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Salient complexities of engaging external consultants in information systems projects

Abstract - Project sponsors have sought to develop the necessary competence to address various challenges they face during project development, implementation and exploitation by employing different initiatives including the engagement and use of external consultants. However, doing so is associated with a number of consequences, including a significant risk of exacerbating project complexities. With this in mind, we set out in this study to examine the salient differences in the key project complexities between projects engaging consultants and those not engaging consultants. Data is obtained from 146 project management practitioners engaged in projects in Canada and the United States. Data analysis is undertaken using 3-way Multidimensional Scaling (MDS). Findings as relates to the key complexities associated with information systems projects, points to the manifestation of six broad dimensions of complexity namely (i) '*Variety'* (ii) '*Control'* (iii) '*Criticality'* (iv) '*Scope and repetition'* (v) '*Information'* and (vi) '*Dependence'*. As relates to how consultant engagement changes the salience of these key project complexities, we find that consultant engagement leads to more varied and stronger structural complexity and higher salience of interpersonal and organisational complexity.

Index Terms - Information systems; Projects; Consultants; Complexities; Salience

I. INTRODUCTION

Information systems (IS) serve a key competitive, operational and strategic role in most organisations [1] [2]. However, despite its importance, the development, implementation and exploitation of IS within organisations remains problematic and has been fraught with failure [3], abandonment [4], escalations [5] and overruns [6]. Seeking to stem the high failure rates of their projects, many organisations have sought to engage consultants [7] [8] [9] [10] [11] [12]. Consultants are primarily subject matter experts [13] and knowledge brokers [14] [15] whose work primarily focuses on the translation of shared knowledge, experience and skills [16] [15] [11] [12] [17]. Consultants also play a major role in efforts by organisations to when necessary, intentionally discard well-established knowledge within the organisation in order to allow new knowledge to be created [18] [19]. This is made possible by consultants not only driving interventions that question established routines and norms within the organisation, but also facilitating the creation of the necessary agile space for new knowledge to be developed and adopted [20] [21].

Consultants come in different types [22] [16] and can be employed either *internally* (as an employee of the organisation) or *externally* (either independently or through an external third party) to the organisation [23] [7] [8] [24] [25]. Organisations engage and use consultants in order "*…to identify management problems, analyse such problems, recommend solutions to these problems, and help, when requested, in the implementation of the solutions*" [26]. The use of consultants has increasingly become the norm in corporate IS development, implementation and exploitation, accounting for the exponential rise in spending by organisations on their services [27] [28].

Despite the various benefits in the use of consultants in IS project development, implementation and exploitation [10], a key challenge faced by project sponsors (organisations) is that the engagement and use of consultants can be unpredictable and therefore, uncertain. It can also add to the inherent '*complexities'* associated with their projects. This complexity arises because it is "*…difficult to understand, foresee and keep under control…even when given reasonably complete information about the project*" [29]. It also arises because consultants also work under conditions where success measures, service lines and quality standards lack clarity and require constant negotiation and renegotiation between the consultant and client [24] [25] [30]. To this extent, while we recognise that complexity can arise in IS projects due to the engagement and use of consultants, there is a paucity of research focused on not only exploring the nature and extent of such complexities, but also articulating how best these complexities may be managed. More specifically, very little is known about the salient differences in the key project complexities between projects engaging consultants and those not engaging consultants and also what interventions will facilitate the effective management of those complexities.

The need to manage such complexity cannot be overemphasised. More specifically, complexity cannot only negatively impact upon project performance [31] [32] [33] [26] [34], but it can also ultimately lead to project failure [29] [35]. With this in mind, and to develop this important body of knowledge, we propose the following research questions (RQs). First (**RQ1**), we ask: *What are the key complexities of IS projects?.* Second (**RQ2**), we ask: *What are* *the salient differences in the key project complexities between projects engaging consultants and those not engaging consultants?*

We set out to achieve our stated aim by examining the differences in the key complexity components between IS projects that (i) do not engage and use external or internal consultants and (ii) those that engage and use either or both external and internal consultants. The study will be guided by prior studies [36] [37], that allows for the articulation of complexity focused on improving IS project management. This characterization is rooted in the idea that as conveyers of knowledge, consultants are critical to the ability of organisations to understand, reduce and respond to complexity as a lived experience in IS projects.

Prior studies have drawn our attention to the need for greater theorization of the role of consultants in project and organisational settings [38] [39] [40] [8] [41] [42] [43] [44] [45] [46]. Thus, in order to meet our stated research aim, we draw upon both complexity theories [21] [47] [48] [49] [50] [51] [52] [53] [54] [55] [56] and external team context theory [46].

Within the IS field, complexity theories represents an overarching/unifying term [52][53], which has been employed to provide essential trans-disciplinary insight into discontinuous changes and associated emergent behaviour and structure of dynamic nonlinear systems [21] [47] [51] [52]. On the other hand, external team context theory [46] [57], represents a theoretical framework that sets out to define the very essence (nature, structure and function) and influence of teams that exist outside the boundaries of an organisation. Multidisciplinary in nature, external team context allows us to construe external consultants as resources who despite residing outside the boundaries of the client organisation, form part of the organisations wider system and also exert influence on it. The literature suggests that understanding complexities is a crucial pre-condition towards its active and effective management [54] [58] [55]. Thus, by integrating complexity and the external team context (of consultants), we are able to provide a platform which allows for a broader appreciation of the role of consultants.

Information systems (IS) projects present an ideal setting for studying both complexity and the impact of consultants on such complexity. There are three reasons for this. First, IS projects are inherently complex [26] [59]. Second, consultants have traditionally played a pivotal role in IS project development and implementation [9] [10] [24] [30]. Third, consultants appear to wield not only significant, but arguably disproportionate influence on how IS projects are conceptualised, implemented, managed and utilised [60]. Bearing this in mind, we will now proceed as follows. In section 2, we review relevant consultant-assisted projects and complexities of projects bodies of literature. We set out our study methodology in section 3. In section 4, we report on our findings. We discuss the findings in section 5 and then conclude in section 6.

II. LITERATURE

A. Complexity of IS projects

Complexity in IS projects arises from both the technology attributes of IS projects itself [26] [59] [61] [62] and also from organisational factors [63] [64] [61] [62]. In terms of technology, IS projects are particularly susceptible to complexity because they entail a high level of technological novelty [61] [62]. Complexity in IS projects also arises because the interactions between various technology components can be characterised as '*non-linear*' and '*heterogeneous*' [65] '*interdependent*' [66] and '*interrelated* [67]. Complexity within IS projects also emanates from the '*dynamic*' [48] [68] [69] [62], '*unpredictable*' [70] [62], and '*non-decomposable*' [71] nature of technology; all which span organizational, structural, informational, human resourcing and financial dimensions of the project (system) [1] [67]. Recent studies [62] identifies characteristics of complexity existing in IS to include (i) embeddedness and digital capabilities (ii) networks connectivity (iii) editable, i.e. allowing for functional amplification (iv) functional flexibility (v) communicability (vi) uniqueness (vii) shared traits.

With recent dramatic acceleration in new technologies such as artificial intelligence, big data and machine learning, using the internet, IS projects are bringing about rapid change and innovation to organisations by increasing digitalisation and connectivity [72] [73]. However, at the same time, these projects present novel and complex challenges to organisations, in the process impacting upon decision-making in various areas including question on how to most effectively and efficiently manage their transformative and potentially, disruptive effects [74] [75].

In addition to complexity in IS projects arising from technology, it also arises from organisational factors. Here complexity arises because the nature of interactions among the various components of IS projects which requires constant re-adjustment [63]. Complexity as a result of non-linear interaction among the various components of an IS project may lead to consequences which are not only unintended, but also, dramatically divergent from what could have be imagined or accurately predicted. Nan [64] cites complexity of IS projects emanating from a recognition that their outcomes are more than likely to be guided by the nature of self-directed interactions between individual-level actors (at the project-level) as against the intentions or policies of management.

Another organisational factor driving the complexity of IS projects is their relatively long implementation and delivery timescales. Long delivery timescales mean that functionality which has been delivered may end up being considerably dissimilar to what was originally conceptualised. As complexity leads to uncertainty and unpredictability [50] [76], and therefore, making it more difficult to undertake formalised planning [50], it is safe to opine that complexity brings about more ambiguity in IS projects [77] [68], serving as a major reason why IS projects may fail.

B. Consultant engagement and consequences

To develop the necessary competence and required knowledge (both explicit and tacit) to address the challenges associated with the failure of their IS projects and in the process, deliver critical solutions, client organisations have engaged in a number of initiatives focused on competency development such as staff training [78] and retention initiatives [79]. They have also sought to engage and utilise the services of professional service firms or consultants [80] [7] [8] [24] [30] [79] [81]. Often than not, when consultants are engaged, they are embedded within the structures of the client organisation [41].

The increased engagement and use of consultant staffs should theoretically enhance the likelihood of IS project success. This is especially so because of the degree of functionality, integration and interoperability that exists in these projects [79]. Furthermore, because consultants (external) are regarded as expert boundary spanners possessing knowledge superior to that which exists within the organisation, their engagement and use is expected to have a positive and significant impact on the formalisation and adoption of risk management methods [82]. Effective risk management plays a significant role in facilitating project success [33] [83] [84] [85] [86].

When engaging and using consultants, organizations may also be pursuing objectives which go further than ensuring successful delivery and implementation of new IS projects [7]. For example, the organisation may also be intent on the acquisition of new ancillary knowledge to support the in-sourcing of IS development to which consultant involvement may be critical to its success. A key positive consequence of engaging consultants is the effective leveraging of their technical and communications expertise. Through extemporaneous interfacing between consultants and project team members, it becomes possible for 'islands of calm' to be propagated across the project giving rise to aggregated behavioural patterns to be propagated across the project, thus reducing the effects of complexity. Thus, engaging consultants may allow for shorter project delivery and implementation timescales and major savings in terms of implementation costs as organizations (or projects) gain access to alternative, unique and valuable knowledge without necessarily expending considerable costs, effort and time to develop such knowledge internally.

Despite identified benefits, the literature has identified a number of drawbacks with the engagement and use of consultants [87] [88] [89] [90] [91]. More specifically, some studies suggest that the prevalence of '*consultobabble*' (so called 'consultant speak') by consultants [91]. This has partly led to a creation of a '*consultocracy*' characterised by the privatization and monopolization of knowledge, weakening of accountability and the erosion of tacit knowledge within client organisations [60]. Furthermore, under pressure to deliver measureable 'success', consultants may drift towards focusing and developing familiar solutions for their clients which are devoid of any form of novelty and are in fact, already being used by competing organisations. Thus, the criticism that consultants simply peddle in re-branded solutions which are generally standard [92] or ambiguous products and services which are packaged and re-packaged in an attractive manner [93]. This may lead to what in effect is a '*capability*' trap in that being in receipt of solutions that have worked for other clients (who may be competitors), clients generally tend to be trapped within their current capabilities.

C. Complexity and consultant engagement

Whilst consultants should help reduce complexity by increasing the amount of alternative insights generated within a project [38], their presence may exacerbate uncertainty and therefore, complexity [79]. This is especially likely to occur where there is little understanding among other project stakeholders of the precise nature of work the consultants are expected to undertake [41] [94]. Altogether, such lack of role clarity can create or lead to major miscommunication within projects [95], leading to an escalation of project costs emanating from coordination and communication. Ultimately, this may lead to the benefit to be obtained from consultant engagement and use being outweighed. Furthermore, rigidity and inertia from the lack of (or poor) coordination and communication can lead to the stifling of collaboration and lack of trust, leading to further complexities as opportunities to transfer and facilitate an understanding of critical knowledge to project team members is lost.

Complexity may also emerge where it is unclear as to where the consultants fit within the overall organisational (or project) structure. For example, there may be uncertainty whether and to what extent; consultants possess requisite managerial or technical capabilities and the extent of such capabilities. A consequence of such complexity is the emergence of major tensions within the organisation (or project) which may impede the effective transfer of specialist tacit knowledge from the consultant to project team members (due to a lack of trust). This may be a major concern where the decision to engage with consultants is perceived to have been primarily driven by intra-organizational power games and dynamics [96].

Similarly, engaging consultants may increase the level of socio-political complexity within the organisation (or project). This follows from consultants (as a distinct stakeholder group), maintaining interests which may not align with the project sponsor/owner [7] [8] [24]. Furthermore, consultants bring their own mannerism, style or working, and cultural behaviours which increases socio-political complexity and may create tensions with employees of the client organisation [80].

In IS projects, complexity in consultant engagement and use also arises because the consultants are in reality embedded in a novel and temporal environment. Consultancy work entails iterative processes encompassing not only the amplification, but also damping of information to the client which creates complexity as new patterns of information emerge which the consultant may not have predicted [97]. To summate, consultant engagement and use may introduce or exacerbate complexity within projects. Left unmanaged, it may have a significant impact upon project performance. There may be a litany of problems such as contractual disputes, communication breakdowns, consultants side-lining the client or vice-versa flowing from poorly managed consultant engagement and use [98]. Hence, one of the most critical issues to consider is the extent engaging consultants can compound existing complexities or introduce new or additional layers of complexities of managing IS projects. Clearly, then, it is valuable to address our research questions since they can help us begin to establish in what ways engaging consultants in IS projects may affect the nature of the different type of complexity.

III. METHODS

A. Survey data

We collected data on IS projects using an online survey on SurveyMonkey™. We began by piloting the survey with a small sample of project management practitioners based in Canada. Subsequently, we refined the survey items according to the project managers' feedback before disseminating the questionnaire. We used the snowballing sampling methodology to reach respondents. Each co-researcher asked project practitioners in their network to complete the survey; then, each participant requested project practitioners in their own network to take part. The snowballing method is non-random, but project management researchers commonly apply in situations like this where the target population of qualifying projects is unknown [99] [100] [101] [102] [103]. It is not possible to accurately estimate the reach of an online survey when using the snowballing methodology although we can estimate the proportion of valid responses out of total attempts. SurveyMonkey™ reported 338 attempts to complete the survey. However, we did not consider some of the attempts valid for three reasons. First was where the respondent did not confirm their relevant experience in the development and implementation of a recent IS project. Second was where the respondent completed the survey in under 10 minutes (despite our assessment that the survey was unlikely to be completed within 10 minutes). Third was where the respondent did not provide critical data for this research on the measures of complexity and/or type of consultants engaged and used by project. Altogether, there were 146 valid responses, which is 43% of the total attempts.

B. Measures

The survey consisted of three sections. In the first section, information on the characteristics of the project was extracted. These characteristics included project size, budget, and duration; main location of project activities; number of people involved and organisations involved; and a brief description of the project. The second section of the questionnaire included 36 measures of complexity. These measures comprise of '*Structural complexity'* [48] [54] [36] [104] [21], '*Uncertainty complexity'* [105] [106], '*Socio-political'* or '*Interpersonal and organisational complexity'* [106] [26] [58] [36] [48] [21], *'Change complexity'* [107]*, 'Urgency' and 'Criticality/importance'* [31]. Table 1 shows complexity measures, derived from consolidated project management and IS project complexities literature.

Table 1: Complexity measures by type

Item number	Variable Type & Label	Survey Item
Change Complexity		
1	CC_1	The project requirements changed frequently
2	CC_2	The project involved frequent reworks
3	CC_3	The project team composition underwent several changes during the project
4	CC_4	The organisations (contractors, external suppliers, etc.) involved underwent several changes during the project
5	CC_5	The external environment changed during the project
Pace and Importance		
6	Criticality_1	The project was considered extremely important
7	Urgency_1	There was a sense of urgency, such that the project had to be initiated and completed in the immediate or near future
Interpersonal and Organisational Complexity		
8	IO_1	There were clearly defined organisational and control structures within the project
8	IO_10	Project parties communicated effectively
10	IO_2	Project parties shared similar organisational cultures
11	IO_3	Organisational politics impacted the project process
12	IO_4	Interpersonal conflict impacted the project process
13	IO_5	Project parties were in agreement about the project objectives
14	IO_6	The project received support from all project parties
15	IO_7	The intentions and motives of all parties involved were clear to other parties, i.e. there were no hidden agendas.
16	IO_8	Project parties trusted each other
17	IO_9	There were good relations among project parties
Structural Complexity		
18	SC_1	The product (service) created by the project was complex

19	SC_10	The project required expertise from several distinct and separate disciplines
20	SC_11	The project was part of a program of many related projects
21	SC_2	Project activities/tasks were interlinked
22	SC_3	The characteristics of project activities/tasks varied substantially
23	SC_4	This project was impacted by other projects
24	SC_5	The project impacted other projects
25	SC_6	The project used several distinct and separate methodologies/approaches
26	SC_7	The project was conducted at several distinct and separate locations
27	SC_8	The project had a broad scope
28	SC_9	The project used several distinct and separate technologies
Uncertainty Complexity		
29	UC_1	Information available to conduct the project was of a high quality
30	UC_2	The project required the use of novel technologies, i.e. unfamiliar technologies or even technologies that had not yet been developed when the project started
31	UC_3	The project involved novel or uncommon contractual arrangements
32	UC_4	The project goals were clear
33	UC_5	The project relied upon familiar methodologies and techniques
34	UC_6	Information required to conduct the project was readily available
35	UC_7	Project scope was well defined
36	UC_8	The project team had had prior experience of the kind of work the project required

To mitigate bias in the responses, our survey presented the complexity measures to respondents in four randomised groups of about nine, rather than as constituents of a type of complexity. For example, constituents of '*Structural complexity*' were not in one block. Instead, they were randomly mixed in with measures from other complexity type. For each complexity item, we used a 100-point sliding scale, rather than a radio button Likert Scale. This is because research shows unnumbered sliding scales, which a web platform such as SurveyMonkey^{TM} can execute, lead to greater variance and higher reliability than radio button Likert Scales, which work better on paper. See, for example, Cook et al. [108] for further discussion of the superiority of unnumbered slide scales in online surveys. For the same reasons, we reverse coded around half of the complexity measures.

Finally, in the third section of the questionnaire, we asked each respondent to describe the type of consultants their project engaged. There were four original categories: *Category 1* ('*Both internal and external*': the project engaged both internal and external consultants). *Category 2* ('*External*': the project engaged consultants from outside the organisation); Category 3 ('*Internal*': the project engaged consultants from within the organisation) and *Category 4* ('*None*': the project did not engage any consultants). However, as we report in the results section, due to the small number of projects that reported no consultants or online external consultants, we combined the categories into two as follows: First – '*None or internal only'* for projects that did not engage any consultants, or the project engaged consultants from within the organisation. Second – '*Both internal and external or external only*' for projects which engaged both internal and external consultants, or where the project engaged consultants from outside the organisation.

C. Modelling (Multidimensional Scaling Procedures)

To analyse the data, we used employed Multidimensional Scaling (MDS) [109]. MDS is a family of techniques for reducing a large amount of data to a smaller number of dimensions that account for most of the variance or dispersion in the data based on either the similarities, known as proximities, among the cases or the variables. For this study, we calculated the proximities among the measures of complexities and then examined differences that may be attributed to engagement of different types of consultants in projects as follows. First, we determined the number of dimensions to retain. Following convention, we ran a separate MDS model using the *PROXSCAL* algorithm [110]. We calculated proximities among the variables using the *EUCLID* metric. We ran the model ten times. First, we set the number of dimensions to retain to one, then two, then three, and so on. For each model we recorded the model fit stats. We then created a '*scree'* plot showing model fit improvement for each added dimension. We determined the number of dimensions using the 'elbow' method, which involves finding the point at which the scree plot turns decisively so that additional dimensions do not achieve substantial improvements in model fit.

Having determined dimensionality, we then ran a 3-way MDS model using the *PREFSCAL* algorithm. In additional to examining data based on similarities among the cases or variables (i.e., in two ways), 3-way MDS also examines the data in a third way based upon preferences that might occur among groups or sources of difference. For this study, the sources were the types of consultants the projects engaged. The *PREFSCAL* algorithm begins by calculating the common space shared by all cases based on the number of dimensions specified earlier. To calculate the differential preferences of the sources, it then shrinks or expands the space to fit the data for each source. Such rescaling of the common space occurs only along the dimensions. Therefore, unlike other types of MDS, the dimensions revealed by

3-way MDS are not infinitely rotatable and should offer the advantage of being easier to interpret.

By examining the rescaling factor required to fit the data for each source, we can know the *weight* the source places on each dimension. Similarly, we can know the *specificity* of each source, by considering the relative weights it places on each dimension. A source with low specificity will place similar weights on the dimensions, whereas a source with high specificity will place much more weight on some dimensions than others. In the extreme case, a source can have a specificity of zero (equal weights on all dimensions). Alternatively, a source can have a specificity of 1 (all weight on one dimension and none on the others). Finally, by calculating the amount of variance each dimension accounts for, we can get an indication of the relative *importance* of the dimensions.

D. Rationale for Choosing Multidimensional Scaling

There are number of reasons why we chose MDS for the analysis. An alternative to MDS would have been a technique that considers each dimension of complexity as a discrete latent scale with observable measures, which have minimal overlap or cross loadings beyond their assigned scales. For example, confirmatory factor analysis and structural equation modelling are such latent variable techniques. However, though they are latent, the analysis of dimensions of complexity does not fit this philosophy of a strict theoretical model, with known, discrete latent scales, which, do not only significantly overlap, but also obey specific distributional constraints, often normality and linearity. It is the nature of complexities to be, while identifiable, inseparable, and interlinked [65] [50] [66] [76] [67]. Therefore, we should not treat them like discrete, psychometric scales. Rather, we should consider dimensions of complexity as recognisable parts of a continuum. We can study the effects of one or several constituent parts, whilst accepting those effects overlap those of neighbouring dimensions. These characteristics of complexities suggest MDS as a well-fitting technique. This is because MDS does not assume the dimensions are discrete nor that they fit prior distributional assumptions; only that each dimension represents a recognisable part of the continuum of complexity.

IV. RESULTS

A. Descriptive Statistics of the projects

Table 2 presents some descriptive statistics from the survey. The 146 projects had a wide range in several measures. Whilst the average project lasted just over a year in duration, the minimum was only just over a week; but the maximum stretched to four years. Similarly, project budgets ranged from very small (no funds allocated) to over $200m (USD). On average there were just over 40 people and 4 organizations involved in the project. However, these numbers could be as high as over 300 people and over 10 organizations, respectively.

Table 2: Summary statistics of project characteristics

Variable Stat	**Duration (days)**	**Actual spend (USD millions)**	**Number of people**	**Number of organisations involved**	**Estimate Number of locations**	**Estimate Number of activities**
Mean	409	7.44	43	4	3	109
STD	271	25.00	44	3	3	169
Min	8	0.00	1	1	1	1
Max	1489	200.00	300	12	18	1592

Each project had an average of over 100 distinct activities, distributed across an average of three locations. However, the main location of most of (78%) the projects was North America, in Canada and the United States. The remainder were spread around the world, as shown in Table 3.

Table 3: Main locations of projects

Country	**Number**	**Percent**
Australia	1	1%
Bahrain	2	1%
Brazil	1	1%
Canada	93	64%
Egypt	2	1%
India	9	6%
Malaysia	2	1%
Mauritius	1	1%
South Africa	4	3%
United Arab Emirates	1	1%
United Kingdom	2	1%
United States	21	14%

Only 12 (8%) of the projects had not engaged any type of consultant. 14 (10%) had engaged only an external consultant. The majority, i.e., 82 (56%), had engaged both an internal and external consultant. The other 38 (26%) had engaged an internal consultant.

Given the small number of projects without consultants or with only external consultants, we decided to combine the categories into two. *Category 1* (*'None or internal only'*) where the 50 (34%) projects with no consultant or only internal consultants. *Category 2* (*'Both internal and external or external only'*) where the 96 (66%) remaining projects with internal and external consultants or with external consultants only. To summarize, then, the difference between *Category 1* and *Category 2* is that all the participants in *Category 1* projects are employed by the project organisation, although some may be working on the project in a consultancy capacity; *Category 2* projects involved external consultants self-employed or employed by an external third-party firm engaged by the organization.

Table 4 shows the full list of the measures of complexity variables. The mean of means was 36, but responses had a wide range. For example, the mean value for criticality (The project was considered extremely important) was only 12.5, indicating low criticality in general. On the other hand, the measure of change complexity (The organizations involved underwent several changes during the project) had a mean of 56, indicating a high level of churn in the organizations involved in the projects.

Table 4: Descriptive Statistics of Complexity Measures

Variable Type & Label	Survey Item	Min	Max	Mean	Std	Reverse?
Change Complexity						
CC_1	The project requirements changed frequently	1	100	55.1	35.1	
CC_2	The project involved frequent reworks	1	100	40.3	32.3	
CC_3	The project team composition underwent several changes during the project	1	100	52.9	34.8	
CC_4	The organisations (contractors, external suppliers, etc.) involved underwent several changes during the project	0	100	56.1	37.0	
CC_5	The external environment changed during the project	1	100	45.2	33.4	
Pace and Importance						
Criticality_1	The project was considered extremely important	0	99	12.5	15.0	
Urgency_1	There was a sense of urgency, such that the project had to be initiated and completed in the immediate or near future	1	100	34.6	33.5	
Interpersonal and Organisational Complexity						

IO_1	There were clearly defined organisational and control structures within the project	1	100	33.7	31.7	Yes
IO_10	Project parties communicated effectively	0	100	34.8	31.4	Yes
IO_2	Project parties shared similar organisational cultures	0	100	37.2	34.2	Yes
IO_3	Organisational politics impacted the project process	0	100	48.4	34.3	
IO_4	Interpersonal conflict impacted the project process	1	100	53.5	37.1	
IO_5	Project parties were in agreement about the project objectives	1	100	17.9	25.5	Yes
IO_6	The project received support from all project parties	1 =	100	27.3	27.8	Yes
IO_7	The intentions and motives of all parties involved were clear to other parties, i.e. there were no hidden agendas.	1	100	22.8	31.4	Yes
IO_8	Project parties trusted each other	1	100	26.4	31.3	Yes
IO_9	There were good relations among project parties	0	100	27.4	29.5	Yes
Structural Complexity						
SC_1	The product (service) created by the project was complex	1	100	30.0	27.9	
SC_10	The project required expertise from several distinct and separate disciplines	1	100	20.8	27.4	
SC_11	The project was part of a program of many related projects	0	100	32.9	35.5	
SC_2	Project activities/tasks were interlinked	1	100	16.9	21.0	
SC_3	The characteristics of project activities/tasks varied substantially	1	100	40.5	28.4	
SC_4	This project was impacted by other projects	1	100	45.3	34.3	
SC_5	The project impacted other projects	0	100	36.8	30.9	
SC_6	The project used several distinct and separate methodologies/approaches	1	100	32.6	35.6	
SC_7	The project was conducted at several distinct and separate locations	1	100	43.5	43.0	
SC_8	The project had a broad scope	1	100	42.7	29.9	
SC_9	The project used several distinct and separate technologies	1	100	34.0	35.1	
Uncertainty Complexity						
UC_1	Information available to conduct the project was of a high quality	1	100	37.1	28.8	Yes
UC_2	The project required the use of novel technologies, i.e. unfamiliar technologies or even technologies that had not yet been developed when the project started	1	100	43.4	38.3	
UC_3	The project involved novel or uncommon contractual arrangements	1	100	37.0	36.3	
UC_4	The project goals were clear	1	100	21.9	30.0	Yes
UC_5	The project relied upon familiar methodologies and techniques	1	100	23.7	26.5	Yes
UC_6	Information required to conduct the project was readily available	1	99	36.6	28.5	Yes
UC_7	Project scope was well defined	0	100	32.7	27.5	Yes
UC_8	The project team had had prior experience of the kind of work the project required	1	100	37.4	35.5	Yes

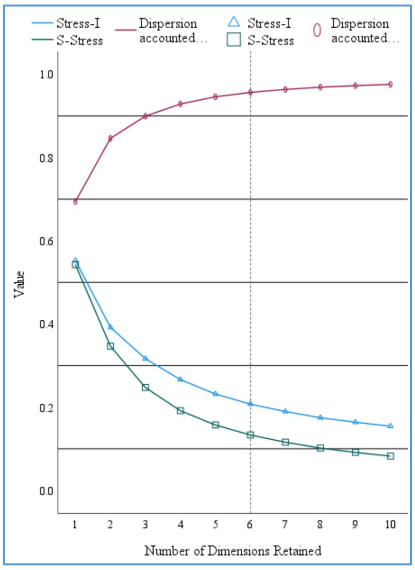
Figure 1 is a word cloud visualizing the descriptions of projects, which we obtained by submitting the full descriptions of the projects provided by the respondents to a word *analyzer* application. The analysis removed common words (such as ‘*project’* and ‘*management’*) and stop words (‘*a’*, ‘*the’*, ‘*is’*, ‘*are’* etc.), and then normalized the remaining words so that words with higher frequency, such as ‘*system’*, were visualized in larger font. We can infer from the visualization that the projects commonly involved ‘*New’*, ‘*System’*, ‘*Application’* and ‘*Data’.* We append the original full descriptions in Appendix I.

Figure 1: Word cloud from brief project descriptions.

B. Dimensionality

We plotted the model fit stats, namely *Kruskal’s Stress-I*, *S-Stress* and *Dispersion Accounted for* (DAF) for each of the ten models. Figure 2 shows the plots. We can observe that the curves turn decisively at dimension 5. By dimension 6, they are asymptotic so that each added dimension produces very little additional value; for example, less than 1% improvement in dispersion accounted per added dimension. For these reasons, we decided to retain 6 dimensions, which explain 96% of the dispersion in the dataset.

Figure 2: Model fit improvement with dimensions added



C. Three-Way MDS Model Fit

The 3-Way MDS model estimated with the *PREFSCAL* algorithm retaining six dimensions was a very good fit for the data. *Kruskal's Stress-I* was 0.2060257*, S-Stress* was 0.3, and the model accounted for 96% of the dispersion. *Sum-of-Squares of DeSarbo's Inter-mixedness Indices* was 0.02, i.e., close to zero, indicating a highly mixed solution. Similarly, *Shepard's Rough Nondegeneracy Index* was high at 0.8, indicating a high likelihood the solution is not degenerate.

D. Three-Way MDS Dimensions

Table 5 shows the coordinates of the complexity measures on each of the six dimensions. The meaning of each dimension is most clearly depicted by those measures that load strongly on it, with large coordinate values in absolute terms. Therefore, we highlight both positive and negative coordinate values greater than an absolute value of 1.

We can observe in the Table 5 that all measures of complexity load highly on at least one of the dimensions. Red coded cells indicate high negative loadings, whereas green cells indicate high positive loadings. In most cases, measures of complexity have high loadings on more than two dimensions, except for the two measures of '*Structural complexity*', which we have greyed out. These are SC_6 (*'The project used several distinct and separate methodologies/approaches'*), and SC_7 (*'The project was conducted at several distinct and separate locations'*). This means that neither of these measures is a strong symbolizer of any dimension of complexity for IS projects. Rather, both measures are universally representative of the dimensions.

Table 5: Dimensional coordinates of complexity measures

Measure	Dim_1	Dim_2	Dim_3	Dim_4	Dim_5	Dim_6	Description
SC_1	-0.997	-0.312	1.682	-1.359	-0.599	-0.819	The product (service) created by the project was complex
SC_2	-1.261	-1.434	0.618	-0.701	0.107	0.381	Project activities/tasks were interlinked
SC_3	-0.750	-0.850	1.729	-1.270	1.248	0.017	The characteristics of project activities/tasks varied substantially
SC_4	1.167	-0.337	0.979	-1.195	-0.623	1.806	This project was impacted by other projects
SC_5	0.172	0.306	1.075	-1.972	1.217	1.938	The project impacted other projects
SC_6	-0.391	0.559	0.637	0.018	0.876	-0.455	The project used several distinct and separate methodologies/approaches
SC_7	0.787	0.788	0.605	0.120	-0.629	-0.047	The project was conducted at several distinct and separate locations
SC_8	0.932	0.401	1.369	-2.046	-0.277	-0.567	The project had a broad scope
SC_9	0.443	0.446	1.527	-2.081	-0.745	-0.931	The project used several distinct and separate technologies
SC_10	-1.242	-0.060	1.532	0.191	1.584	0.826	The project required expertise from several distinct and separate disciplines
SC_11	0.791	-0.476	1.156	-0.345	-0.353	0.045	The project was part of a program of many related projects
UC_1_(-ve)	-0.953	-1.569	-1.069	-0.129	1.965	0.249	Information available to conduct the project was of a high quality
UC_2	0.176	0.919	1.305	-1.315	-0.170	-0.398	The project required the use of novel technologies, i.e. unfamiliar technologies or even technologies that had not yet been developed when the project started
UC_3	0.468	0.840	1.085	-1.766	2.042	-0.223	The project involved novel or uncommon contractual arrangements
UC_4_(-ve)	-1.208	-1.304	-0.645	0.774	0.570	-0.229	The project goals were clear
UC_5_(-ve)	-1.156	-1.450	0.167	0.646	0.518	1.341	The project relied upon familiar methodologies and techniques
UC_6_(-ve)	-1.289	-0.934	-0.921	-0.254	0.990	1.699	Information required to conduct the project was readily available
UC_7_(-ve)	-1.105	-1.696	-0.608	0.658	1.353	-1.777	Project scope was well defined
UC_8_(-ve)	-0.722	-0.185	-0.783	0.297	2.191	0.888	The project team had had prior experience of the kind of work the project required
IO_1_(-ve)	-1.176	-1.418	-0.822	-1.876	0.666	-1.172	There were clearly defined organisational and control structures within the project
IO_2_(-ve)	-1.044	-0.834	-1.134	-0.128	-0.609	-0.580	Project parties shared similar organisational cultures
IO_3	0.855	0.786	-0.103	-1.612	0.516	1.699	Organisational politics impacted the project process
IO_4	0.977	1.280	0.715	-0.080	-0.713	0.806	Interpersonal conflict impacted the project process
IO_5_(-ve)	-1.258	-0.904	0.887	0.662	0.652	-1.498	Project parties were in agreement about the project objectives
IO_6_(-ve)	-1.293	-1.822	-0.452	0.114	0.139	-1.140	The project received support from all project parties
IO_7_(-ve)	-1.186	-1.090	-0.844	0.768	0.522	-0.899	The intentions and motives of all parties involved were clear to other parties, i.e. there were no hidden agendas.

IO_8_(-ve)	-1.283	-1.214	-1.118	0.271	0.538	-0.314	Project parties trusted each other
IO_9_(-ve)	-1.298	-1.181	-0.831	0.568	0.895	-1.296	There were good relations among project parties
IO_10_(-ve)	-1.225	-0.881	-1.279	0.604	0.971	-0.550	Project parties communicated effectively
CC_1	1.058	1.193	0.310	-0.273	-0.888	0.864	The project requirements changed frequently
CC_2	0.169	0.640	1.250	-0.251	1.649	1.163	The project involved frequent reworks
CC_3	0.747	0.970	-0.012	-1.116	-1.311	1.005	The project team composition underwent several changes during the project
CC_4	1.056	0.943	-0.002	-1.262	-0.159	0.192	The organisations (contractors, external suppliers, etc.) involved underwent several changes during the project
CC_5	0.686	0.867	0.603	0.244	1.082	-1.191	The external environment changed during the project
Urgency_1	-1.174	-0.962	-0.752	-0.653	0.655	-0.863	There was a sense of urgency, such that the project had to be initiated and completed in the immediate or near future
Criticality_1	-1.333	-0.724	1.542	0.419	0.571	0.381	The project was considered extremely important

To further aid our interpretation, we constructed 2-dimensional projection maps in order to visualize the complexity dimensions. Where a measure was reverse-coded in the survey, we notate it with a '*-ve*' to indicate that increasing levels of such a measure indicates decreasing complexity of its type. As with the tabulated coordinates, extremities of the dimensions comprise variables that load highly on each dimension and are most helpful for interpreting each dimension. Figure 3 is a map projection of *Dimension* 1 against 2; Figure 4 projects *Dimension* 3 against 4; and Figure 5 depicts *Dimensions* 5 against 6.

Figure 3: Map projection of Dimension 1 against 2

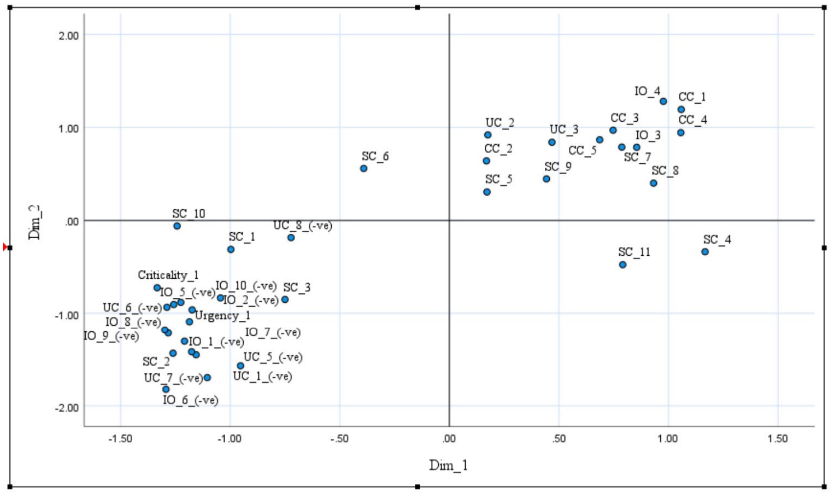


Figure 4: Map projection of *Dimension* 3 against 4

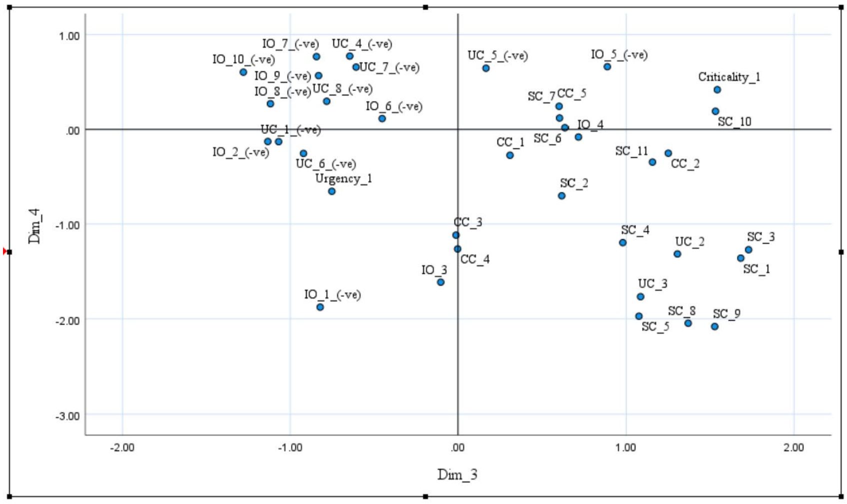
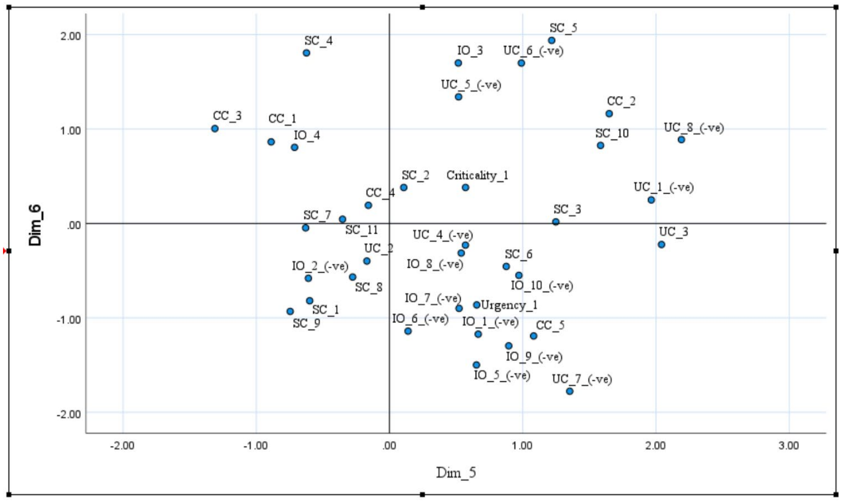


Figure 5 Map projection of *Dimension* 5 versus 6



We can summarize the main features of the six dimensions as follows. *Dimension* 1 is characterised by high levels of most measures of *'Uncertainty complexity'* and most measures of '*Interpersonal and Organisational Complexity'*. This dimension is also characterised by high levels of changes in requirements and organisations involved in project. Another feature of this dimension is that the level of its impact of other projects on project is high, but not vice versa. However, notably, this dimension is characterised by both low urgency and criticality, low inter-interdisciplinary and inter-dependence of activities/tasks.

Dimension 2 is characterised by very high uncertainty (higher than *Dimension* 1) of scope and information. It was also characterised by high '*Organisational complexity'*, especially lack of control structures and also support among participants. This dimension also exhibited high levels of interpersonal conflict and high levels of change requirements. However, it demonstrated weak links among its project activities/tasks.

Dimension 3 is characterised by generally high '*Structural complexity*', especially notably in the complexity of product (service) and task variability, which are very strong. Another characteristic of this dimension was high uncertainty in the use of distinct and separate technologies; and the lack of information necessary for project implementation. This dimension also exhibits high '*Organisational complexity*' in cultural variance among the organisation involved. Another distinguishing attribute of this dimension was the existence of a lack of trust and also poor communication among the organisations. We also observed high levels of change in uncertainty in frequency reworks. A notable characteristic of this dimension was the existence of high criticality but not high urgency.

The main characteristics of *Dimension 4* were low '*Structural complexity*'. In particular, this dimension was also characterised by narrow scope and little or no requirement to use distinct and separate technologies. Another characteristic of this dimension was, low uncertainty with lack of variance in technologies used and well-defined contractual arrangements. This dimension also exhibited low impact of political imperatives. In addition, it also exhibited low number of changes in team structure/organisations and also contractors involved in the project. Despite these, this dimension was also observed to have very low levels of clearly defined organisational and control structures within the project. In other words, its control structures were deemed to be poorly defined.

Dimension 5 on the other hand is characterised by high task/activity variation. It is also characterised by its strong influence on other projects. It also exhibits high levels of inter-*disciplinarity*. However, it not only exhibits a strong lack of information appropriate for project implementation, but is also characterised as exhibiting extremely unusual contractual arrangements. Despite its well defined scope and being staffed by experienced team members and a low frequency of changes within this team, this dimension is characterised by frequent reworks. It is subject to some change in its external environment.

Dimension 6 showed very strong impact on other projects and vice versa. Another feature of this dimension was its low familiarity with methodologies, general low information, very poorly defined scope and poor control structures. This dimension was also characterised by a lack of support among parties (and poor relations among parties) and constant team changes, strong manifestations of organisational politics. Furthermore, despite a stable external environment, there was a lack of agreement about objectives. inevitably, this will lead to frequent reworks and perhaps, team changes.

E. Dimensional saliency across project categories 1 and 2

Table 6 shows the weights, specificity and importance of the six dimensions. The dimensions have decreasing amounts of *Variance accounted for* (VAF). Based on this measure, *Dimension* 1 is the most important, with at least twice as much VAF as *Dimension* 2. On the other hand, *Dimension* 2 and 3 are similar, with *Dimension* 4 not far behind 2 and 3. *Dimension* 5 and 6 both account for much smaller amounts of variance can be viewed as relatively of minor importance.

Table 6: Dimensional Weights

		Dim_1	Dim_2	Dim_3	Dim_4	Dim_5	Dim_6	Specificity[a]
Source	*Category* 1	860.3	**1.2**	**2.0**	474.9	400.9	**13.5**	0.673
	Category 2	198.5	579.8	548.9	**0.0**	**0.0**	343.7	0.632
Importance[b]		0.41	0.17	0.16	0.12	0.08	0.06	

a. Specificity indicates the typicality of a source. The range of specificity is between zero and one, where zero indicates an average source with identical dimension weights and one indicates a very specific source with one exceptional, large dimension weight and other weights near zero.
b. Relative importance of each dimension, given as the ratio between the sum-of-squares of one dimension and the total sum-of-squares.

Both sources are highly specific, with specificity values closer to 1 than 0. Inspection of the weights explains why: Projects in *Category* 1 (internal employees) attached hardly any weight to *Dimensions* 2, 3 and 6. They placed most weight on *Dimension* 1, 4 and 5 in that order of decreasing weight. Projects in *Category* 2 (involving external consultants) placed no weight on both *Dimensions* 4 and 5. They placed all weight, in order of decreasing value, on *Dimensions* 2, 3, 6 and 1. Therefore, *Dimensions* 1 is the only one both categories regarded with significant weight, although *Category* 1 projects much more saliently than *Category* 2 did.

V. DISCUSSIONS

A. Key complexities of IS projects

To address our first research question (*What are the key complexities of IS projects?*), we analysed the measures of complexity with 3-way MDS. We found that nearly all (96%) of the variation in the data can be captured within six dimensions of complexity. In effect, we find six key complexities of IS projects. The six dimensions are hierarchical in that earlier dimensions capture more variance than later ones. As such, *Dimension* 1 is the most important, capturing more than twice the variance of *Dimension* 2. *Dimension* 2, by contrast, is hardly superior to *Dimension* 3, capturing 17% versus dimension 3's 16%. *Dimension* 4 is slightly less important, capturing 12% of the variance. In these terms, we may regard both *Dimension* 5 and *Dimension* 6 as minor since neither one captures a great deal of variance at 8% and 6%, respectively.

When we look at the main characteristics of each dimension as symbolised by those measures that load highly on it as highlighted in Table 5 (shown earlier above) and subsequently visualised by the extremities of the map projections of dimensions in Figures 3, 4 and 5, we begin to see why *Dimension* 1 is important. It captures a variety of complexities. These include elevated levels of uncertainty, interpersonal and organisational complexities, as well as certain aspects of change and structural complexity. Importantly, both urgency and criticality load strongly but negatively on *Dimension* 1. In effect, this dimension is not indicative of complexities arising from urgency and criticality. We term this key emergent complexity of IS projects as '*Variety*'.

Dimension 2 appears quite similar to *Dimension* 1 in that it represents a variety of complexities including high levels of uncertainty, interpersonal and organisational complexities. However, there are some crucial differences. First, *Dimension* 2 strongly accentuates both scope and information uncertainty. Second, it is strongly representative of complexities arising from problems with control structures, lack of support among participating parties and high interpersonal conflict. This key emergent complexity of IS projects is named '*Control*'.

Dimension 3 is the only one with a very high a positive loading of criticality, although still not high urgency. It is universally indicative structural complexity, with nearly all indicators of structural complexity loading strongly on it. Particularly notable among structural complexity indicators are complexity of product (service) and task variability.

Dimension 3 also represents high uncertainty complexity in the use of distinct and separate technologies and the lack of information to conduct the project; as well as change complexity with high frequency of reworks. These features suggest complexities of novel product/service development. Additionally, *Dimension* 3 is indicative of high levels of interpersonal and organisational complexity captured through lack of trust, poor communication and cultural clashes among the organisations involved. This key emergent complexity of IS projects is named '*Criticality'*.

Dimension 4 represents generally low levels of complexity, particularly structural complexity arising from breadth of scope, variety of methodologies used and impact on other projects. Other low loading measures include impact of politics, a measure of organisational complexity as well as two measure of change complexity, i.e., changes in team structure/organisations/contractors involved in the project. However, *Dimension* 4 is also characterised by complexity arising from very poorly defined control structures. We can infer from these features that *Dimension* 4 is likely to represent generally low complexity projects in repetitive projects (not novel) executed by established, autonomous teams, that may well benefit from more clearly defined control structures. This key emergent complexity of IS projects is named '*Scope and repetition'*.

Consistent with their minor levels of relative importance, fewer measures load strongly on both *Dimensions* 5 and 6, making both more idiosyncratic than earlier dimension. *Dimension* 5 is characterised by high uncertainty complexity in terms of lack of information about the project and yet low uncertainty complexity in having well defined scope. There is structural complexity due to high task variation, impact on other projects and inter-*disciplinarity*. *Dimension* 5 also captures situations of high organisational complexity in unusual contractual arrangements; high change complexity in frequency of reworks and change in the external environment, which is contrasted by low change complexity in the stability of the project team over time. Speculatively, the complexity situation captured by *Dimension* 5 may be observed in inter-disciplinary collaborative projects involving established teams, for example projects bringing together existing inter-disciplinary team to work on highly novel basic research. We term this key emergent complexity of IS projects as '*Information'*.

Dimension 6 represents high structural complexity in that there are high levels of inter-project dependence with the projects having high impact on other projects and vice versa. There is high uncertainty complexity due to poorly defined projects, lack of knowledge about how the project should conducted and unclear scope. There is also interpersonal and organisational complexity in poor control structures, impact of politics and lack of agreement about objectives, support among parties and poor relations among parties. Finally, there is some change complexity in frequency of reworks and team structures, although the external environment appears stable. We term this key emergent complexity of IS projects as '*Dependence'*.

B. Salient differences in key project complexities

The high specificities of our two data sources and weight differentials shown earlier in Table 6 suggest clear differences in the salience of the dimensions of complexity between IS projects that do not engage or use external consultants and those that do. As found, *Dimensions* 2 *('*Control'*)*, 3 *('*Criticality'*)* and 6 *('*Dependence'*)* are virtually exclusive to projects that engage and use external consultants. The opposite is true regarding *Dimensions* 4 *('*Scope and repetition'*)* and 5 *('*Information'*)*, which are exclusive to projects where external consultants are neither engaged or used. Therefore, only *Dimensions* 1 *('*Variety'*)* is common to both types of projects.

By comparing how these clusters of dimensions differ, in order words, how *Dimensions* 2 ('*Control'*), 3 ('*Criticality'*) and 6 ('*Dependence'*) differ from *Dimensions* 4 ('*Scope and repetition'*) and 5 ('*Information'*), we can infer the how dimensions of complexity differ between projects that do not engage or use external consultants and those that do. The first key difference we observe is that projects engaging external consultants tend to exhibit higher levels of '*Criticality'* as captured the very strong loading of criticality on *Dimension* 3 ('*Criticality'*). A core aspect of a project's criticality is the scheduling of its different activities [111]. Thus, criticality is impacted by expectations for project completion time [112]. Earlier on, we had alluded not only to IS projects being particularly susceptible to complexity, but also to complexity arising out from consultant engagement. Our finding that projects engaging external consultants tend to exhibit higher levels of '*Criticality'.* The implication being that projects involving external consultant were more likely to be characterized by a zero time in terms of slack. In order words, efforts were made to implement these projects within strictly fixed timescales. The extant literature suggests that consultants consider time management to be directly related to their effectiveness [113]. Our understanding of the literature further suggests that there is a general tendency for IS project development and implementation practitioners to under estimate project completion times [10]. In fact, such under estimation of time (as against over estimation) [114], also represents one of the main reasons for high project failures among IS projects [115] [116], especially in larger ones [117]. This may occur because of optimism bias [118] or strategic misrepresentation [119] [120] [121] [122], both which are not easily reversible [10]. External consultants can play a major and positive role in mitigating (but not eliminating) the potential for under estimate project completion times [10]. They can do so first by relying upon their earlier discussed interrelated knowledge elements, specifically their access to (i) common methods and tools and (ii) project repositories of knowledge. Second, the literature suggests that individuals engaged in observing others perform specific tasks are less prone to overestimation bias than those actually performing the task themselves [123]. Thus, the use of external consultants may reduce the scale to which time has been under estimated in a project.

Also, as captured by *Dimension* 3 (‘*Criticality’*), projects engaging external consultants tend to be characterized by more varied and stronger ‘*Structural complexity’*. They are also characterized by product (service) complexity and activities/tasks variety. Arguably, these findings were not of surprise. Among other reasons, ‘*Structural complexity’* were likely to be manifest in projects where external consultants had been engaged because of the tendency of consultants to bypass organisational structures and processes through their maintenance of high-value and personal relationships with key decision-makers in organisation [124].

Third, when we compared *Dimensions* 1 (‘*Variety’*) and 2 (‘*Control’*), we noted they were similar but also the difference in that *Dimension* 2 (‘*Control’*) accentuated aspects of interpersonal and organizational complexity. This is consistent with *Dimensions* 3 (‘*Criticality’*) and 6 (‘*Dependence’*), which both also represent several measures of interpersonal and organizational complexity. Overall, we can count in Table 4 of 13 measures of interpersonal and organizational complexity with high loading on *Dimensions* 2 (‘*Control’*), 3 (‘*Criticality’*) and 6 (‘*Dependence’*). By contrast, there is only one such high loading on *Dimensions* 4 (‘*Scope and repetition’*) and 5 (‘*Information’*) between them. Therefore, it is clear that projects engaging external consultants are more characterized by interpersonal and organizational complexity. This finding is consistent with evidence from the consultant-assisted projects literature [7] [8] [24] [9].

VI. CONCLUSIONS

We sought in this study to examine the nature of the complexity saliences involved in consultant engagement and use in IS projects. To undertake this study, we posed two research questions. The first, focused on identifying what were the key complexities that existed within IS projects. The findings from our study broadly identified the manifestation of six dimensions of complexity with IS projects namely (i) '*Variety*' (ii) '*Control*' (iii) '*Criticality*' (iv) '*Scope and repetition*' (v) '*Information*' and (vi) '*Dependence*'. The second research question focused on exploring the salient differences in the key project complexities between projects engaging consultants and those not engaging consultants.

Our results show that projects engaging external consultants experience more varied and stronger structural complexity and higher salience of interpersonal and organisational complexity. Additionally, we found that projects engaging external consultants have higher criticality. The implication being that ensuring complexities are actively and well managed is of critical importance. Drawing from Luo and Liberatore [7], this finding is encouraging for consultants: if client organisations perceive that consultant engagement brings about value, they become less to focus on likely negative drawbacks with the engagement and use of consultants.

In demonstrating the nature of complexity with consultant engagement in IS projects, we also articulated the nature of changes in the salience of such project complexities following consultant engagement. In doing so, we advanced an understanding of how complexity ('*Variety*', '*Control*', '*Criticality*', '*Scope and repetition*', '*Information*' and (vi) '*Dependence*') with consultant engagement can arise in IS projects and the implications of such complexity.

Our findings have a number of theoretical and practical implications. In terms of theoretical implications, numerous studies have over the years sought to explore and examine emergent complexities of projects and their constituents through a range of methodologies. Our study is however one of the first within the project management domain to offer a quantitative empirical determination of the multivariate interrelationships among measures of complexity. Our study also makes a number of contributions to an understanding of how complexity and external teams (consultants) interface in the context of IS projects. By incorporating complexity and the work of external consultants, successful IS delivery can be construed to be a function of a number of factors. These include (i) the range of resources available to the consultant, (ii) the manner within which these resources will over time, be transformed and (iii) the degree of influence and power the consultant wields. Not only can influence and power be exercised from a distance [125], but also, the least visible actors may wield the most influence and power in or on an organisation. Consultants may maintain enough proximity to the organisation to be able to some extent, exert influence and power over it (and vice-versa).

Conversely, for practitioners, in acknowledging the need for project management studies not to over-simplify complexity [56], our study goes a long way in articulating the managerial mechanisms best suited (that is, best practice), for any individual, project or organisational-level response to complexity. Maylor and Turner [36] suggest understanding the nature of complexity is a key step to the mitigation of its negative consequences. We offer project practitioners better knowledge on how the pattern of complexities in IS projects may be different when they engage consultants. Practically, our findings could form part of the considerations for project planning, particularly selection of the management team to ensure the team has the requisite competences [126], and selection of the consultants to minimise these potential effects [98]. Furthermore, for the practitioner, understanding project complexity allows for clearer project goal and objectives identification and the selection of appropriate project structures to go with it [34]. This is very important it is questionable as to whether traditional project management approaches, tools and techniques adequately cater for complexity in projects [127] [128]. The value of our particular study is that it provides knowledge that may help managers better understand and manage the complexities of consultant-engaged projects within the information systems space.

As expected for studies of this nature, ours did have limitations. However, these limitations serve as a platform for future studies. The first limitation is that the sample for analysis is drawn primarily from respondents in North America (Canada, 64%; United States, 14%). Future studies could focus on obtaining a much more globally dispersed dataset. Such data will be more generalisability and more likely to provide a more balanced insight into the study imperatives. The second limitation is that by concatenating the categories of consultants into just two categories, namely *Category 1* (‘*None or internal only’*) and *Category 2* (‘*Both internal and external or external only*’), meant that we were not able to determine differences that may be present as a result of engaging internal consultants. Yet, internal consultants represent one of the major and active actors involved in the development and dissemination of management ideas and practices [129] [130] [25]. We are of the opinion that this limitation may be addressed by gathering a larger dataset. Another direction to consider will be determine such categorizations *a priori*; thus categories of consultants could have been pre-identified in the study instead of asking respondents (as we did), to describe the type of consultants their project engaged. Finally, it would be interesting to examine the effects of individual complexity measures, so that we may rank their importance. Doing this might offer practitioners a heuristic for prioritising complexities in projects. Additionally, such modelling could examine the mediation or moderation effects of hiring consultants of different kinds.

In concluding our study, it has become clear that our study was rooted in traditional notions of consultant engagement and use that espouses clear and formal consultant engagement. The priorities of the consultant under these conditions is expected to be heavily driven by the client organisation. However, if we depart from this traditional model, to one that is informal, we will have to recognise that the proximity of consultants to organisation means that they can exert influence which is invisible on how the client’s operations and business are configured and operated. To therefore best appreciate the salient differences in the key project complexities between projects engaging consultants and those not engaging consultants, we have to acknowledge not only that our current understanding of consultant engagement may be much more limited than hoped, but also as Tywoniak et al. [56] observed, that the use of current complexity theories lacks the necessary theoretical sophistication needed to ensure that related research meets practitioner relevance expectations. Thus, we make further calls for research further theorizing complexity within project studies.

Appendix I

Original full project descriptions for word cloud

Please describe the type of information systems project	Frequency
A major Data Centre Infrastructure Upgrade project for 2 Capital Ministries -Ministry of Transportation; Ministry of Infrastructure	2
A sustainable beef traceability pilot project tracking over 2 million lbs of beef from birth to burger across all parts of the s	1
AI and intelligent automation project	1
Adding a new reporting module & interactive analytics dashboard to the existing ERP	2
App development	1
App development and implementation	1
Banking as Service APIs for Caribbean subsidiaries of the bank	2
CRM implementation	2
Cloud consulting and migration	8
Cloud implementation	4
Cloud security based projects	5
Cloud services integration	1
Confidential	3
Customer Management System	1
Cybersecurity	1
Cybersecurity and data protection project	1
Cybersecurity audit and infrastructure project	1
Data	1
Data Science and reporting engagement	2
Data centre Security project	1
Development of a testing equipment to obtain system information on products developed by the company	2
Development of new in-house application which will retire the old application after data migration, and a three month parallel r	2
Development of new software tool	1
Digital Transformation	1
ERP	3
ERP application development	1
ERP implementation	6
Ecommerce project and data integration	1
Ecommerce project, where the old ERP system that syncs only once per day with the main database needed to be made ecommerce read	1
Enterprise Information Management	2
Fintech project	1
IAM project	4
IT Cloud implementation	1
IT infrastructure modernisation	1
IT modernization project	4
ITIL service management tool implementation	3
Implementation of a VAT/Taxation solution for a nation-wide project.	1
Implementation of a new digital technologies in a contact centre	1

Implementation of a new phone system in a call centre	1
Information Management	1
Integration between Content Repository, User Directory and Content Management System.	1
Learning Management System implementation	1
Migrating 3 separate networks and CRM tools to one network.	1
New ERP and Retail Point of Sale systems	1
New Facilities Management system for a University. Linked to a financial system that was changed during the project execution.	1
Our project was to re-build the logical rules of a Security Information and Event Management (SIEM) to better capture information	1
Phone over IP, Introduction to Fibre, Data Room Rebuilt, 2 new servers, building of a call centre, new technology used for phone	1
Planning phase of the National Safety Code Compliance Program, including automation of processes for driver training and certificate	2
RPA driven process automation	3
RPA implementation	1
Replacing an in-house legacy system with an off the shelf system to be interfaced with core systems in the organisation.	1
Risk Assessment of Brokers for insurance companies	2
Shifting the network infrastructure to a different part of the building. This was a remote site. It had to communicate with the	1
Software deployment	5
Software implementation	1
Solutions for a home builder project	1
The project dealt with keeping track of all the Metis Land registry and membership data.	1
The project was an application which works offline and communicates with other systems through synchronization.	2
This is confidential information	1
To build the IS for a new floor including an internationally networked II Operations Centre, and video conferencing.	1
Web based application development	15
Application development	3
Application development and rollout	2

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