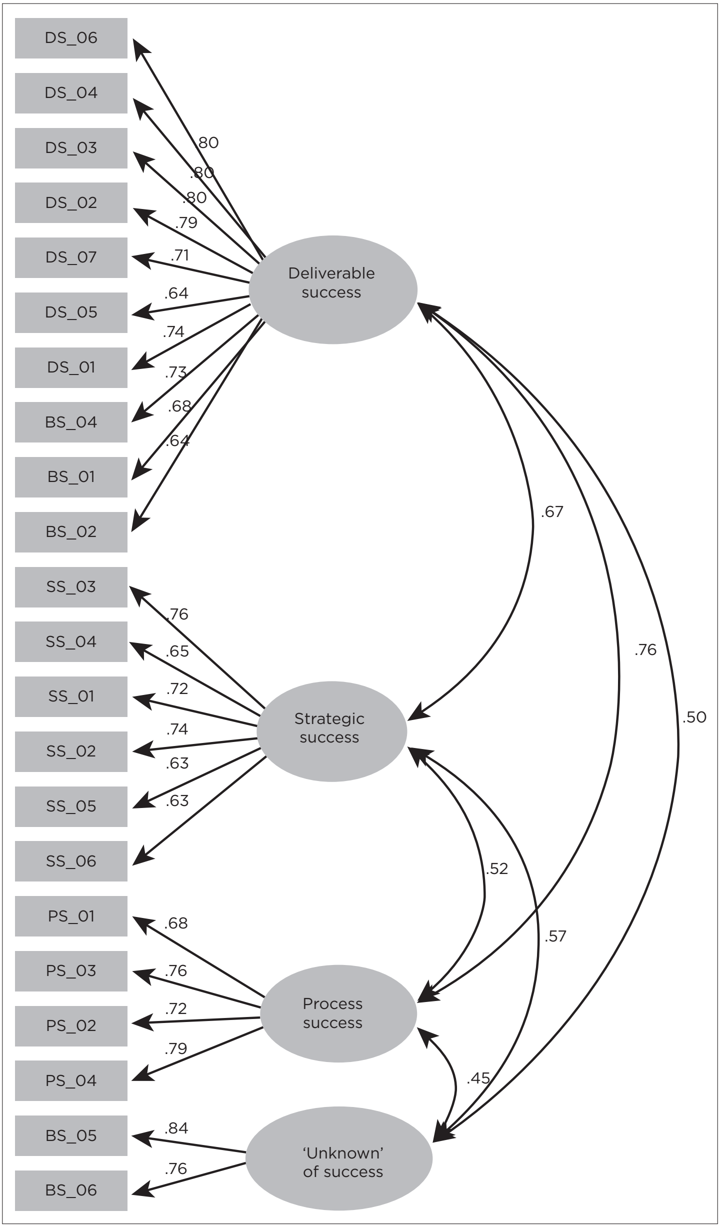

FIGURE 6.3: Unconfirmed model for project success levels.

This model can be confirmed as valid. The following model fit data was obtained from the SEM process as depicted in Table 6.2.

Therefore, for the purposes of this data set, we can confidently conclude that IS project managers take cognisance of the following levels of project success:

- Level 1: Process success.
- Level 2: Project management success as determined by previous studies.
- Level 3: Deliverable success.
- Level 4: Strategic success.

TABLE 6.2: Model fit data for Overall model for project success.

Model fit measures	Description	Cut-off levels employed	Results	Reference
Absolute fit measures	CMIN/DF	≤ 5	2.82	Gaskin (2013e); Marsh and Hocevar (1985); McKinney et al. (2002); Roh, Ahn and Han (2005) ; Ullman (1996); Yatim (2008)
	RMR	≤ 0.05	0.04	Roh et al. (2005); Tabachnick and Fidell (1996);
	GFI	≥ 0.9	0.92	Doloi, Iyer and Sawhney (2011); Kim et al. (2009); Roh et al. (2005);Tabachnick and Fidell (1996)
Relative fit measures	NFI	≥ 0.9	0.93	Doloi et al. (2011); Stahl (2008); Tabachnick and Fidell (1996); Yatim (2008);
	TLI	≥ 0.9	0.94	Doloi et al. (2011); Hair et al. (2006); Stahl (2008); Yatim (2008)
	CFI	≥ 0.95	0.95	Anglim (2007); Doloi et al. (2011); Gaskin (2013e); Hair et al. (2006); Roh et al. (2005); Tabachnick and Fidell (1996); Stahl (2008); Yatim (2008)
Fit measures based on the non-central chi-square distributions	RMSEA	≤ 0.08	0.06	Hoyle (2011); Marsh, Hau and Wen (2004); McQuitty and Wolf (2013); Nunkoo and Ramkissoon (2012); Reisinger and Mavondo (2007)

CMIN/DF, Chi-squared /Degrees of freedom; RMR, Root Mean Square Residual; GFI, Goodness-of-Fit Index; NFI, Normal Fit Index; TLI, Tucker-Lewis Index; CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation.

The variables for business success (Level 4) are distributed between *Process success* and *Deliverable success*. However, project professionals also take note that unintended impacts and consequences somehow form part of the model of project success. It does, however, seem that these are separated from other measures of project success considerations in that they cannot be taken into account.

Results for Waterfall projects

The data can be separated into projects conducted using the Waterfall and Agile methods, the purpose being to determine if there are differences in how project success is perceived and determined between the two methods.

Four factors closely mirroring those of the Overall results were obtained. The factors were once again confirmed as valid with a Cronbach alpha value of above 0.9 for all of them. Table 6.3 indicates the factors loading for each variable and their associated factors.

Slightly less clarity is obtained from this analysis because the number of responses is now less than in the Overall view. On the face of it, the result is very similar to that of the Overall result. The factor groupings remain the same as in Table 6.1:

- **Factor 1: Deliverable success.** The only difference is the omission of the Goals and Objectives variable, which is now to be found in Factor 3, Process success. This could be because Waterfall projects are very structured and are initiated with the goal of the project in mind right from the start.
- **Factor 2: Strategic success.** Is identical to that of the Overall result.
- **Factor 3: Process success.** Is identical except for the variables discussed above and for the addition of one variable associated with business success. Interestingly enough, this variable is Governance. In order for the factors and model to make sense, governance is required. As a Waterfall project follows a very rigid and formalised approach, strong governance lies at the heart of it.

TABLE 6.3: Factors for project success with a Pattern Matrix (Waterfall).

Observed variable[a]	Factor			
	1	2	3	4
DS_04	0.898			
DS_03	0.861			
DS_06	0.794			
DS_07	0.694			
DS_05	0.672			
DS_02	0.653			
BS_04	0.517			
DS_01	0.393		0.304	
BS_02	0.363		0.360	
SS_05		0.834		
SS_06		0.746		
SS_04		0.725		
SS_01		0.721		
SS_03		0.590		
SS_02		0.517		
PS_01			0.803	
PS_04			0.767	
PS_03			0.766	
PS_02			0.678	
BS_01	0.398		0.462	
BS_03			0.319	
BS_05				0.812
BS_06				0.738

Notes: Pattern Matrix: Rotation converged in 7 iterations, Extraction Method: Maximum Likelihood and Rotation Method: Promax with Kaiser Normalisation.
[a], Variable names and associations are presented in Appendix A.

- **Factor 4: Unknowns.** Of a project success also remains unchanged.

The SEM model (Figure 6.4) for these factors is also generated and revealed to be as such.

Here even stronger interrelationships are identified, the strongest relationship once again being between *Process success* and *Deliverable success*. This correlation is very strong. This would imply that the outcome in the preceding level of *Process success* would directly and very strongly impact *Deliverable success*. This is a clear indication on how the Waterfall method impacts the outcome. The Waterfall method is initiated with a set

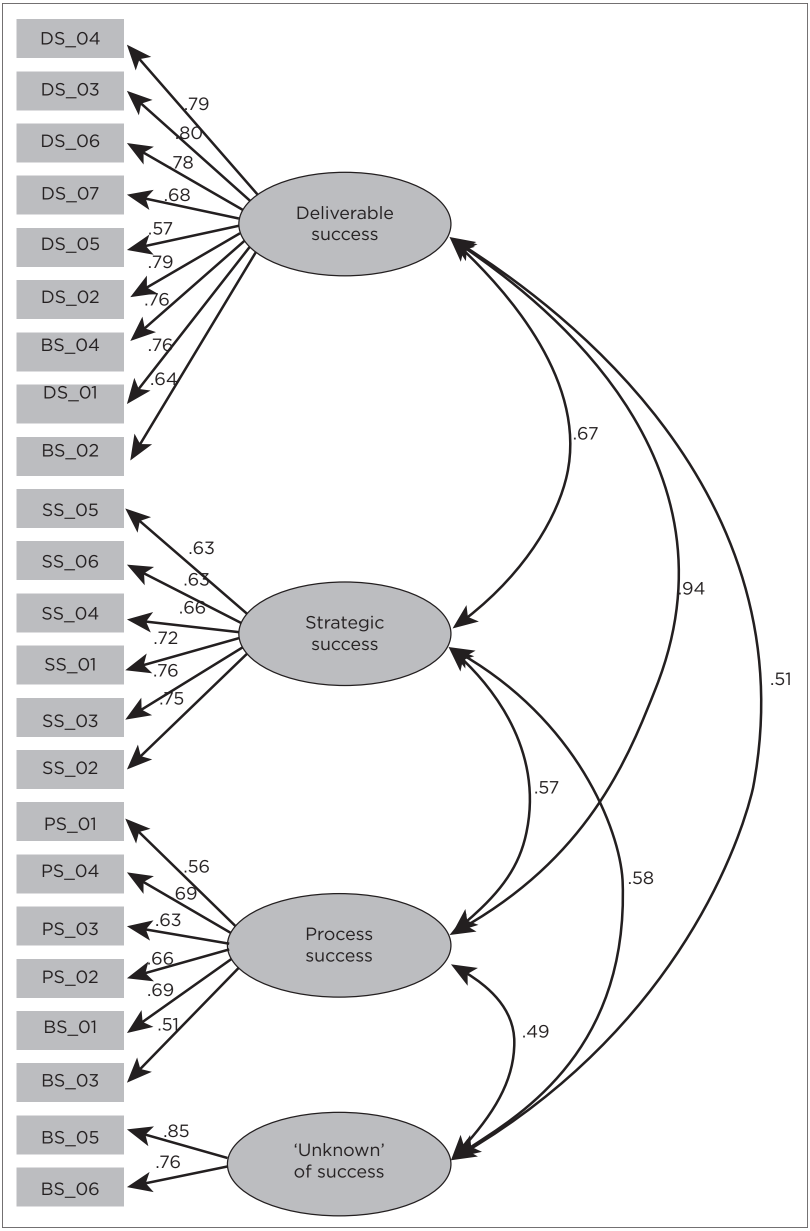

FIGURE 6.4: Unconfirmed model for Waterfall project success levels.

goal in mind to deliver a specific product. To obtain this product, many processes are performed in an iterative fashion.

The model fit measures for this results were obtained as depicted in Table 6.4.

The proposed model can be confirmed given the model fit measures. It is clear that the conclusions for the Overall model also apply to Waterfall projects. The one aspect that that is different is how strongly goals and objectives are associated with Level 1, *Process success*.

Results for Agile projects

The Agile method requires that its adherents only do what is required to successfully complete the delivery of a product. This

TABLE 6.4: Model fit for Waterfall project success mode.

Model fit measures	Description	Cut-off levels employed	Results	Reference
Absolute fit measures	CMIN/DF	≤ 5	2.7	Gaskin (2013e); Marsh and Hocevar (1985); McKinney et al. (2002); Roh et al. (2005); Ullman (1996); Yatim (2008)
	RMR	≤ 0.05	0.04	Roh et al. (2005); Tabachnick and Fidell (1996)
	GFI	≥ 0.9	0.92	Doloi et al. (2011); Kim et al. (2009); Roh et al. (2005); Tabachnick and Fidell (1996)
Relative fit measures	NFI	≥ 0.9	0.93	Doloi et al. (2011); Stahl (2008); Tabachnick and Fidell (1996); Yatim (2008)
	TLI	≥ 0.9	0.94	Hair et al. (2006); Doloi et al. (2011); Stahl (2008); Yatim (2008)
	CFI	≥ 0.95	0.95	Anglim (2007); Doloi et al. (2011); Gaskin (2013e); Hair et al. (2006); Roh et al. (2005); Stahl (2008); Tabachnick and Fidell (1996); Yatim (2008)
Fit measures based on the non-central chi-square distributions	RMSEA	≤ 0.08	0.06	Hoyle (2011); Marsh et al. (2004); McQuitty and Wolf (2013); Reisinger and Mavondo (2007); Nunkoo and Ramkissoon (2012)

CMIN/DF, Chi-squared /Degrees of freedom; RMR, Root Mean Square Residual; GFI, Goodness-of-Fit Index; NFI, Normal Fit Index; TLI, Tucker-Lewis Index; CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation.

approach in no way absolves its adherents of the requirement of a formalised approach.

The results in this data set once again yielded the same four factors as found in the Overall and Waterfall models. All four factors were confirmed as valid with a strong Cronbach alpha above 0.9. The factor loadings obtained are depicted in Table 6.5.

- **Factor 1: Deliverable success.** Is identical to that of the Overall model. This of course differs from the Waterfall project factors where objectives and goals are excluded in favour of Factor 3: Process success. For Agile projects, it seems that objectives

TABLE 6.5: Factors for Agile project success with Pattern Matrix.

Observed variable[a]	Factor			
	1	2	3	4
DS_06	0.851			
DS_03	0.834			
DS_02	0.782			
DS_01	0.737			
DS_04	0.735			
DS_07	0.671			
BS_01	0.633			
BS_04	0.574			
DS_05	0.545			
BS_02	0.421			
SS_03		0.745		
SS_02		0.729		
SS_01		0.723		
SS_04		0.714		
SS_06		0.500		
SS_05		0.433		
PS_03			0.749	
PS_04			0.733	
PS_01			0.667	
PS_02			0.607	
BS_05				1.019
BS_06				0.509

Notes: Pattern Matrix: Rotation converged in 7 iterations, Extraction Method: Maximum Likelihood and Rotation Method: Promax with Kaiser Normalisation.
[a], Variable names and associations are presented in Appendix A.

and goals form part of Factor 1: Deliverable success. This may be because, in Agile projects, not all requirements are immediately visible or identified but only developed during further iterations of the process.

- **Factor 2: Strategic success.** Is identical to all previous results.
- **Factor 3: Process success.** Is identical to the Overall result and only differs from the Waterfall projects' results in two aspects. The model for Agile project success does (1) not require governance or (2) goals and objectives variables must be coherent. This is an interesting result, given the propensity for many Agile adherents to summarily dispense with valuable, formalised techniques. Governance is the activity of guiding behaviour to achieve a desired outcome and objective (Joseph, Erasmus & Marnewick 2014). The fact that the respondents to this questionnaire who practice Agile principles do not see value or need for governance as a contributing factor project success is cause for concern.

The Agile project success model was derived as in Figure 6.5.

This model once again indicates medium to strong relationships between the four factors that were confirmed. Table 6.6 shows the model fit measurements that were obtained.

This model is also confirmed as valid and can be accepted. The medium to strong relationship indicates that once again there are influences amongst the levels of project success that cannot be ignored.

Development and analysis of IS project complexity models

It must be noted that, unlike the IS project success models presented above, no viable or feasible SEM models were possible for all complexity constructs. Exploratory models are subsequently presented as they still provide insight regarding what complexity features to consider for IS projects.

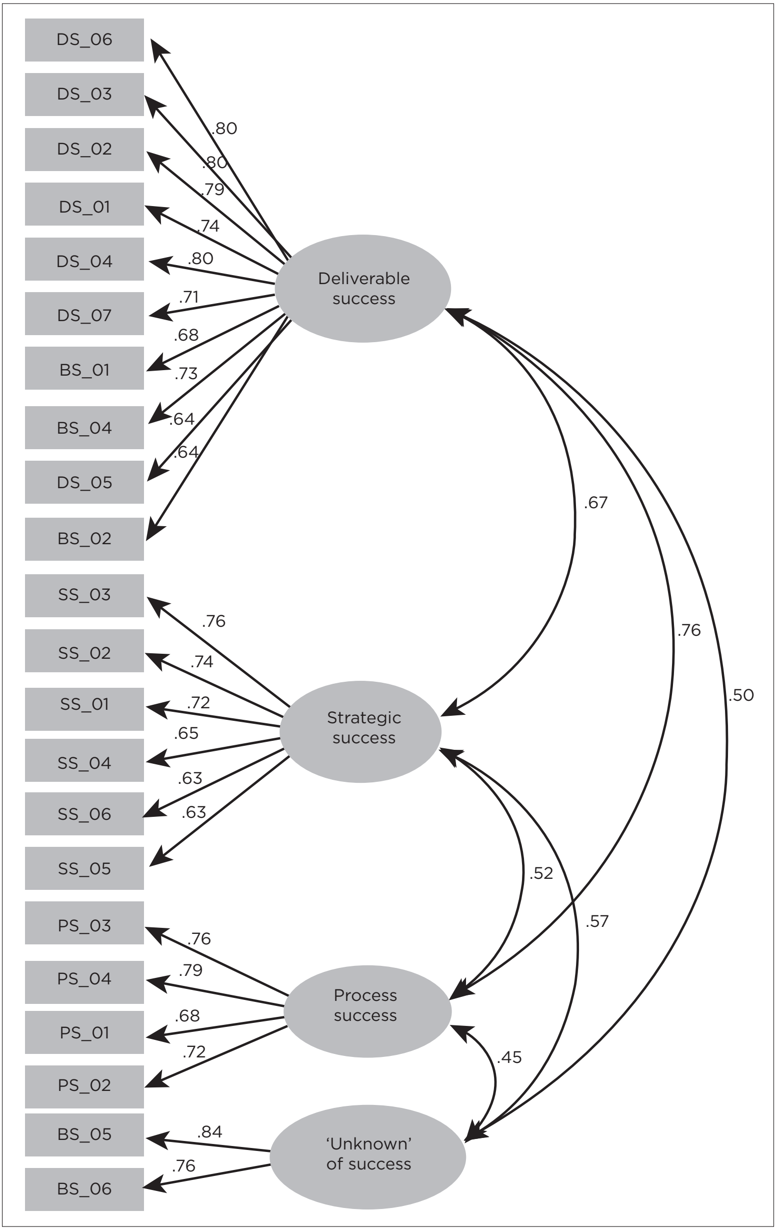

FIGURE 6.5: Unconfirmed model for Agile project success levels.

TABLE 6.6: Agile model fit measurements.

Model fit measures	Description	Cut-off levels employed	Results	Reference
Absolute fit measures	CMIN/DF	≤ 5	2.8	Gaskin (2013e); Marsh and Hocevar (1985); McKinney et al. (2002); Ullman (1996); Roh et al. (2005); Yatim (2008)
	RMR	≤ 0.05	0.04	Roh et al. (2005); Tabachnick and Fidell (1996)
	GFI	≥ 0.9	0.92	Doloi et al. (2011); Kim et al. (2009); Roh et al. (2005); Tabachnick and Fidell (1996);
Relative fit measures	NFI	≥ 0.9	0.93	Doloi et al. (2011); Stahl (2008); Tabachnick and Fidell (1996) Yatim (2008)
	TLI	≥ 0.9	0.91	Doloi et al. (2011); Hair et al. (2006); Stahl (2008); Yatim (2008)
	CFI	≥ 0.95	0.95	Anglim (2007); Doloi et al. (2011); Gaskin (2013e); Hair et al. (2006); Roh et al. (2005); Stahl (2008); Tabachnick and Fidell (1996); Yatim (2008);
Fit measures based on the non-central chi-square distributions	RMSEA	≤ 0.08	0.06	Hoyle (2011); Reisinger and Marsh et al. (2004); Mavondo (2007); McQuitty and Wolf (2013); Nunkoo and Ramkissoon (2012)

CMIN/DF, Chi-squared /Degrees of freedom; RMR, Root Mean Square Residual; GFI, Goodness-of-Fit Index; NFI, Normal Fit Index; TLI, Tucker-Lewis Index; CFI, Comparative Fit Index; RMSEA, Root Mean Square Error of Approximation.

Organisational complexity and project success

Organisational complexity was identified as the IS project complexity construct with the most features at 34. Furthermore, it was depicted and discussed that organisational complexity spans across all the project success levels. Exploratory factor analysis (EFA) was performed to determine the latent constructs within organisational complexity from an Overall, Agile and Waterfall perspective. However, the EFA process was unsuccessful as a valid and reliable exploratory model could not be determined based on the current dataset. It was therefore established that future studies will have to be performed to gain a better understanding and clarity around the organisational complexity construct for IS projects.

The irony that organisational complexity is complex to articulate further iterates the importance of understanding this construct.

Environmental complexity

Failure of the organisational complexity EFA process resulted in environmental complexity being analysed independently as this would still provide value regarding what complexities to assess from an environmental perspective. Similarly, EFA was performed from an Overall, Agile and Waterfall perspective.

Overall exploratory factor analysis modelling of environmental complexity

Various measures were applied when validating the discovered exploratory models. Firstly, the Kaiser-Meyer-Olkin (KMO) was assessed at 0.848, which is a very good adequacy measure (Field 2009; Gaskin 2016; Kaiser 1974). The KMO value was also significant (0.000), which further validates this adequacy measure. Extraction values from the communalities results are also used to determine adequacy and are required to be above 0.3 (Gaskin 2016). This was confirmed as all values were above the acceptable threshold. The total variance explained is another adequacy measure which needs to be assessed. The threshold for this measure is preferably above 50% (Gaskin 2016; Reio & Shuck 2015), but the result was 44.4%. For the sake of research, the results of this EFA will still be discussed as the other validity and reliability measures were acceptable. Convergent validity was established via factor loadings, which are required to be above 0.5 with an average loading, within a factor, of above 0.7 (Ferguson & Cox 1993; Gaskin 2016; Hair et al. 2006). Table 6.7 presents the factor loadings and reveals that further validation is required to confirm the loading values. Cronbach's alpha was used as a reliability check with the threshold set at 0.7 (Badewi 2016; Chow & Cao 2008; Hair et al. 2006). Cronbach values are represented in Table 6.7 next to the factor number in brackets. Both values are

TABLE 6.7: Environmental complexity exploratory factor analysis Patten Matrix.

Observed variable[a]	Factor	
	1 (0.860)	2 (0.811)
EC_09	0.779	
EC_08	0.701	
EC_07	0.678	
EC_13	0.664	
EC_06	0.542	
EC_12	0.542	
EC_10	0.513	
EC_05	0.496	
EC_11	0.470	
EC_04	0.419	
EC_01		0.867
EC_02		0.835

[a], Variable names and associations are presented in Appendix A.

acceptable as Factor 1 and Factor 2 have a score of 0.860 and 0.811 respectively and confirm the factor loadings. Discriminant validity was assessed via the factor correlation matrix where there should be no correlations above 0.7 (Gaskin 2016). The correlation between Factor 1 and Factor 2 was below the threshold at 0.533.

A factor plot is also used to visualise the groupings for each factor (Figure 6.6). It must be noted that factor plot diagrams can only represent three factors effectively as they are limited to three dimensions. The groupings are distinct and confirm the loadings.

An exploratory model for the environmental complexity of IS projects is depicted in Figure 6.7. The EFA revealed that one factor had to be removed, that is political influence (EC_03). Political influence, therefore, has no effect on IS project complexity and subsequently IS project success. Political influence could be a feature which must be handled by external parties such as senior management, as the project should be left to its own devices to deliver as required. Factor 1 is labelled strategic and tactical conditions as the inherent features revolve around strategic aspects such as internal strategic pressure and level of competition. Strategic aspects focus on the greater project goal and its relation to strategic intent. Tactical aspects

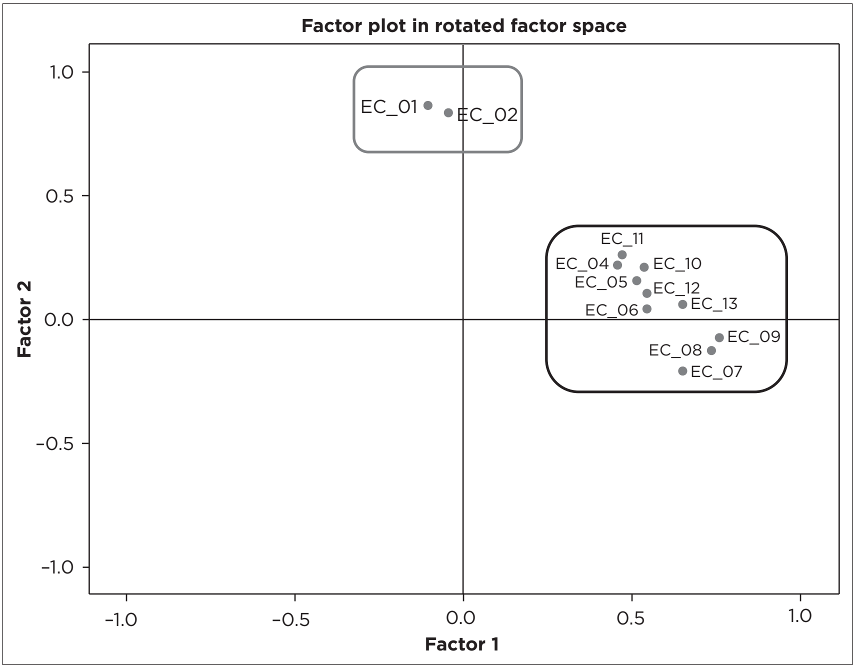

FIGURE 6.6: Environmental complexity factor plot diagram.

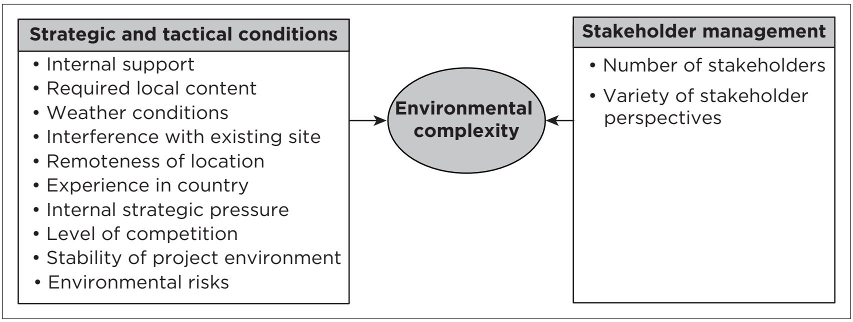

FIGURE 6.7: Exploratory model for environmental complexity of information system project.

include, amongst others, remoteness of location, experience in the country, risks and weather conditions. Tactical aspects focus on practices and considerations around ground level activities of the project itself.

Agile exploratory factor analysis modelling of environmental complexity

The Agile EFA model of environmental complexity applies the same acceptance criteria as before. The KMO was significant (0.000) and accepted at 0.849. All extraction values are above the 0.3 threshold. Total variance explained is accepted on the limit at 50%. Factor loadings presented an issue again, thus Cronbach alpha was applied. The results were 0.823 and 0.832 for Factor 1 and Factor 2 respectively (Table 6.8). Reliability and factor loading validity are therefore accepted and confirmed. The correlation between Factor 1 and Factor 2 was below the threshold at 0.558.

Distinct groupings are represented in the factor plot diagram (Figure 6.8). Complexity features EC_05, EC_06, EC_07 and EC_09 were removed to enhance EFA model validity and reliability.

The results imply required local content, interference with existing site, weather conditions and experience in a country are not complexity features for Agile projects. Local content

TABLE 6.8: Environmental complexity exploratory factor analysis Patten Matrix (Agile).

Observed variable[a]	Factor	
	1 (0.823)	2 (0.832)
EC_09	0.892	
EC_13	0.687	
EC_10	0.644	
EC_11	0.628	
EC_08	0.526	
EC_12	0.447	
EC_03		0.829
EC_02		0.772
EC_01		0.737
EC_04		0.596

[a], Variable names and associations are presented in Appendix A.

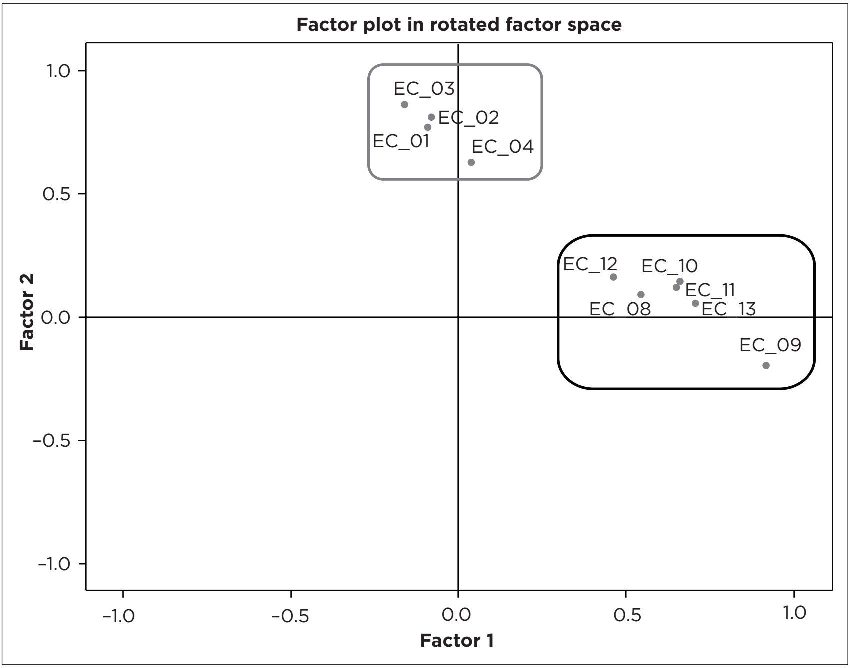

FIGURE 6.8: Environmental complexity factor plot diagram when using Agile.

requirement is arguably not an issue for Agile projects as they adapt and reconfigure where necessary to accommodate the use of local content-based policies where the project is being executed. Similarly, the same could apply for interference with the existing site. Protest action for example does not influence Agile projects as it is dealt with on an ad hoc basis and initiative is taken to continue where possible and minimise productivity loss. Weather conditions was continuously ranked in the bottom five features in Chapter 5 and is confirmed here as a poorly represented complexity feature. Experience in a country may not effect Agile projects as the projects draw on their own experience from various projects to accommodate for country differences. The exploratory model for Agile projects is similar to the Overall model as the latent factors remain stakeholder management as well as strategic and tactical conditions (Figure 6.9).

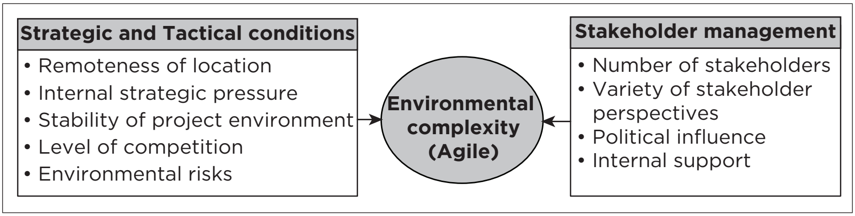

FIGURE 6.9: Exploratory model for environmental complexity (Agile).

TABLE 6.9: Environmental complexity exploratory factor analysis Patten Matrix (Waterfall).

Observed variable[a]	Factor	
	1 (0.799)	**2 (0.793)**
EC_01	0.971	
EC_02	0.747	
EC_11	0.575	
EC_03	0.525	
EC_09		0.787
EC_07		0.722
EC_08		0.667
EC_13		0.610

[a], Variable names and associations are presented in Appendix A.

Waterfall exploratory factor analysis modelling of environmental complexity

The Waterfall EFA model came in at a KMO of 0.720, which is low but acceptable. Extraction values were sufficiently above the 0.3 threshold. Total variance was 53% and met adequacy criteria. Individual factor loadings were above 0.5 where Factor 1 averaged 0.704 and Factor 2, 0.696 (Table 6.9). This discrepancy was addressed via Cronbach alpha tests where the results were 0.799 and 0.793 for Factor 1 and Factor 2. respectively. The correlation matrix revealed a low, accepted correlation of 0.303.

The groupings are further reiterated in Figure 6.10.

The exploratory model for Waterfall projects is presented in Figure 6.11 and shows a different take on environmental complexity

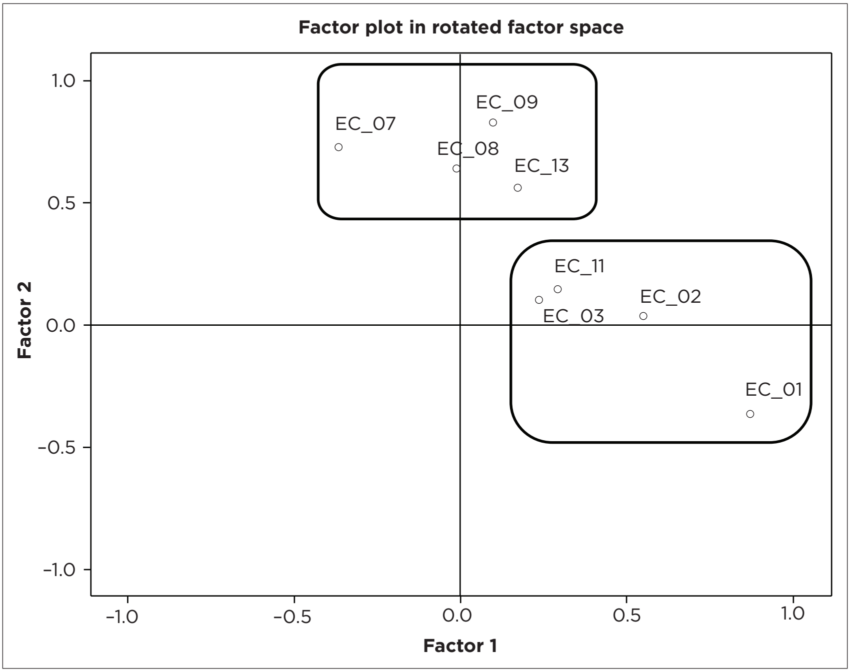

FIGURE 6.10: Environmental complexity factor plot diagram (Waterfall).

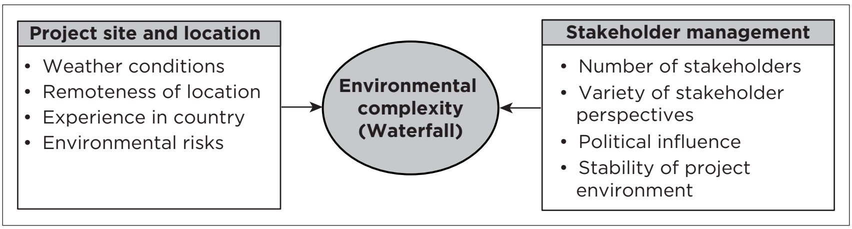

FIGURE 6.11: Exploratory model for environmental complexity (Waterfall).

Stakeholder continues to manifest for Waterfall projects, which arguably confirms its importance regardless of project methodology. Waterfall projects include complexity related to project environment stability and implies that Waterfall projects are affected more significantly when the environment is unstable. This could be attributed to the rigid, structured nature of the

Waterfall method where a systematic approach is adopted and complied with from the outset. Project site and location is the second latent factor identified which differs significantly from the Overall and Agile views. Interestingly, Waterfall projects place more emphasis on weather conditions, location remoteness, experience in country and environmental risks. The remaining complexity features were omitted. Environmental risks in the context of Waterfall projects arguably pertain to site and location risks more than anything else. Waterfall projects thrive on extensive upfront planning which aims to negate future issues. This could be why physical environmental aspects plan such an important role as they are often underestimated or not completely understood.

The following section covers the remaining IS project complexity constructs and their EFA analysis.

Technical complexity, dynamics and uncertainty

Technical complexity, dynamics and uncertainty were mapped within the process and project management success scope. This formed the basis for the next EFA analysis as these three constructs were analysed together to determine complexities which are associated with the first two IS project success levels.

Overall exploratory factor analysis modelling of technical complexity, dynamics and uncertainty

Similar to previous modelling practice, the same validity and reliability measures were adopted. The KMO is 0.933 while all extraction values are above 0.3. The five factors presented in Table 6.10 provide a total variance of 56% which is acceptable. Factor loadings meet the acceptance criteria thus Cronbach's alpha is used to determine further reliability. The results are 0.901, 0.883, 0.848, 0.835 and 0.812 for Factor 1 to Factor 5 respectively. All results are sufficiently above the acceptance level of 0.7 and thus

TABLE 6.10: Technical complexity, dynamics and uncertainty exploratory factor analysis Pattern Matrix.

Observed variable[a]	Factor				
	1 (0.901)	2 (0.883)	3 (0.848)	4 (0.835)	5 (0.812)
U_05	0.869				
U_06	0.791				
U_04	0.788				
U_01	0.738				
U_10	0.651				
U_08	0.637				
U_07	0.629				
U_02	0.613				
U_09	0.547				
U_03	0.516				
D_02		1.067			
D_04		0.772			
D_03		0.731			
D_01		0.547			
D_05		0.473			
D_06		0.459			
TC_07			0.948		
TC_08			0.911		
TC_06			0.576		
TC_12			0.529		
TC_05			0.391		
TC_09			0.326		
TC_03				0.870	
TC_04				0.780	
TC_02				0.542	
TC_11					0.969
TC_10					0.667

[a], Variable names and associations are presented in Appendix A.

confirm the identified factors. Discriminant validity is achieved as the factor correlation matrix reveals no correlations above 0.7. As discussed previously, a factor plot diagram cannot be used where more than three factors exist as the diagram is no longer decipherable and provides no extra analysis value.

As per Figure 6.12, the EFA results revealed five factors, (1) technology experience, (2) project goals, (3) project scope and tasks, (4) dynamics and (5) uncertainty.

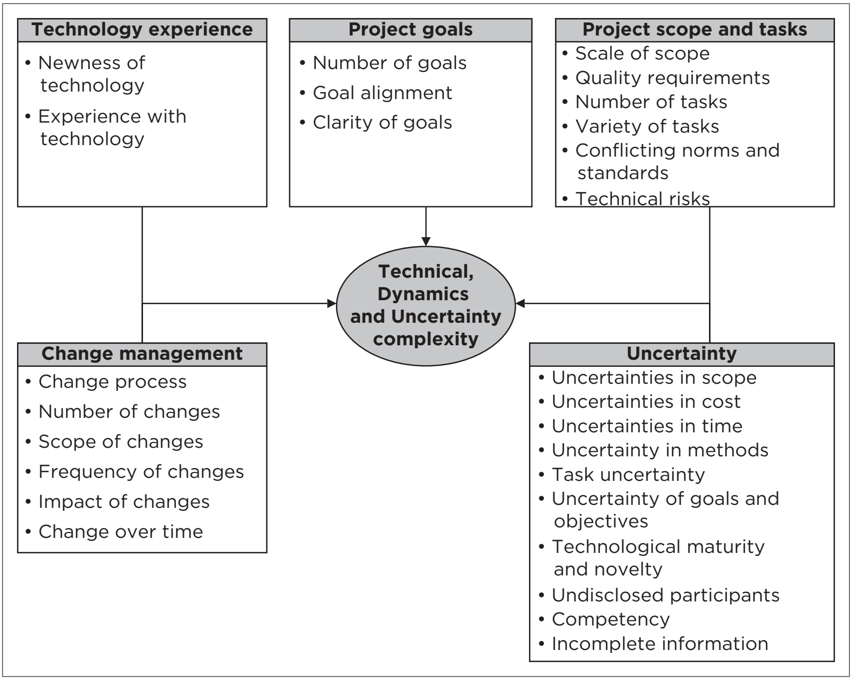

FIGURE 6.12: Exploratory model for technical complexity, dynamics and uncertainty of information system projects.

IS projects experience complexities regarding technology usage as experience and adoption are the two features to be constantly monitored. Given that IS projects thrive on technology usage, whether as a project tool or for project implementation, technology plays a pivotal role as experience is necessary for effective usage. Furthermore, experience should be facilitated through continuous development of project team members to ensure they use appropriate technology for any given IS project. The latent factor of project goals was apparent and signified the importance of effective goal management. The number of goals together with goal clarity and alignment are three prerequisites required for any project, regardless of the methodology employed. Complexities associated with these three features are arguably the key reasons why IS projects perform poorly and do not deliver planned benefits. IS project managers and their teams become so obsessed with delivering within time and cost that key fundamentals like goal delivery are negated. Moreover, project goals relate directly to the next factor of project scope and tasks. Project tasks are based on the project scope, which in turn is directly influenced by the set goals. The scale of the scope determines the number and variety of tasks required to execute the project. Conflicting norms and standards do, however, hinder tasks and activities as various stakeholders abide by different policies and procedures especially with regard to their requirements. This is arguably evident by the inclusion of technical risk in the project scope and tasks factor as risks arise when transitioning from scoping activities to actual project task execution.

The fourth factor perfectly maps the six features of dynamics to change management as argued in the theoretical mappings presented in Chapter 3. Change management is paramount to IS projects as the intangible nature of these projects often results in multiple changes as required particularly during implementation. Change practices therefore have to be sound and promote effective change regardless of what is required. Furthermore, not all changes are positive as previously mentioned, thus these changes must be mitigated and addressed through a robust set of practices. The following question can thus be posed: What change practices should be in place for IS projects to maintain their momentum and experience minimal disruption? Future research should address this contentious question. The final factor of uncertainty also fully encapsulates the theoretical mappings presented in Chapter 3 and confirms the role of uncertainty in IS projects. Rather than focusing on what is known, IS projects should be cognisant of what is unknown so that when the uncertainty arises a more proactive mindset is instilled for addressing uncertainty. Awareness does not imply that a plan exists for any uncertainty incident, it implies that the overall impact is recognised and will not be a ‘shock’ for parties involved.

Agile exploratory factor analysis modelling of technical complexity, dynamics and uncertainty

The Agile EFA has a KMO of 0.858 and all extraction values are above 0.3. Total variance explained equalled 58%, which is well within the threshold criterion. Only Factor 1 has factor loading lower than 0.5 but Cronbach's alpha was performed regardless as part of the reliability check. Factor 1 to Factor 5 have Cronbach alpha's of 0.892, 0.856, 0.786, 0.800 and 0.782 respectively. Factor loading validity and reliability is therefore confirmed. The factor correlation matrix (Table 6.11) also confirmed discriminant validity as no correlation above 0.7 exists.

TABLE 6.11: Technical complexity, dynamics and uncertainty exploratory factor analysis Pattern Matrix (Agile).

Observed variable[a]	Factor				
	1 (0.892)	2 (0.856)	3 (0.786)	4 (0.800)	5 (0.782)
TC_07	0.991				
TC_12	0.769				
TC_08	0.754				
TC_06	0.685				
TC_01	0.599				
TC_05	0.594				
TC_09	0.434				
U_05		0.804			
U_04		0.778			
U_01		0.737			
U_10		0.594			
U_02		0.573			
U_07		0.532			
U_03		0.521			
U_08		0.515			
D_02			1.054		
D_04			0.583		
TC_11				1.014	
TC_10				0.556	
TC_04					1.033
TC_03					0.534

[a], Variable names and associations are presented in Appendix A.

The five factors are identified as per Figure 6.13:

- Factor 1: Project scope and tasks.
- Factor 2: Uncertainty.
- Factor 3: Change management.
- Factor 4: Technology experience.
- Factor 5: Project goals.

Although the factors are similar to the overall view of IS projects, their composition is somewhat different.

Agile projects seem to have the added complexity of multiple inputs and outputs. IS projects use and produce various inputs and outputs throughout until final delivery. Agile projects arguably have more inputs and outputs as the iterative philosophy leads to multiple instances of these events. Furthermore, managing multiple inputs and outputs can become a cumbersome process and escalate to a point where the Agile mindset is its own worst enemy. Uncertainty is the second factor which also has a different composition as goal and objective as well as competency uncertainty are omitted. Goal and objective uncertainty is possibly less of a 'bugbear' as Agile embraces changes through flexible adaptive practices. More interestingly is the exclusion of competency uncertainty which contends that competency deficiencies could hamper a project's

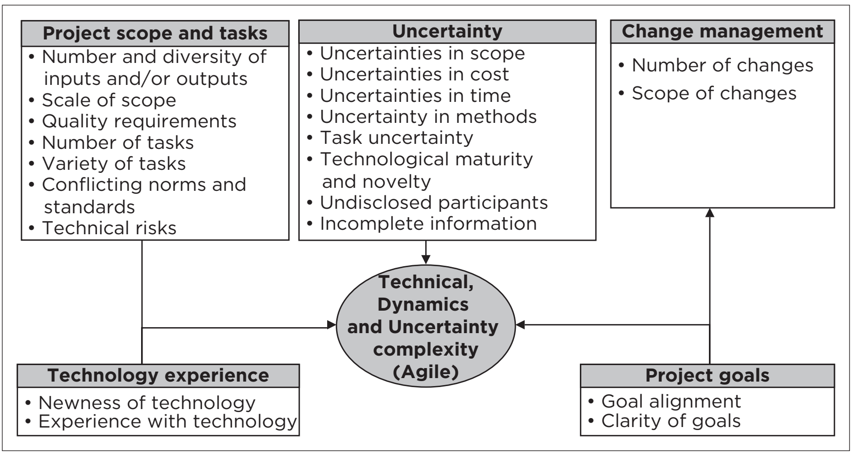

FIGURE 6.13: Exploratory model for technical complexity, dynamics and uncertainty (Agile).

progress. Agile projects also embrace competency deficiencies by identifying these as they occur and addresses them while continuing with the project. Furthermore, the flexibility promoted by Agile allows resources reallocation especially for skill set acquisition. Change management is only represented by the number and scope of changes for Agile projects. The omission of other features implies Agile projects are only concerned with the number and scope of changes. Logically this makes sense given the iterative approach adopted. An argument could be made that an overwhelming number of changes and/or extensive change scopes could derail change management practices. Addressing these two complexities would indirectly address the omitted features of change management. Technology experience remains stable as the two features are the same as the Overall view. Project goals, on the other hand, have also changed relatively as only goal alignment and clarity are considered complexities for Agile projects. The number of goals is no longer an issue as the Agile method promotes incremental development where multiple goals are addressed efficiently. However, there has to be clear alignment between goals to ensure Agile practices deliver the correct project and business benefits.

☐ Waterfall exploratory factor analysis modelling of technical complexity, dynamics and uncertainty

The EFA process for Waterfall projects has an acceptable KMO of 0.876 and extraction values above the 0.3 threshold (Table 6.12). Total variance explained is an excellent 62%. The factor loadings required reliability confirmation using Cronbach's alpha. Factor 1 to Factor 5 have alphas of 0.884, 0.888, 0.827, 0.747 and 0.863 respectively. Discriminant validity is accepted as no correlations above 0.7 exist in the factor correlation matrix.

The five factors are once again similar as presented in Figure 6.14:

- Factor 1: Uncertainty.
- Factor 2: Change management.
- Factor 3: Technology experience.

TABLE 6.12: Technical complexity, dynamics and uncertainty exploratory factor analysis Pattern Matrix (Waterfall).

Observed variable[a]	Factor				
	1 (0.884)	2 (0.888)	3 (0.827)	4 (0.747)	5 (0.863)
U_04	0.813				
U_06	0.809				
U_05	0.804				
U_01	0.674				
U_08	0.625				
U_10	0.606				
U_03	0.595				
U_02	0.575				
TC_05	0.300				
D_02		1.015			
D_03		0.821			
D_04		0.732			
D_01		0.552			
D_06		0.475			
U_09		0.394			
TC_11			0.898		
TC_10			0.809		
TC_12			0.595		
TC_08				0.996	
TC_07				0.485	
TC_03					0.723
TC_04					0.664

[a], Variable names and associations are presented in Appendix A.

- Factor 4: Project scope and tasks.
- Factor 5: Project goals.

The composition has once again changed for Waterfall projects.

The uncertainty factor now includes uncertainty of goals and objectives but omits competency and technological maturity and novelty. This implies competency is not a complexity feature and that technological maturity and novelty do not influence Waterfall projects. Interestingly, scale of scope is included which is commonly associated with project scope complexities. This grouping implies that scale of scope has inherent uncertainties regardless of project requirement size. Change management excludes the impact of changes but encapsulates

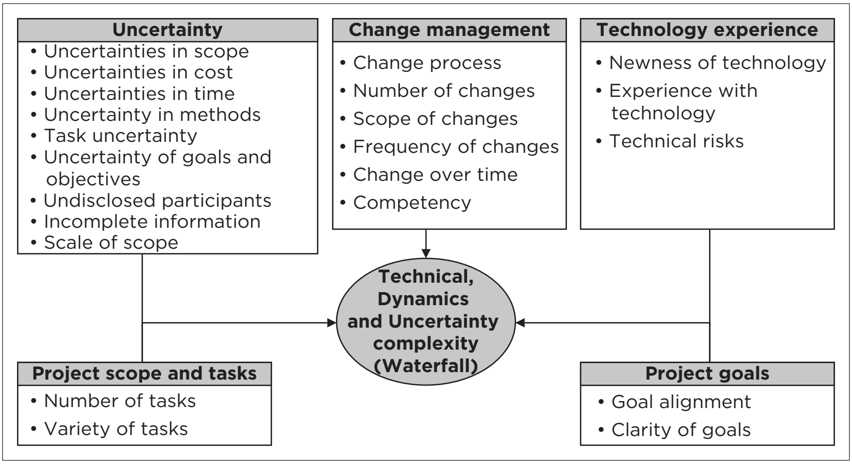

FIGURE 6.14: Exploratory model for technical complexity, dynamics and uncertainty (Waterfall).

the remaining five features based on the theoretical mappings. The surprising inclusion of competency in change management begs the question of whether adequate competencies exist for addressing any change request in Waterfall projects. It could be that competencies required to implement changes are inadequate and lacking thus resulting in deferred delivery date. Technology experience expands to include technical risks, which is arguably a logical inclusion given that technology inherently has risks associated with it regardless of experience or newness. Waterfall projects are only concerned with the number of tasks and variety of task complexities. These low level complexities pertain to the planning phase of project management as the Waterfall method places emphasis on extensive details. Any planning discrepancies which arise during subsequent phases result in derailing the project as tasks have to be reallocated and realigned on an ad hoc basis. This inadvertently delays other aspects of an IS project. Project goals is the fifth and final factor for Waterfall projects. Similar to Agile projects, goal alignment and clarity are the two pillars supporting project goal complexity. Given that Waterfall projects emphasise upfront planning, any volatility with either feature results in adverse effects on all project activities.

Conclusion

The gathered data indicated that, in the information systems project industry, we are dealing with various levels of project success. How they operate in practice may differ slightly in detail. Regardless of which method or approach is followed, IS project managers are aware of process success, strategic success, project management success and, most vitally, deliverable or product success. It can be surmised that this is the focus of IS project management when it is viewed holistically.

Remarkably very few differences are observed between Agile and Waterfall projects. In most respects they are very similar. The following differences are observed:

1. The overall correlations between the factors in Waterfall projects are stronger than in those of Agile projects. This could indicate that the structured and more formalised approach of Waterfall projects have greater effects on subsequent levels of projects success.
2. Objectives and goals seem to be important to Waterfall projects in the process success factor, while in Agile projects these considerations are important in the deliverable success factor. This may point to a difference in focus between the two methods.
3. The aspect of governance seems to play a role with Waterfall projects and not at all with Agile projects. This may once again be a symptom with regard to the underlying philosophy of each. What could be at issue here is the fact that the respondents indicated their own perceptions and as such improperly utilise governance in projects.

What holds for all three confirmed models is the fact that there does seem to be medium to strong interrelationships between all these factors. As these factors can be mapped to Bannerman (2008) levels, this dataset indicates that the outcome of lower levels could have an impact on higher levels. Therefore it is important to successfully complete project processes in order to facilitate project deliverable success as well as ultimate strategic success.

The EFA analysis of the various constructs clearly and interestingly showed that, although each environment has the same number of latent factors, the composition of factors is often different. Arguing that project complexity is uniform regardless of type is clearly rejected, as these results show that within the IS project landscape there are variations when adopting the prevalent approaches of Systems Development Life Cycle and Agile. IS project complexity is clearly not uniform or consistent as different complexities are evident depending on methodology. The exploratory nature of the complexity results suggests further investigation to validate the above claims as more variation could occur upon further analysis. The EFA models presented act as preliminary results and form the foundation of further studies.

Chapter 7

Simple, complicated, complex and chaos

The conclusion that one can make at the end of this book is that IS project success and IS project complexity is not about absolute numbers but more about a mindset. This mindset should be focused on two aspects: The first aspect is that IS project success is measured on a continuum and the second aspect is that IS project complexity needs to be appreciated for what it is, that is complex.

The framework of Bannerman (2008) is used to create this mindset of IS project success as a continuum. Five levels exist within this framework, and an IS project can be successful at any one of these levels. The preference is that the project should be successful at all five levels but this is not possible in real life. Each level addresses a different aspect of success. More importantly, the framework forces all the stakeholders to take ownership for IS project success. IS project success is not the responsibility of just the project manager but it is the

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responsibility of all the stakeholders. Specific stakeholders will have different inputs, insights and influences at the different levels, but at the end of the day it is everyone's responsibility to ensure IS project success.

The results depicted in Chapter 4 highlight that the success rates have improved. This improvement is directly related to the fact that success is measured on a continuum. When the results are interrogated a little further, it is evident that success at a business and strategic level is still at 62% and 59% respectively. This creates an opportunity for organisational leaders to improve the success rates and reap more benefits and value from the investment in IT. The results also indicate that Agile projects are more successful than Waterfall projects. This can result in a product that is delivered by an Agile project being released quicker to the market, thereby creating faster business and strategic success than Waterfall projects. It might be worthwhile for organisational leaders to invest in Agile as a method to deliver IS projects quicker. This said, the emphasis should still be on delivering these types of projects successfully at all five levels.

The modelling of the success levels reduced the five levels to four levels. The last two levels (business and strategic) are merged into one level, that is strategic success. IS project success can then ultimately be measured as per Figure 7.1.

Although the framework of Bannerman indicates that there is not necessarily a relationship between the different levels, that is one level does not necessarily affect the outcome of the next level, the results of SEM indicate that there are positive correlations between the different levels. This implies that the outcome of lower levels influences the outcome of higher levels.

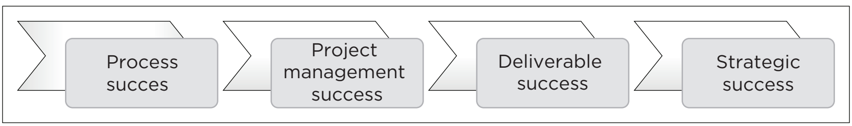

FIGURE 7.1: Information system project success levels.

IS project complexity itself is complex. Five constructs of complexity were identified simplifying the view of complexity. But beyond this simplified view, there are still 75 complexity features that need to be taken into consideration. The problem is that these 75 complexity features can appear in any combination within an IS project. This opens the door for an IS project to change from complex to chaos within the blink of an eye. The analysis of the top five features in every construct make one realise that there is actually no complexity feature that is more important than another or that one construct is more important than another construct. The results do suggest that technical and organisational complexity are the two main constructs that contribute to the complexity of IS projects.

The modelling of complexity did not yield the desired results and only a suggestion of a possible model is provided. The modelling suggests that environmental complexity can be divided into stakeholder complexity and strategic complexity. Organisational complexity is intricate and should be dealt with in its entirety. The remaining three complexity constructs can be divided into five new constructs. This implies that the IS complexity can be viewed as eight new constructs instead of the original five constructs. Whether this makes IS complexity less complex, remains to be seen.

The symbiotic relationship between IS project success and IS project complexity cannot be negated. This study could not provide a definite answer to the problem at hand. Figure 7.2 provides insight into this symbiotic relationship.

Complexity plays a significant role during the lower levels of IS project success as all eight constructs have an impact on process and project management success. When it comes to the deliverable and strategic success, then only three constructs play a role.

What should organisational leaders and specifically IS project managers do in the face of complexity? The impression is created

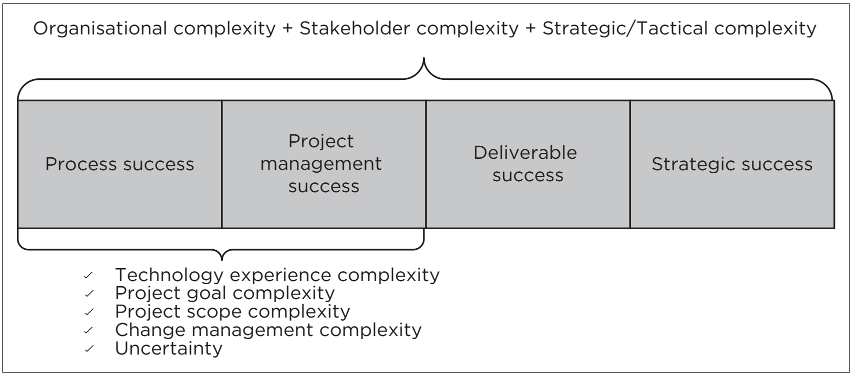

FIGURE 7.2: Symbiotic IS project success and complexity model.

that when IS project managers can manage the complexity surrounding IS projects, then there is a better chance that these projects will be delivered successfully.

Snowden and Boone (2007:69) state that 'wise executives tailor their approach to fit the complexity of the circumstances they face.' This is also applicable to IS project managers that need to understand what they should do. The first step is to identify the level of complexity within the IS project. Four levels of complexity exist, namely simple, complicated, complex and chaotic. IS project managers should manage simple, complicated and complex projects in such a way that they do not become chaotic. The line between complex and chaotic is very thin.

In conclusion, IS project managers cannot rely on the normal competencies as promoted by the various project management competency frameworks. They need to have additional competencies to deal with complexity as the IS domain will become more and more complex in the near future. This new understanding of complexity will allow IS project managers to address complexity and understand the impact it has on the success of a project.

Knowledge and wisdom of IS project complexity will increase the success of IS projects and ultimately the value that IT provides to the organisation.

Appendix

1. Project success variables

Construct	Feature	Variable Name
Process success	Chosen	PS_01
	Alignment	PS_02
	Integrated	PS_03
	Implemented	PS_04
Deliverable success	Specifications Met	DS_01
	Requirements Met	DS_02
	User Expectations	DS_03
	User Acceptance	DS_04
	Product Used	DS_05
	User Satisfied	DS_06
	Benefits Realised	DS_07
Business success	Goals	BS_01
	Business Plan	BS_02
	Governance	BS_03
	Benefits Realisation	BS_04
	Unintended Benefits	BS_05
	Unintended Impacts	BS_06
Strategic success	Market Impact	SS_05
	Industry Impact	SS_05
	Competitive Impact	SS_05
	Investor Impact	SS_05
	Regulatory Impact	SS_05

2. Project complexity variables

Construct	Element	Feature	Variable Name
Organisational complexity	Vertical differentiation	Organisational structure	OC_01
	Horisontal differentiation	Organisational 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	Organisational 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

2. Project complexity variables (continues...)

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
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
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
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

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Writing a book on project management with an interplay between the success and complexity of projects is not only a challenge but also fills a very important gap in the literature. In this, the authors have succeeded exceptionally well. This book is highly recommended to all academics who are teaching project management.

Awie Leonard, Associate Professor, Faculty of Engineering, Built Environment and Information Technology, University of Pretoria, South Africa

Complexity is one of the major aspects that trips up project success, and this book makes a valuable contribution to defining the sources of complexity in projects and how they affect the project outcome. As a project-management practitioner, I thoroughly enjoyed the different definitions of project success. Too often, we only focus on the triple constraint of time, cost and scope (project and process success) rather than on the success of the product and the overall business and commercial success.

Josef Langerman, Executive Group Head for Engineering Transformation at Standard Bank and Visiting Associate Professor at the University of Johannesburg, South Africa

A growing number of researchers suggests that information systems are more appropriately conceived as complex socio-technical systems. This book explores numerous dimensions of complexity – dimensions such as organisational and technical complexity. Its timely investigation is insightful and will stimulate further thoughts and discussion within the academic community. That is why this book is so valuable.

Rennie Naidoo, Associate Professor Department of Informatics, University of Pretoria, South Africa

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