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Editorial

The mission of the *IJISPM - International Journal of Information Systems and Project Management* is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

It is our great pleasure to bring you the first number of the sixth volume of IJISPM. In this issue readers will find important contributions on adoption of cloud computing, determinants of analytics-based managerial decision-making, ERP systems selection, and lifespan of information service firms.

As Mark Stieninger, Dietmar Nedbal, Werner Wetzlinger, Gerold Wagner and Michael A. Erskine state in the first article "Factors influencing the organizational adoption of cloud computing: a survey among cloud workers", cloud computing presents an opportunity for organizations to leverage affordable, scalable, and agile technologies. However, even with the demonstrated value of cloud computing, organizations have been hesitant to adopt such technologies. Based on a multi-theoretical research model, this paper provides an empirical study targeted to better understand the adoption of cloud services. An online survey addressing the factors derived from literature for three specific popular cloud application types (cloud storage, cloud mail and cloud office) was undertaken. The research model was analyzed by using variance-based structural equation modelling. Results show that the factors of compatibility, relative advantage, security & trust, as well as, a lower level of complexity lead to a more positive attitude towards cloud adoption. Complexity, compatibility, image and security & trust have direct and indirect effects on relative advantage. These factors further explain a large part of the attitude towards cloud adoption but not of its usage.

The second article, "Determinants of analytics-based managerial decision-making", is authored by Usarat Thirathon, Bernhard Wieder and Maria-Luise Ossimitz. This paper investigates how managerial decision-making is influenced by Big Data analytics, analysts' interaction skills and quantitative skills of senior and middle managers. The results of a cross-sectional survey of senior IT managers reveal that Big Data analytics (BDA) creates an incentive for managers to base more of their decisions on analytic insights. However, interaction skills of analysts and – even more so – managers' quantitative skills are stronger drivers of analytics-based decision-making. Finally, the analysis reveals that, contrary to mainstream perceptions, managers in smaller organizations are more capable in terms of quantitative skills, and they are significantly more likely to base their decisions on analytics than managers in large organizations. Considering the important role of managers' quantitative skills in leveraging analytic decision support, the findings suggest that smaller firms may owe some of their analytic advantages to the fact that they have managers who are closer to their analysts – and analytics more generally.

The Enterprise Resource Planning (ERP) system selection is an early phase in the ERP adoption process. When organizations evaluate an ERP, they commonly develop their own selection criteria that usually involve various system and vendor related factors. While the selection process is critical, however, there is an apparent research gap in literature. The ERP selection effort also focuses on the system's fit with the organizational requirements and needs. Thus, the selection phase is critical, because if an organization chooses an unfit ERP, the whole project could be predestined to fail. The third article "ERP systems selection in multinational enterprises: a practical guide", authored by Moutaz Haddara, provides an overview of an ERP selection process at an overseas branch office of a multinational company. The process employed a simple multi-attribute rating technique (SMART) for evaluation. In addition, this research presents how cross-border data protection laws between the parent company and its branch have influenced the selection process. As the ERP system has been implemented successfully, the method and the selection factors have been proven adequate for the selection process.

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The purpose of the fourth article "Lifespan of information service firms in Japan: a survival analysis", authored by Seigo Matsuno, Yasuo Uchida, Tsutomu Ito and Takao Ito, is an analysis of survival in the Japanese information service industry. Information service firms are generally classified into two typical patterns. One is the group of independent firms such as software vendors, and the other is the group of non-independent such as subsidiaries established by spinning off and so on. The authors used a sample of 334 firms in Japan and analyzed by Kaplan-Meier estimator method and Cox proportional hazard regression model in order to investigate the difference of survival between these two groups and/or among other attributes. As a result, the lifespan of the information service firms significantly depends on the degree of system integration sales ratio, software development sales ratio, and entrusted processing sales ratio. On the contrary, property of non-independence and high sales ratio with main customers have a negative influence on their survival rates, i.e. lifespan. The article discusses these results and offers some managerial implications, and future research opportunities are provided.

We would like to take this opportunity to express our gratitude to the distinguished members of the Editorial Board, for their commitment and for sharing their knowledge and experience in supporting the IJISPM.

Finally, we would like to express our gratitude to all the authors who submitted their work, for their insightful visions and valuable contributions.

We hope that you, the readers, find the International Journal of Information Systems and Project Management an interesting and valuable source of information for your continued work.

The Editor-in-Chief,

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João Varajão is currently professor of information systems and project management at the *University of Minho*. He is also a researcher of the *Centro Algoritmi* at the *University of Minho*. Born and raised in Portugal, he attended the *University of Minho*, earning his Undergraduate (1995), Masters (1997) and Doctorate (2003) degrees in Technologies and Information Systems. In 2012, he received his Habilitation degree from the *University of Trás-os-Montes e Alto Douro*. His current main research interests are in Information Systems Management and Information Systems Project Management. Before joining academia, he worked as an IT/IS consultant, project manager, information systems analyst and software developer, for private companies and public institutions. He has supervised more than 80 Masters and Doctoral dissertations in the Information Systems field. He has published over 300 works, including refereed publications, authored books, edited books, as well as book chapters and communications at international conferences. He serves as editor-in-chief, associate editor and member of the editorial board for international journals and has served in numerous committees of international conferences and workshops. He is co-founder of CENTERIS – Conference on ENTERprise Information Systems and of ProjMAN – International Conference on Project MANagement.

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Factors influencing the organizational adoption of cloud computing: a survey among cloud workers

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Abstract:
Cloud computing presents an opportunity for organizations to leverage affordable, scalable, and agile technologies. However, even with the demonstrated value of cloud computing, organizations have been hesitant to adopt such technologies. Based on a multi-theoretical research model, this paper provides an empirical study targeted to better understand the adoption of cloud services. An online survey addressing the factors derived from literature for three specific popular cloud application types (cloud storage, cloud mail and cloud office) was undertaken. The research model was analyzed by using variance-based structural equation modelling. Results show that the factors of compatibility, relative advantage, security & trust, as well as, a lower level of complexity lead to a more positive attitude towards cloud adoption. Complexity, compatibility, image and security & trust have direct and indirect effects on relative advantage. These factors further explain a large part of the attitude towards cloud adoption but not of its usage.

Keywords:
Cloud Computing; Cloud Adoption; Cloud Services; Diffusion of Innovations; Technology Acceptance Model; Structural Equation Modelling.

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1. Introduction

Cloud computing is a beneficial way of delivering information technology (IT) services to individuals and organizations [1–5]. Even though cloud computing offers ways to improve their IT performance, the attitude towards cloud computing is influenced by significant concerns toward this innovation [6, 7].

Being an important area for IT innovation and business investment [4], the adoption of cloud computing has received increasing attention in both practice and research [8]. Although recent studies have provided information on the current state of the adoption of cloud computing, there is still a need to study both the attitude towards adoption and the actual usage of certain cloud application types across organizations of different sizes, industries and locations. Therefore, this paper develops an explorative multi-theoretical model to examine important factors affecting cloud adoption among organizations.

The goal of this paper is to verify a multi-theoretical research model recombined by factors originating from Davis' Technology Acceptance Model (TAM) and Rogers' Diffusion of Innovation (DoI). While the factors are theoretically based, this paper examines their practical relevance within the context of cloud computing. The remainder of this paper is arranged as follows: Section 2 frames the background and motivates the necessity to derive factors relevant for the intended purpose. In Section 3, the research model is presented, included factors are described and the proposed hypotheses are deduced. Section 4 summarizes the operationalization of the influencing factors. Section 5 provides the empirical results using variance-based structural equation modelling (PLS-SEM). Finally, conclusions and future work are provided in Section 6.

2. Literature review: background and factor exploration in the context of cloud computing

As research on the diffusion of innovations dates back to the 1940s [9], various explorations of the drivers for innovation adoption are found in the literature. Of primary interest for this research are empirical studies based on widely accepted theories that are related to the topic of cloud computing. Furthermore, it is important to distinguish between the adoption of innovations by individuals and adoption within organizations, as the adoption processes may be quite different [10]. Several sources of recent topic-related literature show empirical evidence indicating that certain factors influence the adoption decision regarding cloud services [2, 4, 6–8, 11–17].

To form a rigorous understanding of innovation, it is necessary to consider several factors of innovation simultaneously and to evaluate their relationships [10]. For example, Holland and Light identified several critical success factors from a larger list of potential factors found in relevant research [18]. The innovation factors that have the most consistently significant relationships with innovation adoption are *compatibility*, *relative advantage* and *complexity* [10]. These three factors originate from Rogers' Diffusion of Innovation (DoI) theory, which suggested that diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system" [9], whereas an innovation is "an idea, practice or object that is perceived as new by an individual or other unit of adoption" [9]. *Compatibility*, *relative advantage* and *complexity* are perceived attributes of innovations that help to explain the adoption of innovative technologies and therefore are considered to be relevant in the context of this research. In addition to the factors stated by Rogers' DoI, Moore and Benbasat considered *image* an important factor within their development of an instrument to measure the perceptions of adopting an information technology innovation. Some authors include *image* within the factor of *relative advantage* (e.g. 9). This has been criticised, as the effect of *image* is rather different from the effect of *relative advantage*. Therefore, *image* should be specified as independent factor [10, 19, 20].

To examine the adoption of complex, new and interactive technology, it is beneficial to take factors from more than one theoretical model into account in order to appropriately express the multi-faceted nature of such an adoption phenomenon [4]. For this purpose, Davis' Technology Acceptance Model (TAM) is also included in this study [21]. Davis suggested TAM to explore reasons for users to accept or reject information technology and to explain the impact

of design features of a system on user acceptance. Specifically, causal relations between external stimulus, cognitive response, affective response and behavioural response are investigated. The factors *perceived usefulness* and *perceived ease-of-use* determine the cognitive responses to system design features. However, even with the similarity of perceived usefulness to relative advantage of perceived ease-of-use to complexity [19], these factors have been included as they are of particular interest in the context of cloud computing research. Davis' TAM primarily aims at influences on the behaviour of individuals whereas this research focuses on the organizational perspective. However, Benamati and Rajkumar stated that many IT decisions, such as that of outsourcing, are made by single individuals at the executive levels of an organization [22]. Thus the application of TAM, which is designed to elicit responses of an individual, is appropriate to evaluate acceptance of certain organization-wide technology decisions. However, TAM and its modified versions are criticized for failing to address certain issues such as *security & trust* [2].

Furthermore, an examination of the adoption of innovations should focus on both the attitude towards adoption and actual usage as the dependent variables [10]. Davis' TAM also suggests distinguishing between those two variables. In a recent study on Software-as-a-Service (SaaS) adoption, based on the theory of planned behaviour [23], Benlian, Hess, and Buxmann found that the attitude toward the behaviour to adopt influences the actual SaaS adoption as well [11].

Based on these considerations, existing literature on influencing factors of technological innovations were compared and categorized into the factors *compatibility* (CPT), *relative advantage* (REL), *complexity* (CPX), *image* (IMG) and *security & trust* (SEC) which are widely accepted and verified in IS research. Stieninger et al. provide a comprehensive examination of these factors [24]. This overview includes mainly empirical surveys that analyse different factors based on well-established models and frameworks, as well as conceptual papers that aggregate these factors. All of the empirical surveys [2, 4, 7, 12–17, 25–29] focus on only some of the aforementioned factors. Therefore, there is a lack of studies that consider these factors simultaneously and evaluate their relationships.

3. Research Model

In this section, we describe the research model developed to explore the adoption of cloud computing. The model consists of the factors derived from literature and hypotheses concerning relationships between these factors and towards the constructs of *attitude towards cloud adoption* and *actual cloud usage*. Figure 1 (in next page) provides an overview of the research model. The following subsections define and briefly discuss the factors and hypotheses derived.

3.1 Attitude towards cloud adoption and actual cloud usage

Research studies on innovation characteristics should focus on both *planned adoption* and *actual implementation* as dependent variables [10]. As mentioned earlier, Davis' TAM suggests distinguishing between these two variables. Additionally, in a recent study on SaaS adoption, based on the theory of planned behaviour [23], Benlian, Hess, and Buxmann found that the attitude toward the adoption influences the actual SaaS adoption as well [11]. Therefore, we hypothesize:

H1. (+) The attitude towards cloud adoption (ATT) positively affects the actual usage of cloud computing (USG).

3.2 Compatibility

The factor of *compatibility* is derived from Rogers' DoI theory. "*Compatibility* is the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters" [9]. Tornatzky et al. define *compatibility* in a more operational way as "congruence with the existing practices of the adopters" [10]. In addition, there is a need to distinguish between technical compatibility and organizational compatibility [30]. Consequently, the proposed hypotheses are based on the assumption that increased compatibility influences the adoption intention and the actual adoption of cloud computing in a positive way [4, 10, 16, 20].

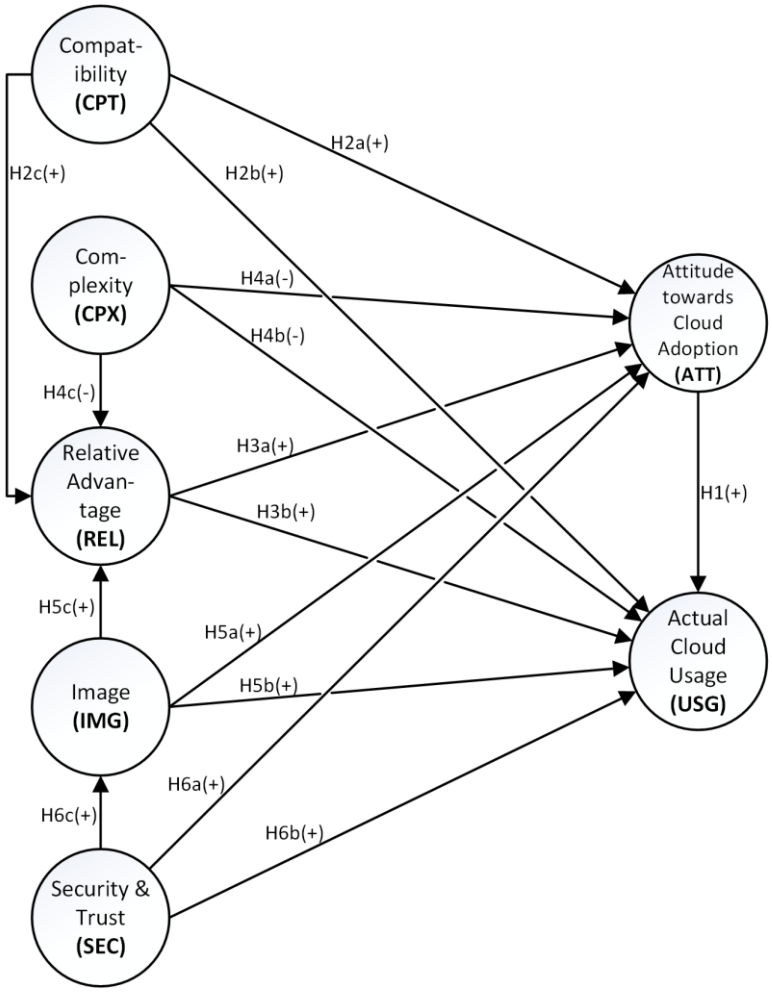

Fig. 1. Research Model

Additionally, we assume that when cloud computing is compatible with existing data structures and processes, it will be perceived to have a relative advantage [25].

H2a. (+) A higher level of compatibility (CPT) will positively affect the attitude towards cloud adoption (ATT).

H2b. (+) A higher level of compatibility (CPT) will positively affect the actual usage of cloud computing (USG).

H2c. (+) A higher level of compatibility (CPT) will positively affect the perceived relative advantage (REL).

3.3 Relative advantage

The factor of *relative advantage* also originates from Rogers' DoI theory. *Relative advantage* is defined as "the degree to which an innovation is perceived as being better than the idea it supersedes" [9]. In the context of IS, the application of this theory revealed that *relative advantage* is one of the most important factors for adoption decisions [31]. Cloud computing solutions provide several relative advantages, including load relieving of the network infrastructure,

reduction of hardware maintenance and infrastructure operation, flexibility, simple administration, collaboration opportunities, potential cost savings and increased automation [6]. Consequently, the corresponding hypotheses are:

H3a. (+) A higher level of perceived relative advantage (REL) will positively affect the attitude towards cloud adoption (ATT).

H3b. (+) A higher level of perceived relative advantage (REL) will positively affect the actual usage of cloud computing (USG).

3.4 Complexity

C*omplexity* has been extensively studied in the IS literature [25]. Rogers defines *complexity* as "the degree to which an innovation is perceived as relatively difficult to understand and use" [9]. The longer it takes to understand and to implement an innovation, the more likely it is that *complexity* turns into a barrier for adoption of a new technology. This is why complexity usually negatively affects adoption of technologies [4, 16, 30]. However, a study among small and medium enterprises (SMEs) revealed that experts do not consider cloud computing as a very complex technology to implement due to simple administration tools, high usability, as well as a high degree of automation [6]. In TAM, Davis describes *complexity* from a positive point of view and uses the term *ease-of-use*. He defines it as "the degree to which an individual believes that using a particular system would be free of physical and mental effort" [21]. Even though there are general differences between Rogers' DoI theory and Davis' TAM (i.e., Rogers focuses on the organizational and Davis on the individual perspective, concerning *complexity* and *ease-of-use*), they are both discussing the perception of individuals. Several studies suggest that individuals will see greater relative advantage in innovations that are perceived as easy to use (e.g., [7, 25, 27]). Hence, increased complexity probably inhibits the adoption of technological innovations. For that purpose, the factors are negatively correlated in the proposed hypotheses [4, 16].

H4a. (-) A higher level of complexity (CPX) will negatively affect the attitude towards cloud adoption (ATT).

H4b. (-) A higher level of complexity (CPX) will negatively affect the actual usage of cloud computing (USG).

H4c. (-) A higher level of complexity (CPX) will negatively affect the perceived relative advantage of cloud computing (REL).

3.5 Image

Moore and Benbasat define *image* as "the degree to which use of an innovation is perceived to enhance one's image or status in one's social system" [19]. Existing research suggests that *image* can be seen as the reputation of the service provider [26], the reputation of the company adopting the solution [32], and the innovativeness of the solution itself [26]. In the context of cloud computing, the factor *image* is of high importance, because attitudes towards the adopted technology might also be transferred to the company and thereby influence its image [6]. Previous studies also found that the influence of image is partially mediated by relative advantage [25]. Therefore, we hypothesize:

H5a. (+) A better image (IMG) will positively affect the attitude towards cloud adoption (ATT).

H5b. (+) A better image (IMG) will positively affect the actual usage of cloud computing (USG).

H5c. (+) A better image (IMG) will positively affect the perceived relative advantage of cloud computing (REL).

3.6 Security & trust

As a literature overview by Gefen et al. found, there is a multitude of differing approaches for the conceptualization of trust [33]. For the scope of this paper, the factor is considered as the ability of the involved actors to convey the perception of trustfulness [6]. Trust is characterized as a critical quality of service (QoS) parameter to be considered for service requests within the context of cloud computing [34]. This factor is especially crucial regarding scenarios involving public cloud [35]. Following Wu, perceived security and safety were applied as an element of trust and thus

security and trust were combined to a single factor [2]. Issues in *security & trust* are also likely to affect the image of cloud computing [32]. Accordingly, the following hypotheses are proposed:

H6a. (+) A higher level of security and trust (SEC) will positively affect the attitude towards cloud adoption (ATT).

H6b. (+) A higher level of security and trust (SEC) will positively affect the actual usage of cloud computing (USG).

H6c. (+) A higher level of security and trust (SEC) will positively affect the perceived image of cloud computing (IMG).

4. Operationalization of the research model

In this section, we describe how the factors of the previous section were operationalized and measured. Based on existing literature for each of them, a number of relevant measurement items were identified. Additionally, every item was described by a statement that has been used in the survey (see section 5.1). Table 1 shows these factors, items, statements and the literature reference it was derived from. Three popular cloud computing applications in the business context [36], namely (i) *cloud storage*, (ii) *cloud e-mail* and (iii) *cloud office* were chosen to clarify the term cloud computing itself. Example statements in Table 1 refer to *cloud storage* only. Additionally, participants were also asked to respond to questions concerning *cloud-based e-mail* and *cloud office applications.* For example, item CPT1 was surveyed using the following three statements: "Data can easily be exchanged between the existing IT services/applications and *the cloud storage",* "Data can easily be exchanged between the existing IT services/applications and *cloud office applications*", and "Existing *e-mail data* can easily be transferred to the cloud service provider".

Table 1. Operationalization of factors.

Factor / Construct	Item	Statement	Adapted from
Compatibility (CPT1)	Data exchangeability	Data can easily be exchanged between the existing IT services/applications and the cloud storage.	[16]
Compatibility (CPT2)	Process integrability	Cloud storage solutions can easily be integrated into the existing process landscape.	[16]
Compatibility (CPT3)	Vendor interoperability	Data from the cloud storage can easily be transferred between different cloud service providers.	[16]
Relative advantage (REL1)	Usefulness	The application of cloud storage services is useful for the accomplishment of tasks.	[28]
Relative advantage (REL2)	Quality	The application of cloud storage services increases the quality of the results.	[28]
Relative advantage (REL3)	Convenience	The application of cloud storage services improves the convenience of task fulfilment.	[28]
Relative advantage (REL5)	Speed	The adoption of cloud storage solutions led to increased speed of business communications.	[4]
Relative advantage (REL6)	Performance	The use of cloud storage solutions increased my job performance.	[29]
Complexity (CPX1)	Flexibility	Cloud storage solutions are more flexible than conventional solutions.	[28]
Image (IMG1)	Reputation of the cloud service provider	The willingness to transact with a certain cloud storage provider is influenced by its overall reputation.	[26]
Image (IMG2)	Reputation of the company	The adoption of cloud storage solutions influences the company's reputation.	[32]

Factor / Construct	Item	Statement	Adapted from
Image (IMG3)	Innovativeness	Cloud storage solutions are considered innovative.	[26]
Security & trust (SEC1)	Data security	The improvement of data security played a role in the decision process towards the adoption of cloud storage.	[6]
Security & trust (SEC2)	Trustfulness of the cloud service provider	The trustfulness of the cloud storage provider is a crucial factor within the adoption decision process.	[2]
Security & trust (SEC3)	Contractual agreements	Detailed contractual agreements with the cloud storage provider (e.g. SLAs) contribute to an improved perception of data security and safety.	[6]
Attitude (ATT1)	Attitude	Overall, using cloud storage on business is … (...) negative-positive	[11]
Attitude (ATT2)	Attitude	Overall, using cloud storage on business is … (...) harmful-beneficial	[11]
Attitude (ATT3)	Attitude	Overall, using cloud storage on business is … (...) unimportant-important	[11]
Usage (USG1)	Actual Usage	How often do you use cloud storage services on business?	

5. Empirical Results

This section discusses the instrument for data collection and provides a profile of the sample. Furthermore, the results of the data analysis, which was done by structural equation modelling (SEM), are presented.

5.1 Data collection and sample description

The measurement instrument was delivered online and subjects were recruited using Amazon's Mechanical Turk (www.mturk.com), an online labour market, in the light of cloud computing also referred to as Humans-as-a-Service (HaaS) [37]. While subjects are paid for their responses, sample errors (e.g., coverage error) and risks (e.g., dishonest responses) are low or moderate compared to traditional recruiting methods for laboratory, traditional web study and web studies through purpose built websites [38]. It was also reported that subjects appear to be truthful when providing self-report information because of their intrinsic motivations and the incentive structure of Mechanical Turk. Submissions can be rejected by the requesters and subjects can be screened, for example on the basis of past approval rates, or the number of tasks completed [39]. Furthermore, the efficacy of using Mechanical Turk for behavioural research has been explored in the domains of political science [40], linguistics [41], psychology [42], economics [43] and information systems [44–47]. As task seekers in online labour market may utilize cloud computing services to complete technical tasks, and as such markets include participants with a wide variety of demographic statistics, the sample used in this study exhibits traits of strong generalizability.

The survey was available for participation from April 11th to May 18th, 2014. As the survey was executed in English language, the participants were asked to indicate their level of English proficiency in order to avoid misunderstandings due to language deficiencies. Furthermore, a requirement for participation in the survey was a positive employment status to ensure that the participants were in the position to judge a statement from the organizational perspective.

At the beginning of the survey, the participants were asked to provide some demographic data such as age, sex, and nationality. Then they were asked to indicate their familiarity with certain types of cloud computing applications (e.g., cloud storage, cloud e-mail and cloud office). Depending on the answers to these questions, the participants were subsequently asked to rate a set of statements on the particular cloud computing application types with which they had indicated to be familiar with. For that purpose, a 5-point Likert scale has been applied ranging from "*I strongly agree"*

to "*I strongly disagree"* (e.g., [2, 12]). The attitude towards the particular type of cloud computing application was queried through the semantic differential approach and the use of three bipolar dimensions (negative-positive, harmful-beneficial, and unimportant-important), likewise on a 5-point Likert scale [11, 48] (cf. Table 1).

We included several mechanisms to assess the seriousness of the responses:

- The survey was only available to workers who demonstrated consistent accuracy. Specifically, the survey was only available to subjects with an approval rate of at least 97% and who previously completed at least 500 approved tasks.
- The participants were not told about the initial requirements to be included in the sample. Instead, a short survey with the possibility to take part in an extended survey was launched. The resulting sample only includes participants with a professional English proficiency level and an employment status either "employed" or "self-employed" (i.e., participants with limited English skills, as well as unemployed people, students, or pensioners were excluded).
- To prevent repeated submissions by an individual participant, the unique identifiers assigned to each user by Amazon's Mechanical Turk ("Worker ID") was verified to be unique prior to the data analysis.
- The participants were asked to reflect on the accurateness of their responses in a final question ("What describes best what you have just done?"), remarking that their answer would not have any influence on the reward. Only respondents answering with "I focused on each question and answered them to the best knowledge and belief" were included in the sample.
- Only completed surveys were included. As additional indicator of the accuracy of the task, a 10-digit code titled "response id" was displayed within the text at the last page. Respondents were required to provide this code to the Mechanical Turk system. Only responses with a valid code were included in the sample.
- The overall time needed to fill out the survey was also monitored, as response time may serve as additional indicator of the seriousness of the answers [47]. Instead of removing the fastest responses, a minimum of two minutes for answering the questions on each cloud application type was used as reference time for inclusion in the sample.

Overall, the final sample includes responses from 203 individuals, with more men (63%) than women (37%) participating. 60% of the participants were younger than 35 years. The geographical distribution shows that the majority of them were located in North America (41.87%), Asia (33.50%) and Europe (18.72%). Participation in other continents (Africa, Australia, South America) was lower (combined 5.91%). Since each participant filled out one set of questions for each cloud application type (e.g., cloud storage, cloud e-mail, cloud office) he/she had indicated to be familiar with, the dataset includes 518 complete responses (182 for cloud e-mail, 174 for cloud storage and 162 for cloud office). Regardless of how many application types they filled out due to the familiarity, each participant received 2 USD for the completion of the full survey via their Amazon Mechanical Turk account. Consequently, the sample can be considered heterogeneous. While participation in online labour markets, such as Amazon Mechanical Turk are popular in Asia, this study was able to generate a sample with a good mix in respect to sex, age and location.

5.2 Evaluation of the research model

Due to the complexity of the relationships between the factors, structural equation modelling (SEM) was used to evaluate the research model [49–51]. This statistical multivariate technique combines factor analysis and regressions. It enables the examination of relationships among measured variables and latent variables. Latent variables are abstract, complex and not directly measurable. In the context of this study, the factors of the theoretical research model are latent variables (see Figure 1).

There are two forms of structural equation modelling (SEM): variance-based structural equation modelling (PLS-SEM) and covariance-based structural equation modelling (CB-SEM). For this study, we applied PLS-SEM (Partial Least Squares Structural Equation Modelling) as (i) it has no requirements as to the normality of the latent values in the

population, (ii) it is used in exploratory research for predictive applications, and (iii) it is designed to explain variance in dependent variables [50, 51].

During the analysis, five indicators (CPX1, CPX3, REL4, SEC4 and USG2) were eliminated as they did not meet the required criteria. Thus, henceforth, the eliminated indicators are no longer mentioned within this paper. As all items are manifestations of the latent variables, the investigated model is considered reflective.

To evaluate the model using PLS-SEM a two-step approach was conducted, consisting of (i) the evaluation of the measurement model followed by (ii) the evaluation of the structural model [50].

5.3 Measurement model evaluation

Evaluating the measurement model involved four steps including an examination of (i) t-values of item loadings, (ii) internal consistency reliability, (iii) convergent validity, and (iv) discriminant validity.

T-values of item loadings. The bootstrap draws a large number of sub-samples from the original data with replacements to approximate the sampling distribution and derive the standard error and standard deviation of the estimated coefficients to calculate their t-values. For the tested model, all items can be considered reliable and valid, as the t-values of the loadings of each of them are greater than 25.

Internal consistency reliability. The internal consistency reliability is checked by examining Cronbach's alpha and composite reliability (CR). As a general rule for exploratory research, Cronbach's alpha should be greater than 0.65 and CR should be greater than 0.70. Table 2 shows that these conditions are met. Cronbach's Alpha of the factor *image* is just slightly above 0.65, but all other factors show high values. Note that we had to eliminate items because of reliability issues and therefore we ended up with a single item measurement for complexity and usage. Composite reliability values are also high for all factors. Consequently, the internal consistency reliability can be considered to be high.

Table 2: Internal Consistency Reliability measures and Convergent Validity measure AVE

	Cronbach's alpha	**Composite reliability (CR)**	**Average variance extracted (AVE)**
Attitude towards cloud adoption (ATT)	0.836	0.901	0.753
Compatibility (CPT)	0.738	0.850	0.654
Complexity (CPX)	1.000	1.000	1.000
Image (IMG)	0.677	0.823	0.608
Relative Advantage (REL)	0.852	0.894	0.629
Security and trust (SEC)	0.777	0.870	0.691
Usage (USG)	1.000	1.000	1.000

Convergent Validity. The convergent validity check is done by measuring the magnitude of outer loadings and the average variance extracted (AVE). They measure whether the items share a large proportion of variance. The magnitude of outer loadings measures the reliability of indicators. The bold values in Table 3 represent these loadings, which are all above 0.70 and therefore support indicator reliability. Average variance extracted (AVE) is a measure that describes how much the variation in the items is explained by the latent variable. Table 2 shows that AVE of all items is above 0.50. Therefore, latent variables explain a high part of the variance of their items. Since both measures are above the recommended limits, the convergent validity can be considered to be high.

Discriminant validity. The discriminant validity describes whether each latent variable is distinctly different from the others. This can be measured using (i) the item cross-loadings and (ii) the Fornell-Larcker criterion.

The item cross-loadings are used to examine if each indicator (or item) loads highest on the latent variable to which it is assigned. Table 3 shows that all items only load very strongly (>0.75) on its own latent variable and loadings on other variables are much smaller. Therefore, the discriminant validity is confirmed.

Table 3: Item loadings

	ATT	**CPT**	**CPX**	**IMG**	**REL**	**SEC**	**USG**
CPT1	0.364	**0.816**	0.317	0.379	0.410	0.321	0.080
CPT2	0.430	**0.856**	0.377	0.435	0.522	0.339	0.209
CPT3	0.334	**0.750**	0.315	0.372	0.364	0.252	0.059
CPX2	0.466	0.418	**1.000**	0.525	0.549	0.380	0.127
IMG1	0.342	0.382	0.409	**0.753**	0.458	0.456	0.111
IMG2	0.413	0.409	0.386	**0.778**	0.436	0.439	0.107
IMG3	0.391	0.360	0.432	**0.807**	0.525	0.424	0.027
REL1	0.486	0.465	0.411	0.510	**0.776**	0.324	0.125
REL2	0.547	0.444	0.493	0.471	**0.821**	0.329	0.208
REL3	0.493	0.461	0.423	0.466	**0.834**	0.320	0.160
REL5	0.493	0.381	0.415	0.487	**0.747**	0.374	0.169
REL6	0.499	0.400	0.428	0.477	**0.784**	0.303	0.148
SEC1	0.325	0.315	0.314	0.466	0.366	**0.864**	0.107
SEC2	0.392	0.350	0.392	0.528	0.429	**0.860**	0.126
SEC3	0.323	0.274	0.222	0.398	0.218	**0.766**	0.060
ATT1	**0.876**	0.403	0.441	0.413	0.532	0.315	0.166
ATT2	**0.835**	0.367	0.332	0.441	0.539	0.386	0.157
ATT3	**0.891**	0.448	0.438	0.424	0.582	0.389	0.243
USG1	0.220	0.155	0.127	0.104	0.205	0.120	**1.000**

The Fornell-Larcker criterion is a more conservative measure of discriminant validity. It compares the square root (SQRT) of AVE with latent variable correlations. When the square root of the AVEs is greater, this indicates that the particular variable shares a greater variance with its indicators than with the other variables. Consequently, the square

root (SQRT) of each AVE should be greater than the correlation with any other variable. Table 4 shows this is the case for all factors (SQRTs of AVEs are bold).

Table 4: Latent variable correlations and SQRT-AVE

	ATT	**CPT**	**CPX**	**IMG**	**REL**	**SEC**	**USG**
ATT	**0.868**						
CPT	0.470	**0.809**					
CPX	0.466	0.418	**1.000**				
IMG	0.490	0.491	0.525	**0.780**			
REL	0.636	0.543	0.549	0.608	**0.793**		
SEC	0.420	0.379	0.380	0.563	0.416	**0.831**	
USG	0.220	0.155	0.127	0.104	0.205	0.120	**1.000**

Since all these measures are above the recommended values, the measurement model evaluation can be considered satisfactory. We therefore proceed to evaluate the relationships in the structural model in the next section.

5.4 Structural model evaluation

The evaluation of the structural model reveals the relationships between its latent variables. For that purpose, (i) the path t-values, (ii) the path coefficients between latent variables, (iii) amount of variance in the dependent variables, and (iv) the effect sizes were evaluated.

Path t-values. First, the hypotheses have to be tested. This is done by evaluating the path t-values which are provided by the bootstrap routine. These values indicate the significance levels of each path and thereby the strength of support for the proposed hypotheses [50]. Table 5 provides an overview of the proposed hypotheses, the corresponding t-values and levels of significance and reveals that not all hypotheses are supported. The path t-values show significant support for the hypotheses H1, H2a, H2c, H3a, H4a, H4c, H5c, H6a and H6c. The remaining hypotheses (H2b, H3b, H4b, H5a, H5b and H6b) do not show any significant support.

Table 5: Hypotheses testing results

Hypothesis	**t-value**	**p**	**support**
H1. (+) The attitude towards cloud adoption (ATT) positively affects the actual usage (USG) of cloud computing.	2.503	<0.05	weak
H2a. (+) A higher level of compatibility (CPT) will positively affect the attitude towards cloud adoption (ATT).	2.840	<0.01	medium
H2b. (+) A higher level of compatibility (CPT) will positively affect the actual usage of cloud computing (USG).	0.805	ns	rejection
H2c. (+) A higher level of compatibility (CPT) will positively affect the perceived relative advantage (REL).	5.894	<0.001	strong
H3a. (+) A higher level of perceived relative advantage (REL) will positively affect the attitude towards cloud	9.465	<0.001	strong

Hypothesis	t-value	p	support
adoption (ATT).			
H3b. (+) A higher level of perceived relative advantage (REL) will positively affect the actual usage of cloud computing (USG).	1.891	ns	rejection
H4a. (-) A higher level of complexity (CPX) will negatively affect the attitude towards cloud adoption (ATT).	2.364	<0.05	weak
H4b. (-) A higher level of complexity (CPX) will negatively affect the actual usage of cloud computing (USG).	0.080	ns	rejection
H4c. (-) A higher level of complexity (CPX) will negatively affect the perceived relative advantage of cloud computing (REL).	5.635	<0.001	strong
H5a. (+) A better image (IMG) will positively affect the attitude towards cloud adoption (ATT).	0.719	ns	rejection
H5b. (+) A better image (IMG) will positively affect the actual usage of cloud computing (USG).	1.447	ns	rejection
H5c. (+) A better image (IMG) will positively affect the perceived relative advantage of cloud computing (REL).	6.851	<0.001	strong
H6a. (+) A higher level of security and trust (SEC) will positively affect the attitude towards cloud adoption (ATT).	3.260	<0.001	strong
H6b. (+) A higher level of security and trust (SEC) will positively affect the actual usage of cloud computing (USG).	0.748	ns	rejection
H6c. (+) A higher level of security and trust (SEC) will positively affect the perceived image of cloud computing (IMG).	16.730	<0.001	strong

Figure 2 (next page) illustrates the results of the analysis with the asterisks next to the t-values indicating the level of significance of hypothesis support. Not supported hypotheses ("ns") are shown greyed out. For the four variables *attitude towards cloud adoption* (ATT), *actual usage of cloud computing* (USG), *perceived relative advantage* (REL), and *perceived image* (IMG) the values for the corresponding R^2 can be found in the respective circles.

Path coefficients. The next step of the evaluation of the structural model focuses on the path coefficients that reveal the direct and total effects as well as the relationship (positive or negative) between latent variables. Running the PLS algorithm provides the values shown in Table 6.

Table 6: Direct and total effects

	ATT	CPT	CPX	IMG	REL	SEC	USG
ATT	/ 1.000						0.144 / 0.144
CPT	0.121 / 0.237	/ 1.000			0.268 / 0.268		0.047 / 0.115
CPX	0.109 / 0.221		/ 1.000		0.258 / 0.258		0.004 / 0.068
IMG	0.035 / 0.183			/ 1.000	0.341 / 0.341		-0.090 / -0.021
REL	0.434 / 0.434				/ 1.000		0.123 / 0.168

	ATT	CPT	CPX	IMG	REL	SEC	USG
SEC	0.132 / 0.235			0.563 / 0.563	/ 0.192	/ 1.000	0.040 / 0.047
USG							/ 1.000

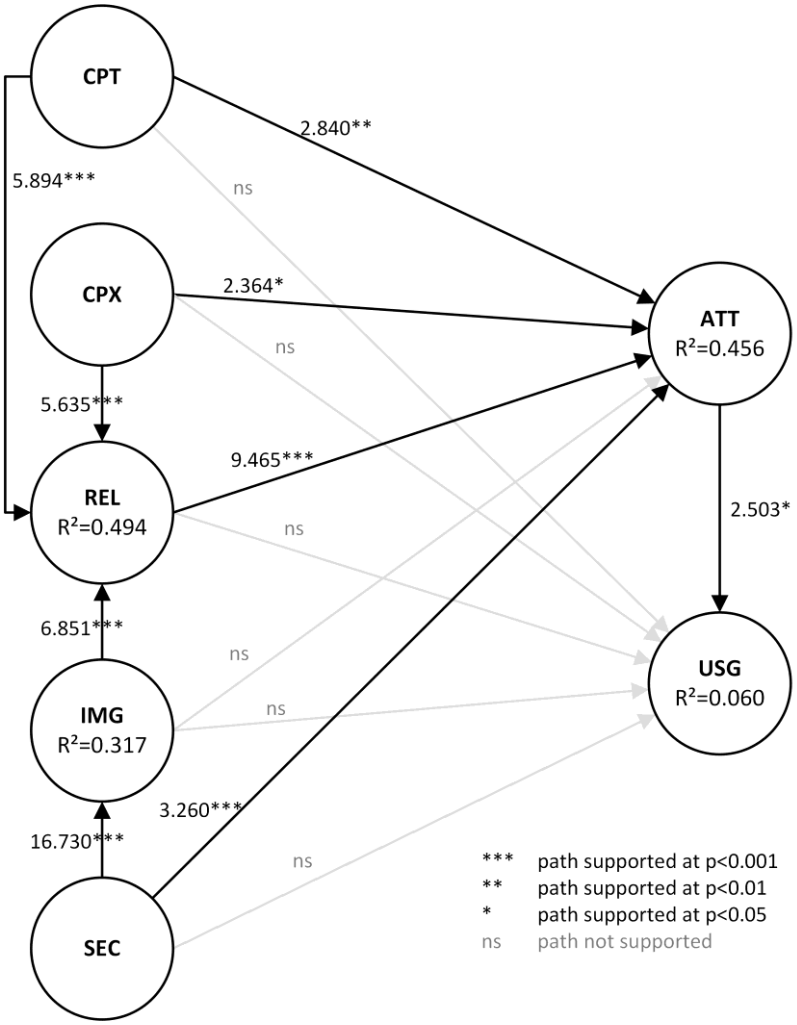

Figure 1. Analysis results

The factors of *attitude towards cloud adoption* (0.144), *compatibility* (0.115) and *relative advantage* (0.168) have the greatest total effect on *actual cloud usage*. All other factors have a quite weak effect. The *attitude towards cloud adoption* is mainly affected by *relative advantage* (0.434) which is further affected by multiple other influencing factors (*compatibility*, *complexity*, *image*, security *& trust*), all showing considerable effects (0.192-0.341). Additionally, it is worth mentioning, that the effect of *security & trust* on *image* is rather high (0.563) which agrees with the results of prior investigations indicating significant correlations between these two factors [6].

Amount of variance in the dependent variables. The coefficient of determination, or R Square (R^2), is a measure of the model's predictive ability. It represents the combined effects of the independent variables on a dependent variable by the amount of variance in the dependent variable that is explained by all the independent variables connected to it. It ranges from 0 to 1 [50]. Figure 2 presents the R^2 values in the circle of the factors. The analysis shows that R^2 of *attitude towards cloud adoption* has a value of 0.456, which means 45.6% of the variance of this dependent variable is explained by the independent variables *compatibility*, *complexity*, *relative advantage*, *image* and *security & trust*. This is a high value that indicates that the above-named factors influence a large proportion of the users' attitude towards cloud adoption. Conversely, R^2 of the factor *actual cloud usage* has a value of 0.06, which is very low. This implies that only 6% of the variance is explained by all the other variables of the model. Therefore, actual cloud usage is mainly influenced by factors that are not included in the theoretical research model. This is already indicated by Table 5 and Figure 2, which illustrate that the path t-values of four factors show no significant support on *actual cloud usage*. Furthermore, the R^2 values of *relative advantage* and *image* are also high. *Security & trust* accounts for 31.7% of the variance of *image.* 49.4% of the variance in *relative advantage* is explained by *compatibility*, *complexity*, *image, and security & trust*. Consequently, the predictive ability of the model regarding these factors is satisfying.

Effect Sizes. Cohen's f^2 is a quantitative measure of the strength of a phenomenon that assess how much every independent variable affects a particular dependent variable's R^2. According to [52], for multiple regressions these effects can be considered weak (0.02 - 0.15), moderate (0.15 - 0.35) or high (>0.35). Table 7 shows that *relative advantage* is moderately affected by *capability*, *complexity* and *image*. Furthermore, *image* has a strong effect on *security & trust*. *Attitude towards cloud adoption* is moderately affected by *relative advantage* and weakly influenced by *security*. Effects on *actual cloud usage* are all below the limit of 0.02.

Table 7: Effect sizes (f^2)

	ATT	**CPT**	**CPX**	**IMG**	**REL**	**SEC**	**USG**
ATT							0.012
CPT	0.018				0.103		0.002
CPX	0.014				0.091		0.000
IMG	0.001				0.146		0.004
REL	0.175						0.007
SEC	0.021			0.465			0.001
USG							

6. Conclusions and future work

In this paper, relevant factors influencing the intention to adopt and the actual usage of cloud services were discussed. The focus was on public cloud services in the organizational context. Based on widely accepted theories such as Rogers' DoI theory [9], Davis' TAM [21], and its various extensions, the paper identifies factors that impact the adoption and usage of cloud computing, integrates them in a theoretical research model, and operationalizes the factors. The research model is tested in an empirical online survey using Amazon Mechanical Turk for the acquisition of participants. In doing so, a sample with a fairly good mix in respect to sex, age and location was generated.

The analysis of the structural equation model followed a two-step approach. In a first step, the measurement model was evaluated. Since Internal Consistency Reliability (using Cronbach's Alpha and Composite Reliability), Convergent Validity (using magnitude of outer loadings and Average Variance Extracted) as well as Discriminant Validity (using

item cross-loadings and Fornell-Larcker criterion) could be confirmed, the measurement model evaluation was considered satisfactory. Consequently, the structural model evaluation revealed that the *attitude towards cloud adoption* (ATT) positively affects the *actual usage of cloud computing* (USG). All other hypotheses regarding the direct influence of certain factors on the *actual usage of cloud services* were rejected. However, the effect of the *attitude towards cloud adoption* (ATT) on the *actual cloud usage* (USG) is also low. Therefore, there are other factors, which were not considered in our model, that affect the *actual cloud usage.* A better image (IMG) seems to neither positively affect the *attitude towards cloud adoption* (ATT) nor the *actual cloud usage* (USG). All other factors influence the *attitude towards cloud adoption* (ATT). A higher level of *compatibility* (CPT), *relative advantage* (REL) and *security & trust* (SEC) as well as a lower level of *complexity* (CPX) lead to a more positive *attitude towards cloud adoption* (ATT).

Limitations of this study include the data collection and sample composition using Mechanical Turk. In an experiment, using data collected from a large Midwestern U.S. university, an Internet board and Mechanical Turk, Paolacci and Chandler found that the response error was significantly lower in Mechanical Turk than in the Internet board [38]. Although it was noted to be more diverse than usual college samples, respondents using Internet technology are not a representative sample either [39], leading to the suggestions that research should be transparent in the recruiting and excluding of participants. As stated, this study included several mechanisms to assess the validity of the results based on several technical possibilities in combination with a self-assessment of the cloud workers. While efforts were undertaken to ensure that subjects had experience using cloud computing, their degree of knowledge concerning cloud computing may be quite varied. In addition, due to the diverse applications of cloud computing, the application types cloud storage, cloud e-mail, and cloud office were queried separately. While these are commonly used, individuals may actively use other cloud computing applications not included, such as cloud based customer relationship management or enterprise resource planning systems. However, inquiring each item for up to three cloud computing application types, entailed a multiplication of questions to be answered by the participants. For that reason, the number of items was kept low to avoid loss of data quality due to participants increasing frustration through a cavalcade of questions. This again led to ending up with only one item left for complexity (CPX) and actual usage of cloud computing (USG) after the evaluation of the research model. Concerning this matter, other possible approaches could be either to focus on fewer factors, or to ask questions on cloud services in general and not on multiple specific cloud application types.

Furthermore, the results show that the model's predictive ability on *actual cloud usage* (USG) is low. Consequently, there seem to be other factors that influence USG. While many factors that explain the motivations and barriers toward broad organizational adoption of cloud computing services are explored in this research, some additional factors may have inadvertently been omitted. This may be due to the scope of the reviewed studies, as some focus on cloud computing in a general context while others focus on very specific cloud services. In future research we intend to identify additional factors and conduct further empirical studies.

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Abstract:
This study investigates how managerial decision-making is influenced by Big Data analytics, analysts' interaction skills and quantitative skills of senior and middle managers. The results of a cross-sectional survey of senior IT managers reveal that Big Data analytics (BDA) creates an incentive for managers to base more of their decisions on analytic insights. However, we also find that interaction skills of analysts and – even more so – managers' quantitative skills are stronger drivers of analytics-based decision-making. Finally, our analysis reveals that, contrary to mainstream perceptions, managers in smaller organizations are more capable in terms of quantitative skills, and they are significantly more likely to base their decisions on analytics than managers in large organizations. Considering the important role of managers' quantitative skills in leveraging analytic decision support, our findings suggest that smaller firms may owe some of their analytic advantages to the fact that they have managers who are closer to their analysts – and analytics more generally.

Keywords:
Big Data analytics; decision-making; quantitative skills; interaction skills; firm size.

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1. Introduction

During the past few years, the terms *Big Data* (BD) and *Big Data Analytics* (BDA) have become increasingly important for both academics and business professionals in IT-related fields and other disciplines [1]. Furthermore, executives increasingly acknowledge the potential benefits associated with BD [2] and global private and public investment in BD has reached billions of dollars per annum [3],[4]. BD has become a popular term which essentially represents the fact that data generated and available today is *big* in terms of volume, variety, and velocity [4],[5].

But being *big* does not per se make data *useful*. It is rather the insights gained from analyzing the data which provide benefits [5], which in turn requires organizations to develop or acquire new quantitative skills [6]. The claimed power of BDA does not replace the need for human insight [7]. Equipped with BDA experts, who can provide such insights from data, managers are expected to make better (informed) decisions [6],[8],[9] – provided they actually use those insights to guide their decision-making.

Some high-performing organizations use BDA as critical differentiator and driver of growth [1],[11],[12], but often executives still struggle to understand and implement BD strategies effectively [10]. Furthermore, it is unclear to what extent managers actually use any available BDA output to support their decisions. Some even argue that the biggest challenge in BDA is that managers do not comprehend how to gain benefits from analytics [11], and even managers themselves are concerned about their ability to uncover and take advantage of meaningful insights [11]. Accordingly, the first research question in this paper is: *Are managers in organizations with sophisticated BDA more likely to base their decisions on analytics (facts, evidence) than managers in organizations low on BDA?*

Being able to provide sophisticated BDA is, however, not the only skill data analysts require. They also have to be able to effectively relate to, cooperate with and communicate with internal and sometimes external parties. Such professional interaction skills are often associated with being able to effectively liaise with stakeholders and sponsors, understand the needs of internal customers, effectively collaborate and contribute to team results, successfully negotiate and resolve conflicts, and effectively communicate problems and solutions [12]. Accordingly, our second research question inquires *to what extent interaction skill levels of analysts/analytic experts influence the level of reliance on analytics in managerial decision-making.*

Considering that some managers have particular difficulties understanding analytics in the BD era [10], our third research question addresses the role of managerial capabilities in the context of BDA and decision-making. Managerial quantitative skills (MQS) refer to the collection of experience, skills, and know-how of managers with regards to quantitative methods [13]. *But do variations in managers' quantitative skills actually influence the extent to which they rely on analytics in their decision-making?*

To answer these research questions, we collected survey responses from 163 senior finance managers across a broad range of industries in Australia. The results suggest that managerial quantitative skills are the strongest driver of analytics-based decision-making, but both BDA sophistication and interaction skills of analysts also have a significant effect. Our test results also reveal an unexpected negative effect of the control variable firm size on analytics-based decision-making.

The remainder of the paper is organized as follows: Section two elaborates on the constructs of interest and makes predictions about their relationships (hypotheses); section three explains the research methods, including construct measurement, and section four presents the results. Finally, the implications and the limitations of our research are discussed in section five.

2. Theory/Hypotheses development

Big Data (BD) refers to a set of techniques and technologies that require new forms of integration in order to uncover hidden value from large datasets that are diverse, complex, and of a very large scale. Today, data are generated, changed and removed more frequently than in the past, and increasingly analogue data are converted into digital form [14]. Consequently organizations need new platforms and tools for analyzing data. "Analytics is the science of analysis" [15, p. 86]. Data analytics uses data for quantitative and/or qualitative analysis to help organizations to better understand their business and markets (knowledge discovery) and to support timely business decisions [5],[20],[24],[16]]. Data analytics in a BD environment is different from conventional data analytics, because many of the analytic algorithms used on BD had to be adapted or newly developed in response to the high volume, variety, and velocity of data [7].

Big Data Analytics (BDA) applies scientific *methods* to solve problems previously thought impossible to solve, because either the data or the analytic *tools* did not exist [17]. BDA can help organizations to create actionable strategies by providing constructive, predictive and real-time analytics, and to gain deeper insights in how to address their business requirements and formulate their plans [18]. With new technologies and analytic approaches, BDA can provide managers with information for real-time planning and continuous forecasting [7],[18],[19]. BDA techniques are capable of analyzing larger amounts of increasingly diverse data. With algorithms advancing BDA can help improve decision efficiency and effectiveness [20]. In summary, BDA can have a significant impact on decision-making processes, provided managers perceive analytic output as useful and use it to support their decisions [28]-[30].

Research findings are still inconsistent in terms of what managers base their decisions on. Even when managers claim to use a rational approach in their decision-making process, they still also use soft problem structuring methods [21] and heuristics (including intuition) to cope with bounded rationality at some stages in this process [22]. However, when analytic results are insightful and timely, and when they contradict intuition, managers are said to set aside their intuition and rely on data [7]. We therefore predict as follows:

H1: Big Data analytics sophistication leads to more *analytics-based* decision-making.

Sophisticated analytic methods and tools are, however, not always enough to convince managers of the *usefulness* of analytics. Analysts also need to be able to properly communicate solutions or insights to their stakeholders – both verbally and visually [23]. In addition, they require relationship skills to facilitate an interaction and ongoing communication with decision makers [24] and to enable a shift from ad hoc analysis to an ongoing managerial conversation with data. As analysts make discoveries, they have to be able to communicate what they have learnt and suggest implications for new business directions [23]. In the context of business analytics, such "interaction skills are represented by the business analyst's ability to relate, cooperate, and communicate with different kinds of people including executives, sponsors, colleagues, team members, developers, vendors, learning and development professionals, end users, customers, and subject matter experts" [12, p. 207]. It is argued that analysts' interaction skills (AIS) can improve managers' perceptions of the usefulness of analytic output, and therefore have a significant impact on managerial decision-making processes.

H2: Better interaction skills of analysts lead to more *analytics-based* decision-making.

Quantitative skills refer to the ability of generating, transforming and interpreting numerical data by applying mathematical and/or statistical rules, thinking and reasoning [25]. Quantitative skill requirements vary depending on the roles and responsibilities of individuals, as well as the scope and sophistication of the organizational operations and data [26]. Analytic professionals are expected to have advanced quantitative skills, but whether such capabilities are required at the managerial level is questionable – even more so as newer Artificial Intelligence (AI) methods are capable of making decisions without human involvement.

On the other hand, research shows that organizations still need managers with sound quantitative skills [27]. Managers are required to identify and define business problems, ideally with having quantitative solution methods in mind.

Decision makers are also required to use their judgment and focus on what they perceive to be potentially important so as to enable the selection of the right subsets of the available data [10],[28]. Managers also need quantitative skills in order to properly evaluate analytic outputs (of new analytical methods) [27] and to correctly deploy resulting actions in their organizations [27].

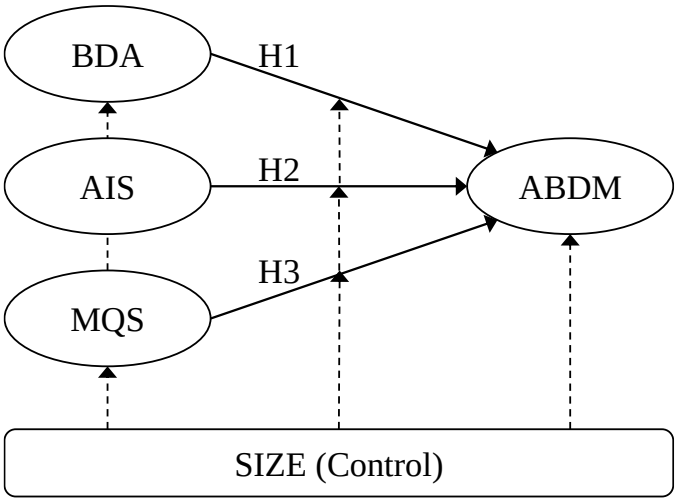

Figure 1: Research Model

When competing with analytics, quantitative skills are also required at the strategic decision-making level [29],[30], and previous studies suggest that there is indeed a positive association between managers' quantitative skills and the quality of their decisions [31],[32]. In fact, engineers often become successful CEOs, because they are detail-oriented and possess strong quantitative and problem-solving skills [33].

As far as the use of analytic 'output' in managerial decision-making is concerned, we expect that managers with stronger quantitative skills perceive such output as more useful, because they better understand the methods used to generate it. Accordingly, they will be more likely to base their decisions on analytics.

H3: Managers' quantitative skills have a positive effect on *analytics-based* decision-making.

In our research model (Figure 1), we control for firm size, because larger firms are considered to (a) have more financial resources available for investment into BDA (both analytic human capital and analytic tools); (b) be in a better market position for hiring managers with strong quantitative skills (MQS); and (c) have more formalized procedures for decision-making and therefore rely more extensively on analytical decision support [34]. As such effects may also interact with the relationships predicted in H1-H3, we also test for moderation effects of firm size.

3. Research method

To acknowledge the exploratory nature of this research, a cross-sectional survey was considered to be the most suitable research method [35]. The survey targeted CIOs and senior IT managers of Australian-based medium to large for-profit organizations. The survey procedures were guided by Dillman et al. [36]. As each variable in the hypotheses is latent, constructing proper indicators and scales was essential. This process was informed by previous academic studies, but where required, practitioner literature was also consulted. During questionnaire design, necessary procedural remedies were applied to control for and minimize the impact of common method biases [37]. The face and content validity of

the prototype of the questionnaire as well as the appropriateness of Likert scale endpoints were assessed as follows [37]: Five experts in survey research were invited to evaluate the draft questionnaire, and their feedback was used to refine the design and content of the survey. The revised version of the questionnaire was then delivered to a group of industry experts and academics for final pilot testing.

3.1 Construct Measurement

In the absence of any (known) measurement scale for *analytic sophistication* in the context of BD, we had to develop our own scales. As a starting point, we operationalized BDA along three dimensions [38]: (a) analytic methods, (b) analytic tools and (c) quantitative skills of analysts. Analytic *methods* include a vast range of statistical methods, machine learning/data mining/artificial intelligence, operations research techniques (e.g. optimization models), and decision analysis [39]. Analytic *tools* refer to software applications that analytic professionals use in data analytics. They range from basic spreadsheet models to business intelligence (BI) tools, large-scale statistical packages, data mining suites, data visualization tools, high performance computing tools and combinations of the former. During pilot testing, respondents were asked to rate their analytics expert or expert team in terms of quantitative skills and in terms of frequency of use of various analytic tools and methods, as derived from industry surveys [40],[41] and professional guidelines [12] (Table 1). The analysis of the pilot test data revealed that *skills* and *methods* cross-loaded on each other and that the skill-construct did not meet the required measurement quality criteria. The latter was therefore dropped from the survey, and only the first order constructs *methods* and *tools* were used to generate *BDA sophistication* as a second order formative construct BDA (following the recommendations of Wetzels et al. [42]).

Table 1 - Descriptive statistics and validity and reliability measures (first order constructs)

	Mean (Range)	**Std. Dev.**	**Composite Reliability**	**Cronbach's Alpha**	**AVE**
Analytic Tools	1 - 7		.860***	.807***	.508***
Spreadsheets[#]	6.55	0.795			
BI Planning/Reporting Suites	4.88	2.056			
Data ETL/Management Solutions	4.32	2.246			
Statistical Suites – Basic Use	2.73	1.966			
Statistical Suites – Advanced Use	2.42	1.866			
Specialized Data Mining Suites	2.02	1.593			
Data Visualization Tools	3.53	2.215			
BD/High Performance Computing Tools[#]	2.13	1.709			
Analytic Methods	1 - 7		.911***	.855***	.774***
Statistical Methods	3.44	2.114			
Machine Learning, Data Mining, AI	2.45	1.846			
OR, Optimization Methods	2.53	1.789			
Path Modelling[#]	1.76	1.285			
Analytics-based Decision-Making	1 - 7		.936***	.918***	.710***
Decisions about Products/Services/Markets	4.73	1.667			
Decisions about Strategic/Key Suppliers	4.46	1.508			
Decisions about Outsourcing/BPM	4.32	1.570			
Decisions about Sales and Marketing	4.80	1.576			
Decisions about Operations	5.02	1.486			
Decisions about Procurement	4.52	1.446			
Overall, Organization Acts on Insights[#]	4.78	1.445			
Analyst Interaction Skills	1 - 7		.923***	.889***	.749***
Understanding the needs of (internal) customers/clients	5.22	1.237			

	Mean (Range)	Std. Dev.	Composite Reliability	Cronbach's Alpha	AVE
Collaborating & contributing to team results	5.20	1.319			
Liaising with stakeholders & sponsors	5.11	1.252			
Effectively communicating problems and solutions	4.96	1.244			
Managers' Quantitative Skills	1 - 7		.920***	.900***	.594***
Strong analytical skills (senior managers)	4.52	1.619			
Strong numerical skills (senior managers)	5.47	1.353			
Subst. experience with quantitative methods (senior mgr.)	3.66	1.599			
Competent in statistics (senior managers)	3.74	1.574			
Strong analytical skills (middle managers)	4.42	1.494			
Strong numerical skills (middle managers)	5.31	1.420			
Subst. experience with quantitative methods (middle mgr.)	3.50	1.668			
Competent in statistics (middle managers)	3.66	1.608			

1-tailed: p <.05; p <.01**; p <.001***; # Indicator omitted from final analysis*

Interaction skills refer to the ability of the analyst to relate, cooperate and communicate with internal and external parties. Successful interaction requires liaising with stakeholders and sponsors, understanding the needs of internal customers, collaborating and contributing to team results, negotiating and conflict resolution[1], and effectively communicating problems and solutions [12]. In our study, respondents were asked to rate their analytics expert/team in those areas on a seven point Likert scale (1 = very poor and 7 = excellent).

Experience and competence in analytic methods are typically associated with the quality of decisions [31]. Quantitative skills assist managers at all levels with identifying problems, interpret scenarios and solutions and monitor/assess the impact of decisions. Considering the seniority of the survey respondents, we did however only ask for an assessment of the analytic competencies of other (non-IT) senior and middle managers. Quantitative skills encompass general numeracy skills (mathematics) and proficiency in statistical concepts and methods and other quantitative methods (such as Operations Research methods). Respondents were asked to rate the level of quantitative skills of their senior and middle managers in those areas on a seven point Likert scale (1 = strongly disagree and 7 = strongly agree). We also included two reverse coded questions to assess – and confirm – the quality of the responses.

When deciding about the measurement scale for *analytics-based decision-making*, the following constraints had to be considered: (a) the level of seniority of the respondents, and (b) the cross-sectional nature of the survey. To acknowledge the former, the questions were kept broad, representing the tactical and strategic levels of decision-making [43]. To comply with the latter constraint, the questions had to be applicable to all industries in the target sample. Respondents were asked to rate for each decision area to what extent their organization relies on insights derived from data analysis/analytics (Likert scale: 1 = strongly disagree and 7 = strongly agree) (Table 1).

Firm size was measured using a scale based on the number of full-time equivalent (FTE) employees distinguishing small (50-100 FTE employees), medium (101-500) and large business units (501+). Organizations with less than 50 FTE employees were excluded, because overall they were not expected to have dedicated BD-Analysts.

[1] 'Negotiating and conflict resolution' loaded poorly on the analyst interaction skills construct and was therefore eliminated.

3.2 Survey response

The initial survey invitation was emailed to 1,595 potential respondents, but 263 invitations did not reach the addressees (bounce-backs). A total of 174 responses were received during the survey period, but 11 had to be excluded, because they did not meet the selection criteria (e.g. a minimum tenure of one year in that organization, or a minimum response time of five minutes). The final response rate of 12.24% may appear low, but is not unusual in Australian business surveys, even more so as BD is still an emerging topic for many. 84% (43%) of the responses came from organizations with more than 100 (500) FTE employees, and CIOs (52.1%) and other senior IT managers (47.9%) were almost equally represented.

3.3 Data characteristics and quality

In order to determine appropriate analysis and testing techniques (parametric vs. non-parametric) [44], test for normality were conducted for both indicator data and latent constructs. Both the *Shapiro-Wilk* test and the *Kolmogorov-Smirnov* test revealed that none of the indicators is normally distributed ($p < .05$). Accordingly, we used non-parametric data analysis and testing techniques (PLS-SEM and bootstrapping) [45].

In addition to the procedural remedies applied during the development of the questionnaire, post-hoc statistical remedies were used to test for potential method bias [37]. *Harman's* single factor test was run across the set of 31 measurement indicators yielding seven factors with Eigenvalues exceeding 1, therefore indicating that common method bias is not present.

Responses were also tested for non-response bias by comparing early and late responses. The results of independent samples test (*Levene*'s Test for Equality of Variances and t-Test for Equality of Means) confirm that there are no significant differences in the indicator values between the early (n = 83) and late (n = 80) response group.

After the elimination of four low-loading indicators, all remaining items have significance levels of $p < .001$ and load primarily on their assigned construct. The measurement model was further assessed for reliability and validity of the construct measures. Reflective measurement models are assessed for: (a) internal consistency (composite reliability), (b) indicator reliability (composite reliability), (c) convergent validity (average variance extracted and communality), and (d) discriminant validity [35],[45]-[47]. Table 1 confirms that the first three of those criteria are fully met. The *Fornell-Larcker* criterion [48] was applied to assess for discriminant validity of latent constructs, and all of them meet the criterion (Table 2).

Table 2 - Fornell-Larcker criterion for discriminant validity

	Tools	Methods	ABDM	IA Skills	MQS
Tools	**.713**				
Methods	.600	**.880**			
ABDM	.367	.387	**.842**		
Analyst Interaction Skills	.370	.256	.445	**.866**	
Managers' Quantitative Skills	.364	.484	.584	.460	**.771**

Values in the diagonal are the square-roots of the AVE of each of the constructs.

The heterotrait-monotrait (HTMT) ratio between the average of the heterotrait-heteromethod correlations and the average of the monotrait-heteromethod correlations [47] is used to further ensure discriminant validity. A HTMT value of two latent constructs of less than .85 confirms discriminant validity between the pair. Table 3 reveals that all HTMT scores are clearly below the benchmark confirming discriminant validity of our model.

Table 3 - HTMT values for discriminant validity (first order constructs)

	Tools	Methods	ABDM	IA Skills
Methods	.718			
ABDM	.408	.427		
Analyst Interaction Skills	.423	.280	.474	
Managers' Quantitative Skills	.411	.543	.630	.505

4. Results

The structural model shown in Figure 1 was used to test all hypotheses, while controlling for direct and moderating SIZE effects. The results of the PLS analysis and bootstrapping are presented in Table 1, both for direct (model 1) and moderating (model 2) effects. The bootstrapped significance levels were identical for the t-statistic, the confidence interval and bias-corrected confidence interval methods [35]. The analysis was performed with SmartPLS Version 3.00 M3. To report the measurement quality and structural model results (see Table 4) we use the guidelines provided by Chin [49] and Ringle et al. [50]. The significance of each effect was determined using bootstrapping with 2,000 samples. For the moderating effects the two-stage procedure with standardized product terms was used [35].

Table 4. Structural model results

	Model 1	f square	Model 2a	Model 2b	Model 2c
BDA → ABDM (H1)	**.158***	**.03**	**.150***	**.149***	**.157***
AIS → ABDM (H2)	**.202****	**.05**	**.196****	**.196****	**.202****
MQS → ABDM (H3)	**.404*****	**.19***	**.403*****	**.395*****	**.405*****
Controls:					
SIZE → ABDM	*–.128* #)*	*.03*	*–.132***	*–.127**	*–.128**
SIZE → BDA	*.094*	*.01*			
SIZE → MQS	*–.104*	*.01*			
*SIZE * BDA → ABDM*			*–.048*		
*SIZE * AIS → ABDM*				*–.078*	
*SIZE * MQS → ABDM*					*–.002*
R-square: ABDM	**.409*****		**.412*****	**.417*****	**.410*****

1-tailed: p < .05; p < .01**; p < .001****

#) The total effect of SIZE on ABDM is –.155, but the indirect effects of SIZE on ABDM via BDA and MQS are not significant.*

As predicted in hypothesis 1, BDA sophistication has a significant positive effect on ABDM (H1: β =.158, p <.05), although the effect size in terms of relative R-square contribution (f square) is rather small (.03). Hypothesis 2, which predicted a positive effect of AIS on ABDM, is also confirmed (H2: β =.202, p <.01; f = .05), but the dominating predictor of ABDM are managers' quantitative skills (MQS) (H3: β =.404, p < .001; f =.19), which account for the majority of the R-square in the model.

Contrary to the rationale for including firm size as a control, this variable has a significant *negative* direct (β = –.128, $p < .05$, $f = .03$) and total (β = –.155, $p < .01$) effect on ABDM. Such negative effect is also evident in the moderation models (models 2a – 2c), but the interaction terms with SIZE are not significant. As expected, larger firms are able to provide slightly more sophisticated BDA (β = .094, *n.s.*), but managers in those firms tend to have less quantitative skills (β = –.104, *n.s.*) and base their decisions to a significantly lesser extent on analytics than managers of smaller firms (β = –.128, $p < .05$).

5. Conclusion, implication, and limitations

The study presented in this paper attempted to determine the impact of Big Data analytics (BDA) sophistication, analysts' interaction skills (AIS) and managers' quantitative skills (MQS) on managers' decision-making behavior, in particular the extent to which they base their decisions on analytics (rather than heuristics and intuition). The results of our analysis suggest that while each of those three factors is positively associated with analytics-based decision-making (ABDM), MQS has by far the strongest impact.

These findings have important implications for research and practice: First, the results empirically confirm the often unverified claims that BDA has an impact on managerial decision behavior insofar as more advanced analytics creates an incentive for managers to actually base their decisions on the analytic insights. Second, the results also confirm that particular soft skills expected from analysts [12] do make a difference, i.e. higher interaction skills presented by analysts do create an incentive for managers to make analytics-based decisions. Third – and most importantly – our findings suggest that quantitative skills of senior and middle managers are the main underlying driver of analytics-based decision-making [51]. The practical implications of these findings are as follows: Investing in BDA tools and data scientists/analysts creates an incentive for managers to make more informed decisions, even more so if analysts match their technical skills with interaction skills. But in order to fully leverage such analytic resources, it requires managers who possess strong quantitative skills.

One possible interpretation of these findings is that managers with poor quantitative skill do not appreciate the value of analytics as much as managers who have developed such skills. Alternatively – or in addition – quantitatively capable managers may find it easier to interpret the analysis provided by data scientists and are therefore more likely to use it. Overall, 'upskilling' of managers in terms of quantitative methods or using the latter as job selection criteria for managerial positions may have a more beneficial effect on decision-making than investing into advanced analytic tools and broadly skilled data scientists.

Our study also yielded some unexpected but interesting side-results: When including firm size as control, our test results reveal that managers in smaller organizations are significantly *more* likely to base their decisions on analytic outcomes than managers in large organizations. This finding contradicts the mainstream view held in academic literature assuming that larger organizations have more formalized procedures for decision-making and (therefore) rely more on extensively on analytical decision tools and information [34]. On the other hand, the finding is in line with some cases reported in the practitioner literature, which suggest that smaller businesses are in a good position to compete on analytics [10]. Our findings are corroborated by the fact that the smaller organizations in our sample scored higher on managerial quantitative skills. Considering that the latter play a very important role in creating BDA impact, we conclude that smaller firms may owe some of their analytic advantages to the fact that they have managers who are 'closer to' analytics. More research is required though to investigate the impact of firm size on managerial decision making in more detail.

Like any study, our research is not free of limitations. Despite the fact that we deployed several procedural and statistical remedies to avoid biases [37], survey-based research is never completely immune against biases. Second, the survey respondents were exclusively CIOs and other senior IT managers, which inevitably introduces an IT-centric perspective. Future research could attempt to capture a more balanced perception, especially with regards to managerial decision-making in the context of a more holistic enterprise information management perspective [52]. Finally, we do

not explicitly measure decision-making quality, but rather rely on prior research [31],[48], which suggests that ABDM is associated with better decision-making.

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ERP systems selection in multinational enterprises: a practical guide

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ERP systems selection in multinational enterprises: a practical guide

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Abstract:
The Enterprise Resource Planning (ERP) system selection is an early phase in the ERP adoption process. When organizations evaluate an ERP, they commonly develop their own selection criteria that usually involve various system and vendor related factors. While the selection process is critical, however, there is an apparent research gap in literature. The ERP selection effort also focuses on the system's fit with the organizational requirements and needs. Thus, the selection phase is critical, because if an organization chooses an unfit ERP, the whole project could be predestined to fail. This research provides an overview of an ERP selection process at an overseas branch office of a multinational company. The process employed a simple multi-attribute rating technique (SMART) for evaluation. In addition, this research presents how cross-border data protection laws between the parent company and its branch have influenced the selection process. As the ERP system has been implemented successfully, the method and the selection factors have been proven adequate for the selection process.

Keywords:
ERP selection; SMART analysis; multinational enterprise; cross-border data exchange.

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1. Introduction

Enterprise-wide information systems (IS) adoptions require careful selection and implementation efforts, especially enterprise resource planning (ERP) systems. ERP systems are modular and bundled information systems that integrate the enterprise-wide business processes and functions. ERP systems emerged in order to replace the legacy silo systems through providing a unified and integrated solution for the organization's information-processing needs [1]. One of the main aims of ERP systems is to support the process-oriented view of the enterprise, as well as standardization of business processes across business functions, within the enterprise. Thus, enterprises worldwide are allocating a substantial portion of their IT budgets towards new ERP adoptions, completion of their initial ERP system installations, or upgrades, extensions and integrations to their existing systems. Among the most important characteristics of an ERP, is its ability to unify, automate, and integrate an organization's data and business processes across the entire enterprise, in a near real-time environment. In general, many organizations have their own custom processes set in place, however, several of these businesses re-engineer their non-standard processes to fit the ERP in order to take advantage of future updates, benefit from the standardized best-practice processes, and avoid costly irretrievable errors [2, 3]. Also, this could dramatically decrease the system customization costs.

ERP systems are regularly implemented as multi-phased projects. The implementation projects have several stages and milestones that typically starts with an adoption decision, then goes through selection of the ERP package and vendor, the actual implementation, use and maintenance, and finally future evolution [4]. Generally, ERP implementation projects involve internal IT & key business personnel from inside the organization, as well as, external consultants, or consultants from the implementation partners. This draws a picture of how resource consuming and costly ERP projects are [5].

During the selection phase, system/organization fitness is a crucial endeavor. Several large information systems implementations fail due to the selection of a non-matching system. The matching process happens between the organization needs, requirements, and expected future evolvement and scalability. The topic of “fit” has been frequently discussed in IS literature, specifically in enterprise resource planning literature. A wrong ERP system selection would either fail the project, or critically weaken the system, and hurdle the company performance [6]. In their study, Carton and Adam [7] argued that the ERP selection process in multi-site/multinational organizations may differ from monolith ones. There are several factors that would affect and influence the choice of the ERP system at subsidiaries and international branches. Some of them are related to system standardization issues [7], data sharing regulations across borders [8], and other operational and integration issues [9, 10]. Thus, the ERP selection process is a non-trivial task. This is mainly due to the scarcity of available resources, complexity of the ERP packages, and the diverse ERP system alternatives in the market [10]. In practice, the ERP selection process involves several factors. One of the important factors is the functional fitness of the system with the business requirements [10, 11].

Although the ERP adoption process has several phases, this paper focuses-on the ERP selection criteria and process. The remainder of the paper is organized as follows: section 2 presents the related literature, followed by the research methodology and case description in section 3. Section 4 illustrates the research analysis, and finally the research conclusions are presented in section 5.

2. Related literature

2.1 ERP systems

ERP systems are standard software packages that provide integrated transaction processing and access to information for the multiple organizational units and multiple business functions. These functions include finance and accounting, human resources, supply chain, manufacturing, and customer services. The standard in-house ERP system is based on a unified database. The database could be locally stored in case of on-premise ERP implementations, or residing outside the organization boundaries in cloud-based ERP systems. Regardless of the technical architecture of this database, it

gathers data from the various business functions. The database also feeds the data into modular applications supporting virtually all of the company's business activities – across functions, and across business units. When a new process (transaction) is registered at one corner of the organization, related data in other units is then automatically updated accordingly. Most companies expect their ERP systems to minimize their operational costs, increase process efficiency, improve customer responsiveness, provide process-level integration, enhance reporting, and subsequently decision-making [1]. In addition, several organizations also want to standardize their processes and utilize the best practices embedded in ERP systems, in order to ensure quality and predictability in their global business interests. This also could aid in order-to-delivery cycle time cuts [3].

When organizations adopt ERP systems, they face several challenges. Some of those challenges are related to the degree of business process re-engineering (BPR) needed to accommodate the new system. In addition, customization and change management are also considered critical challenges during the project. On the other hand, in some cases, organizations are leaning to adopt a vanilla implementation approach, which could be the least risky implementation approach [3]. Vanilla implementations radically minimize the degree of customization and clean-slate business process reengineering, as they follow the standard ERP functionalities, best practices, and process models instead of customizing the ERP package to fit the enterprise's unique processes [12]. Regardless of the company size, and the type of implementation, all ERP implementations require careful project management activities, a committed team, and a various degree of BPR. After the implementation, organizations usually experience a "shakedown" phase, during which they encounter performance instability while adjusting to the newly re-engineered processes [13]. This might result in operational commotions or abridged productivity for a certain period of time.

2.2 ERP fit

ERP fit with the organization, is a paramount criterion in the selection process. The fit perspective can be defined as the task to technology fit [14]. Goodhue and Thompson [14] argue that the fit is the degree (or process) of matching the capabilities and functionalities of a certain technology to the demands and requirements of a particular task or process. This has also been linked to employee performance, as information systems will most likely have a positive impact on employees or organizational performance only when the technology functionalities and features are fitting to user task requirements [14, 15]. Hence, identifying the capabilities of the potential ERP system to accommodate the critical business processes of organizations is the first step in insuring a successful ERP selection. Existing research has provided cases of early ERP retirement and project terminations, because of a wrong selection due to the gap or "no fit" between the system and the unique business processes, and organizational requirements [4]. In their study, Haddara & Elragal [4] recommended that organizations should not ignore the formal ERP selection practices, and emphasized the importance of user engagement during the selection process, as this could aid in avoiding ERP failures and erroneous system evaluations. In addition, they have advocated for business process requirements mapping with the potential system's technical capabilities, prior to the acquisition decision [4]. In general, several scholars in IS literature have argued that the organization-specific characteristics and contexts have also been important research aspects throughout IS implementations. Likewise, studies in the ERP domain are prompting researchers to investigate the implications of contextual factors, and organizational characteristics on the ERP implementation process. The majority of literature acknowledges that the organization size has a direct impact on ERP implementation success [16]. Instead, other factors like "ERP size" could also be a critical factor because of its influence on businesses and implementation complexity. The fit between the strategic business goals and ERP objectives is also considered an important factor for creating business benefits from the ERP adoption project [11]. In ERP adoptions, users must identify which goals to achieve with the new system, how the functionality of the system can realize this, and how to configure, customize, and technically implement the package [17].

Research results on Greek SMEs suggest that a number of organization-related factors like business process complexity, change management, and external factors like supply-chain partners and value networks pressure, have a strong effect on the ERP selection process [18]. Other research conducted in Australian enterprises, suggests that business requirements, system flexibility, acquisition costs, scalability of the ERP system [19], and the degree of ERP alignment/fit with the business processes, have a great influence on the ERP selection decisions [20]. In van

Everdingern et al. [21], their study suggested that the *fit* of the ERP application with the adopting enterprise's business processes is the most critical selection criterion in Nordic European SMEs. Other studies suggested and identified critical factors that could lead organizations to a successful selection process. The factors were local support, cost, and suppliers' business domain knowledge [22]. In addition, CEOs' technology awareness, employees' IT competence, firm size, ERP compatibility [23], and project management [24], were also identified among the critical success factors (CSF) for selecting the right ERP for SMEs.

2.3 Cross-border and data privacy laws

Due to globalization, communication and technology advancements, the need for cross-border data exchange is becoming increasingly needed and desired. Multinational and global organizations with international offices and branches seek to exchange data among its various locations in order to generate consolidated reports and analyze their global data. In addition, several of these multinationals have certain centralized operations, like centralized human resource management at the headquarters for example. Yet, nowadays such data exchanges and transfers are becoming more problematic and costly from a business perspective. This is due to the fact that an increasing number of countries and regions (e.g. EU) are adopting more strict data exchange and privacy laws that regulate and limit cross-border transfers of personal data, including transfers to headquarters, branch offices, and subsidiaries [25]. Many of these laws were decreed based on the mounting public concern about the potential misuse of personal data by some organizations or parties. Thus, these regulations and laws either clearly forbid transfers to other countries except particular pre-set conditions are met, or enforce regulatory requirements on the organizations exchanging the personal data [25]. Hence, the ERP selection process usually differs in the contexts of multinational organizations. In best-case scenario, if a subsidiary needs an ERP system, the easiest option is to create user accounts on the main ERP system at the headquarters. However, due to cross-border and data privacy laws in some regions, and separation of operations and finances, this scenario is not suitable in most situations [7]. In many cases, the headquarters enforces subsidiaries and international branches to adopt a pre-designed implementation, which would be replicated in each site; this could lead the individual sites to lose the richness of their local practices and competitive edges. This may lead to large-scale organizational problems [7]. Thus, the ERP selection process at subsidiaries might be dramatically influenced in cases of multinational enterprises.

2.4 ERP selection

In order to better understand and evaluate the selection and acquisition process, several studies identified the factors that affect ERP selection in organizations, and proposed criteria to optimize the selection process. For example, Velcu [26] has identified several factors that affect the selection criteria, which includes the ERP-to-organization fitness as an important factor. In addition, Velcu [26] has argued that all the ERP adoption phases are highly interdependent with the critical success factors of each stage. Moreover, Deep et al. [27] have developed a framework for the ERP system and vendor selection process, presented in figure 1. The framework demonstrates several phases in the selection process, which starts with the requirements and project planning, identifying potential vendors, evaluation, and finally selection of the appropriate ERP package. The framework also illustrates several iterative tasks to be accomplished by the project team at each stage.

In their research on ERP implementations risks, Aloini et al. [6] underlined the importance of fitness between the organizational business process requirements and the ERP system's functionalities and capabilities. They have categorized the inadequate ERP package selection as being the paramount cited risk factor in ERP implementations (see table.1). They have also suggested that a wrong package selection is a key concern and could lead to time, cost, and risk escalations, which can lead to dire events that could ultimately result in total project failures [6]. In addition, they have encouraged for a structured multi-criteria approach for evaluating the ERP system and vendor. The criteria are comprised of several factors, including functionality, technology, support, and costs.

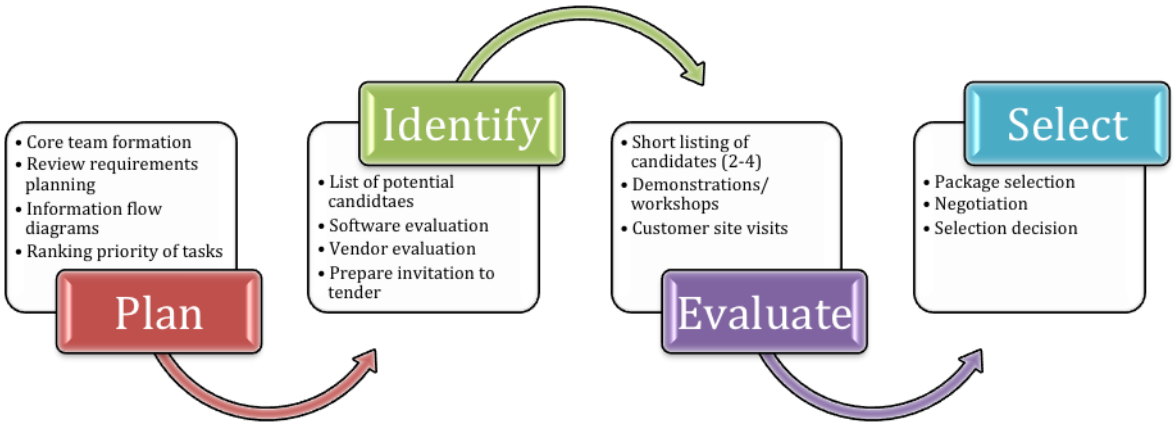

Fig. 1. ERP selection framework. Adapted from [27]

Table 1. Risk factors frequency in ERP literature. Adapted from [6].

Risk factor	**Frequency rate**
Inadequate ERP selection	High
Poor project team skills	Medium
Low top management involvement	Medium
Ineffective communication system	Medium
Low key user involvement	Medium
Inadequate training and instruction	Medium
Complex architecture and high number of modules	Low
Inadequate business process reengineering (BPR)	Medium
Bad managerial conduction	Medium
Inadequate financial management	Low
Inadequate change management	Medium
Inadequate legacy system management	Low

A multiple case study conducted in Egypt, indicated that *the weighted scoring SMART* (simple multi-attribute rating technique) analysis is commonly used as an ERP selection technique among Egyptian organizations [28]. In addition, the paper suggested that the responses from the vendor's references were one of the top deciding factors in the ERP selection in their target case. Although it is facile to apply and widely used in practice, the SMART analysis' quality and usefulness varies between organizations, depending on the factors and weights they ascertain and include in the analyses. While there is plenty of research on the ERP selection phase, only a few papers present real-world cases.

Due to limitations of available resources and expertise, the high complexity of ERP systems, and the diversity of selection criteria, selecting the proper ERP system is thus not a trivial task.

3. Research methodology and target case

This research employs a single in-depth explanatory case study research approach [29]. Explanatory case studies are useful in presenting cases when exploring new phenomena, or when there is a lack of theory [29]. In addition, according to Yin [30], the explanatory case study research method is recommended when "how" and "why" questions are demanded, when the researcher has little control on the occurrences, and when the focus of the researcher is on a current phenomenon that occurs in a real-life context. In general, case studies may involve the analyses of persons, events, decisions, periods, projects, institutions, or any other systems that are scrutinized and studied holistically through one or more research methods [31].

Generalizability and transferability from qualitative research and case studies may present some challenges to researchers. This is mainly because of the relatively small samples or cases in which it could be difficult to replicate their findings in other contexts [32]. On the other hand, several researchers have argued that it is viable to generalize and develop theories from such case studies [33]. Guba and Lincoln [34] argue that the well-reported and 'thick descriptions' of case studies could help other researchers in considering the transferability of the descriptions to their own contexts and lexicons.

The purpose of this study is to increase our knowledge of the factors, which lead to a successful and systematic ERP selection decision. The study also aims at providing rich descriptions of the ERP selection phase in a manufacturing SME in its natural setting. Although single case studies generalizability is limited, this research may provide important insights and directions for future research.

3.1 Data Collection

During this research, the author had access to various data sources. In total, ten qualitative face-to-face and semi-structured interviews were conducted [30]. The interviews were carried out in one Egyptian branch and strategic business unit of a multinational enterprise, and the interviews were mainly focused on the ERP system selection process at the organization. The interviews ranged from 30 to 60 minutes, and notes were taken during the interviews. The participants included a mixture of stakeholders who had been involved in the ERP system selection and evaluation. The interviewees' positions included the general manager, IT manager, business function managers, mid-level staff, and the external ERP selection consultant. The variety of interviewees stimulated different perspectives, which augmented the data collected through data triangulation [32], and the analysis consequently.

In general, convenient access to all the resources needed for the successful completion of this research was granted. In addition, the author had access to the selection criteria, and the final selection report proposed by the ERP consultant who assisted Sphinx company in the selection process. In addition, the author had access to the data used for the comparison of the ERP packages, project documentation, internal organizational documents, company profiles, vendors' websites, and emails related to the selection process. During the selection process, the consultant asked all the employees to fill out a "business process form", in which they described all the business processes they conduct in their day-to-day operations. Then the consultant compiled and modelled all of this information as business process maps (e.g. Fig. 2), which the author also had access to.

3.2 The Sphinx Company

Sphinx is an Egyptian branch, and strategic business unit (SBU) of a multinational enterprise. Sphinx is a small-to-medium-sized enterprise, which manufactures and supplies oil derivatives that are used as raw materials in several industries. The company's headquarters is located in Europe. The parent company has been in business for more than sixty years, and is listed in the New York Stock Exchange (NYSE). It has nine SBUs that virtually cover the world. The Egyptian company's name has been concealed for anonymity. There are currently twenty-three employees at Sphinx. Given the separate operations, financial, scale, and market size of the Egyptian SBU, the Sphinx Company has been regarded and categorized as an SME, and a small enterprise in particular. At the end of 2013, the parent company

directed Sphinx to prepare for an ERP implementation. The ERP selection process started in January 2014 and was completed in April 2014. The selection process was conducted by an external ERP consultant, which was brought into the project to aid Sphinx in their ERP evaluation and selection process.

The parent company has an SAP™ ERP All in One installed at its premises. When the consultant was asked to join the ERP adoption project team, he inquired about the possibility of just creating accounts for the Egyptian SBU users on the main ERP system at the headquarters. While Sphinx is a branch of the parent company, the creation of users on the main ERP wasn't possible, due to the European Union (EU) Directive and cross-border data privacy and protection laws [35]. As Sphinx resides out of the EU, the 1995 EU Directive on data protection legislation (DPL) prohibits the sharing and transferring of data to countries without proper DPL. Until now, Egypt does not have any formal data protection laws [36], which makes it difficult for multinational organizations operating in Egypt to share the same data repository [8]. Hence, the Sphinx company had to have a fresh and separate ERP implementation.

According to the ERP selection consultant, the selection process at Sphinx was limited to SAP products. That is mainly because the parent company and all its SBUs use SAP ERP. Thus, Sphinx was directed to acquire an SAP ERP to facilitate yearly reporting and interoperability, and as the ERP has proven fitting to their industry. A previous consultant, who worked briefly on the selection process, suggested implementing an SAP All in One ERP, like at the headquarters. With a great difference in implementation complexity, target organization size, and costs between SAP's All in One and Business One, the current ERP consultant decided that the selection decision should be based on business requirements, processes, organization size, and other factors. Initially, there were three SAP ERP system candidates in the evaluation process, SAP All-in-One™ (A1), SAP Business-one™ (B1), and SAP ByDesign™ (BYD). However, based on a decision by the Sphinx Company, only two SAP ERP systems have been short-listed for selection. The systems were SAP A1 and SAP B1. The third system (SAP BYD) was eliminated from the comparison. SAP BYD is only available as a software-as-a-service in the cloud. While a recent survey on cloud-based ERP suggests that security is no longer regarded as a prime barrier for cloud-ERP adoptions in organizations [37], the headquarters communicated to Sphinx that it is not a favourable option due to security concerns. Additionally, B1 is already available on both: premise as well as in-cloud. Thus, the ERP consultant had a narrow window of selection options at Sphinx company. The ERP implementation was successfully completed at 2015.

In the next section, details about the ERP selection criteria and comparisons between SAP A1 and B1 ERPs are provided in more detail.

4. Analysis

The ERP system fit with the organization is a critical factor in the selection process. Thus, the ERP solution must accommodate the company's information needs and processes. If the selected ERP system is not able to match the organization's strategic goals, it could lead to an early ERP retirement or project termination. Software and hardware aspects are also very important dimensions and factors to be included in the appropriate ERP system evaluation and selection. At the target case, the criteria for the selection and package comparisons was set after the consultant met with the Sphinx company's top management and key users. The selection criteria was not directly dictated, instead, it was inferred in part, and suggested in part.

The selection process principally employed a process mapping method, and adopted a structured multi-criteria evaluation that had been developed through literature and the consultant's practical experience in the field. Besides the organization's size and specific contextual dimensions, the evaluation and assessment factors mainly included 11 factors: functionality of the ERP system - Business process mappings with the ERP package, technical criteria, cost & budget, service and support, vision, systems reliability, compatibility, market position, modularity and integration, implementation methodology, and organization size and context.

The abovementioned factors are discussed in more detail below, and an overview of the ERP systems evaluations and comparisons are provided in table 2.

1. The first criterion included in the evaluation was the ***functionality of the ERP system***. Functionality is said to be the most essential selection factor. This factor should usually carry a heavy weight in the whole evaluation procedure. The first aspect in the functionality is called completeness or comprehensiveness. Completeness entails that the ERP solution should have adequate or even more modules related to the organization's main activities, and supports the critical business processes.

   During this evaluation criterion, the consultant had developed business process maps (e.g. Fig. 2), which were compiled from the business process profiles created by the Sphinx Company's employees. The process maps were then compared against the candidate systems' business process maps and best practices. This was a critical criterion, as it was a yes/no evaluation factor. This means that if the required business requirements were not matched by a system, the system would be directly excluded from the candidacy.

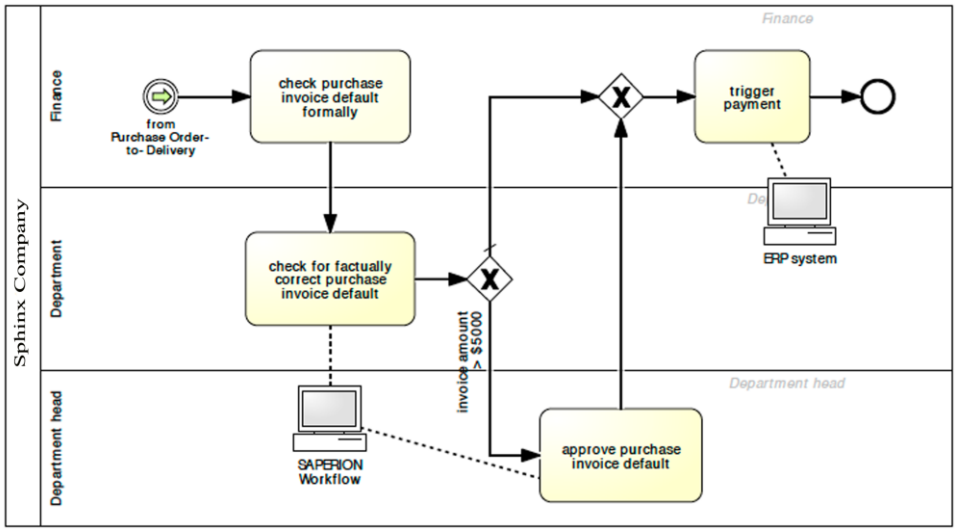

Fig. 2. Process map sample: delivery-to-payment

As Sphinx's business processes were mainly following the market standards, both systems turned out to be accommodating and compliant with the Sphinx's core business processes. Thus, both systems went through all of the selection and evaluation stages.

2. The second criterion is the ***technical criteria***. The selection of hardware and software is of huge importance during the approval of an ERP solution. Preferably, the system should accommodate the current trends and state-of-the-art in information and communication technologies. Organizations should verify that vendors will provide upgrades to their ERP products to ensure best utility of technologies and security updates that are more likely to exist in the future. It is fundamental for organizations to use knowledgeable internal staff, or an external consulting group to assess and evaluate the ERP system's technical features. Technical criteria would

also reveal the simplicity of using the software, and other technical aspects, such as system stability and quality.

3. The third criterion considered in the evaluation is ***the cost & budget*** of adoption. Organizations must have financial strategies to estimate the required budget, which also must include maintenance and upgrade costs in the total budget. Although the ERP solution should have an attractive price, putting realistic expectations for the whole cost is crucial for top management and the acquisition procedure. The cost is not only about the ERP solution and license costs, it contains many other cost factors including the hardware, software, consulting, training, human resources, organization change management (OCM), etc.

4. Another criterion is ***service and support***. The service and support linked with the implemented application are with high importance to the success of the strategic project. The majority of organizations usually face technical issues with the application during the implementation, execution, or after the go-live period. Integration with currently available systems, customization, and security measures are the most severe problems for organizations. For handling these difficulties, organizations require maintainability and support from suppliers, both in provision of information technology expertise and the availability of contextual field/industrial knowledge.

5. The ***vision criterion*** is regularly included in the selection criteria, which relates to the evaluation of the ERP vendor. Organizations should observe and evaluate the vendor's vision properly. The vision includes investigating the future direction of the vendor's business, and whether it is prone to continue in its current position during the lifetime of the ERP solution. In addition, the continuous enhancements of the vendors' products and services are also important, as well as how the vendor is planning for these future enhancements. The vision would also reveal the supplier's business image, the current international state, as well as its background and history. The market position (below) of the vendor is also considered to be an important aspect when evaluating the ERP vendor. In addition, improvement support and constant support are also crucial.

6. Another criterion is the ***system reliability***. This is sometimes considered to be the second essential criterion in the whole evaluation process. Integrating the business practices of all areas, including the new information technology developments, is often imperative for the new ERP system. Having a strong vendor, which is considered a market leader in this type of business, can be beneficial for the organization. For example, some information like knowing how many years the ERP vendor has been working with the core of ERP business solutions, and if the current users of the system in other organizations are satisfied with the system.

7. ***Compatibility*** is deemed as a critical criterion, which means the ERPs compatibility with other legacy or current systems. There is virtually no one application that can cover all organizations' requirements. Thus, the chosen ERP solution must be compatible and ready to be integrated with all the internally grown systems as well as the niche software or products that the organization may be using to accomplish specialized requirements. From this perspective, compatibility or integration with other systems is a crucial criterion when selecting the ERP solution.

8. The ***market position*** of the supplier. A large number of organizations rely heavily on vendor's reputation, status, as well as service infrastructure when choosing the ERP solution. The world's leading ERP suppliers have been following the best global practices in their ERP products. From this perspective, organizations can look at the ERP products as a process helper or advisor. Specifically, the successfully completed ERP projects in the same type of business or industry can be considered as a vital criterion and indicator during the selection process of the ERP system. In addition, the company should choose the ERP supplier based on the industry experience.

9. A very important criterion is the system's ***modularity and integration***. The ideal ERP system should have its modules integrated with one another and provide modularity, in which it should enable organizations to freely choose the modules they seek to implement, without the need to implement the whole package.
10. Another chief criterion is the solid ***implementation methodology*** while running the project. The presence of a reliable, previously tested, and consistent methodology would enhance the project's success likelihood. In each phase of the methodology, activities should be defined; carrier, inputs, outputs, milestones, etc.
11. Finally, ***ERP package fitness*** with the organization's size must be evaluated. Larger packages implemented in small-to-medium-sized enterprises (SMEs) may impose unneeded and avoidable challenges and complexities during the project implementations and use.

Table 2. Selection overview at Sphinx.

	A1	**B1**
Functionality of the ERP system	Both systems have the ability to manage core business operations *(e.g. Sales-Purchasing-Accounting).*	
	According to SAP, both A1 and B1 are able to support virtually all industries [38].	
Technical criteria	- Requires more complicated, as well as higher IT footprint.	- Entails simple IT footprint.
	- A1 could only be offered on-premise.	- B1 could be offered on-premise and on-demand.
	- Requires NetWeaver.	- Does not require NetWeaver.
Cost & budget	- Requires a substantial budget (IT footprint; annual license; SAP User; Personnel), as well as, a higher total cost of ownership (TCO)	- Requires a substantially smaller budget (IT footprint; annual license; SAP User; Personnel) as well as less total cost of ownership (TCO).
	- Requires a team of: Database Administrator (DBA); Basis Consultant; as well as Functional Consultants (at least 3 consultants).	- One of the key strength here is that, B1 requires only 1 person to manage and support.
	- The starter package of 5 users (5000) + 1 developer (9000) + 1 professional (5000) + 22% annual maintenance *(total cost of USD 45,000; rough before partner discounts).* Add, cost of required *H/W.*	- As for the costs, B1 starter package could be between 1 and 5 users *(Total cost of USD 7,000 in USA)*. Reusable budget when upgrading to full-fledged B1.
Service and support	Both systems would not be different when it comes service and support, as they come from the same vendor (SAP), which manages the upgrades, fixes, and Enhanced Packages (EHP). To avoid the complexity of full system upgrades, the gap between the current version at the organization and the new versions from SAP, SAP releases enhanced packages with minimal updates that include only the main new features.	
Vision	Both systems come from the same vendor; SAP. In fact, more than 80% of SAP's revenue comes from the SME market. The same business segment to which Sphinx Company belongs.	
System reliability	Both systems come from the same vendor; SAP. With higher rates of successful ERP implementations (A1 and B1), the system reliability score of both systems marks high ratios that are sufficient to secure Sphinx Company's future business.	
	In 2015, SAP B1 had more than 50,000 customers, in 150 countries and available in 41	

	A1	B1
	country specific versions and 20 languages. SAP ERP systems also provide Arabic support.	
Compatibility	A1 is 100% compatible with Headquarters in Europe, which also runs the same system (SAP ERP A1).	B1 is fully integrated with A1 out of the box, based on its powerful Integration Framework. Various scenarios e.g., Business Suite-to-B1 or NetWeaver-to-B1 for master data, sales, purchasing, HQ reporting, and finance.
Market position	Both systems come from the world's leader in ERP systems SAP. Therefore, they have the best market position.	
Modularity and integration.	- All A1 modules are fully integrated. - CRM is a different license/product. - Has a mobile application, which is free and ready out of the box, for access from smart phones and tablets (same as B1). - Can run on Oracle, MS SQL Server, IBM RDBMS. - Can run on SAP HANA (same as B1).	- All B1 modules are fully integrated. - B1 comes with both CRM, as well as WHM functionality. It should also be clear that there is no independent CRM product. Instead, the CRM functionality has been integrated into the sales and marketing module/functionality. - Has a mobile application, which is free and ready out of the box, for access from smart phones and tablets (same as A1). - Can run on MS SQL Server RDBMS (does not run on Oracle). - Can run on SAP HANA (same as A1).
Implementation methodology	In fact, both systems follow the same implementation methodology from SAP. That is, the "ASAP" (accelerated SAP). The ASAP implementation methodology is consisted of five phases: project preparation, business blueprinting, project realization, final preparation, and go-live and support. According to SAP [38], implementation time takes 2-4 weeks with B1, while it takes 8-16 weeks with A1.	
Package fitness to size	A1 targets medium to large organizations.	B1 targets small-to-medium-sized organizations. More suitable to Sphinx.

The two SAP ERP systems have been evaluated against the selection criteria factors as presented in table 2. After the selection process was completed, SAP B1 was recommended for implementation at the Sphinx company, as on-premise rather than in-cloud/on-demand solution. This is fundamentally due to the security recommendations by the parent company and other integration related issues. As a matter of fact, both SAP ERP systems are able to meet the requirements of Sphinx Company; and able to integrate with HQ's ERP system; but B1 has significantly less TCO and reduced implementation complexity. Table 3 provides a summary of the two ERP systems, the selection criteria, and their match with the organization requirements and characteristics.

Table 3. Selection summary.

Criteria	A1	B1
ERP Functionality	✓	✓
Technical Criteria		✓
Cost and Budget		✓
Service and Support	✓	✓
Vision	✓	✓
System Reliability	✓	✓
Compatibility	✓	✓
Vendor's Market Position	✓	✓
Modularity and Integration	✓	✓
Implementation Methodology	✓	✓
ERP Package Fitness		✓

5. Conclusions

The selection process and ERP acquisition decisions are becoming increasingly complex in a rapidly changing and competitive environment. Established vendors and third-party partners are offering a large assortment of ERP core and extended modules, and various support services. In addition, several free and open-source ERP alternatives are offered over the web. Organizations pursuing systems standardization and integration should evaluate and select ERP systems that contribute to these goals without sacrificing the functionality of applications they believe are crucial for their business. Thus, the careful selection of vendors, products, and services provided is necessary, but the final decision has to be made considering the amount of organizational change required for the adoption and the implementation of the selected ERP system. This research provides an example of the ERP selection process at an SBU of a multinational organization. The ERP selection in this case, was to a great extent, narrow in the scope of ERP choices. The reasons for this limitation were mainly due to cross-border data exchange regulations, integration, and interoperability issues between the SBU and headquarters. As the parent company uses SAP A1 ERP, thus the headquarters recommended the exclusive evaluation of the various SAP ERP packages for Sphinx.

This study also illustrates the actual ERP selection process and criteria applied at the Sphinx Company. The selection process followed the SMART analysis in an innovative manner. That is, 11 criteria factors have been devised and weighted in order to score the two shortlisted ERP systems. The selection criteria factors included business process mappings, and packages comparisons among other dimensions. Finally, the final ERP selection/recommendation report was submitted by the ERP consultant to the Sphinx Company's top management and the parent company. The report was approved, then the company progressed in the acquisition, and later in the successful implementation of the chosen SAP B1 package.

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Lifespan of information service firms in Japan: a survival analysis

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Lifespan of information service firms in Japan: a survival analysis

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Abstract:
The purpose of this paper is an analysis of survival in the Japanese information service industry. Information service firms are generally classified into two typical patterns. One is the group of independent firms such as software vendors, and the other is the group of non-independent such as subsidiaries established by spinning off and so on. We used a sample of 334 firms in Japan and analyzed by Kaplan-Meier estimator method and Cox proportional hazard regression model in order to investigate the difference of survival between these two groups and/or among other attributes. As a result, the lifespan of the information service firms significantly depends on the degree of system integration sales ratio, software development sales ratio, and entrusted processing sales ratio. On the contrary, property of non-independence and high sales ratio with main customers have a negative influence on their survival rates, i.e. lifespan. The paper discusses these results and offers some managerial implications, and future research opportunities are provided.

Keywords:
Survival analysis; Kaplan-Meier estimator; Cox proportional hazard regression model; information service industry.

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1. Introduction

In general, firms in the private sector can be classified into two typical groups. One is the group in which firms are placed under the capital of its major parent company and the other consists of independent firms. It is no exception in the information service and/or software industry. Hence, information service industry has two groups: (1) the group of non-independent such as subsidiaries established by spinning off and so on, and (2) the group of independent firms such as software vendors or software houses [1]-[7]. In Japan, especially in larger companies, it can be said that subsidiaries related to the information service or system (IS subsidiaries) have been established and utilized so far.

Indeed, the Japan Information Processing Development Corporation (2006) made it appear that the rate of companies setting up their own IS subsidiaries is 8.3% as a whole in Japan [8]. However, depending on the size of the company, its own IS subsidiaries tend to be established. That is to say, 25.5% of the companies who have from 1000 to less than 5000 employees are setting up their own IS subsidiaries. In addition, it reaches the rate of 61.8% in the companies having 5000 employees or over. Moreover, this report reveals in detail that large-scale companies tend to establish their own IS subsidiaries by spinning off their in-house information systems department.

However, few studies have empirically analyzed differences in characteristics between the two groups: Ind. group and Non-ind. group mentioned above. Even more, to the best of our knowledge, only a few studies of the determinant factors that have influence on the survival or lifespan of information service firms have been published until today. The main contribution of this paper is to identify the effects of factors influencing firm survival in the Japanese information service industry.

This paper is organized as follows. In Section 2, we mention about the background of this study and briefly review some relevant researches about the survival or life-span of firms. Section 3 describes the data and method of survival analysis. Section 4 presents the results of the log-rank test of survival analysis and Cox proportional hazard regression analysis. Finally in Section 5 we conclude by a summary of this paper.

2. Background and literature review

A previous research concerning the information service and/or software industry in Japan is the empirical study that Baba et al. [9] have conducted. According to this study, the user-driven nature, that is the role played by the large users of software as compared to the roles of independent software houses, is an important factor to structure this industry in Japan. The main conclusion is that the structure of the Japanese software industry has inhibited the development of packaged software and also the evolution of innovative independent software houses. Therefore, with the current trend in the computer industry towards down-sizing and open systems, the structure of the Japanese software industry presents critical weaknesses.

Anchordoguy [10] analyzed the key cause of the current weakness of Japan's software industry, and concluded that it arises from the institutional arrangements of Japan's system of catch-up capitalism. These are said to include industrial policy; the *Keiretsu* industrial groups; a centralized, bank-centered financial system; lack of enforcement of the antimonopoly law; a weak intellectual property regime; and education and employment systems that emphasize conformity, loyalty, and stability. *Keiretsu* means the group of large Japanese financial and industrial relationships through historical associations and cross-shareholdings.

Thus, literature has attributed Japan’s weakness in the global business software sector to the specific institutional settings or social system, however, Storz [11] argues that it is precisely the dynamics within innovation systems which have enabled Japan to charge forward as a global leader in a highly innovative field: the game software sector.

On the other hand, the survival analysis as methodology has been widely used in many studies in the field of management. For example, Demirbag et al. [12] analyzed the factors affecting survival of foreign subsidiaries in the context of Japanese foreign equity ventures in the Middle East and North Africa. Morikawa [13] analyzed the relationship between family ownership of firms and productivity growth and survival by using data on a large number of Japanese firms. The conclusion is that their probability of survival over a six-year period is 5-10% higher than that of non-family firms. Kim and Lee [14] investigated whether the type of technological regime moderates the effects of entry timing, entry size, and active learning on firm survival. The study found that the effects of the factors influencing firm survival differed substantially across technological regimes. Using Kaplan-Meier estimator method and Cox proportional hazard regression model, Gemar et al. [15] analyzed the probability of survival of hotels in Spain. The findings indicate that the survival of hotels depends on their size, location, management and business cycle. And however, survival rates doesn't depend on significantly the particular types of hotels or configurations of their economic and financial structures.

In light of the abovementioned previous studies, we engage in further discussion concerning the survival of the information service firms in Japan. For that purpose, this paper has no working hypotheses in advance, but makes exploratory approach and analyses empirically the factors influencing firm survival.

3. Data and method

In this section, the data and method of survival analysis are described. We use the non-parametric Kaplan-Meier estimator in order to detect the difference of life-span between Ind. group and Non-ind. group. Semi-parametric regression is applied with the Cox proportional hazard model, confirming which factors clearly influence the survival of the information service firms.

3.1 Outline of the Sample

We used a sample of 334 firms that belong to the information service industry which was extracted from the *Data Book* of Information Service Firms, edited by Ministry of Economy, Trade and Industry (METI) in Japan [16]-[20]. Publication of the *Data Book* was discontinued unfortunately, and 2000 edition is the latest available one.

Starting from 1997, we traced forward the sample for each four years: 2001; 2004; 2007; 2010 and calculated the amount of years that a firm in sample has stayed in business. If an existing (a registered) firm remained at a given year on the *Data Book*, it was considered as surviving until that year. While, if the firm disappeared from the *Data Book* due to either a closure or bankruptcy, it was regarded as an exit. However, even in that case, if the existence of the firm was confirmed by other media such as the Internet, we regarded it as still surviving.

For instance, if a firm is registered in the 2001's *Data Book* and not listed in the 2004's, it has been alive for 4 years from 1997 to 2001 and died even until 2004. However, because it cannot be said that it died just in 2004, the survival period is regarded as 6 years on average for simplification. Similarly, if a firm is registered in the both 2001's and 2004's *Data Book* but its survival is not able to be confirmed in the 2007's, we regard the survival period of the firm as 9 years on average.

Figure 1 shows the definition of the observation period in this study. Both left truncation and right censoring is taken into account [21]. Right censoring occurs because the firms are still in operation at the end of the observation period. And left truncation is present because information on exit is only collected from 1997 onwards.

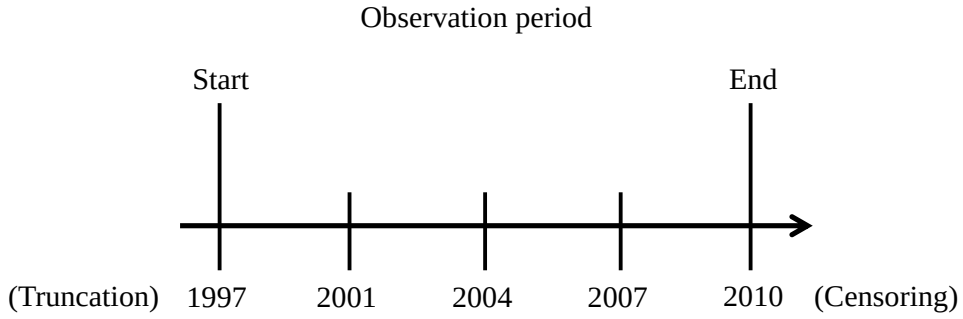

Fig. 1. Definition of the observation period

3.2 Kaplan-Meier estimator

The Kaplan-Meier estimator is a non-parametric method for estimating time-related events (Kaplan and Meier, 1958) [22]. It is known as a robust technique because it has few restrictions. That is, the only restriction to consider is that the observed firms - if the data are censored - are assumed to have continued behaving the same way as they did until the event (e.g. bankruptcy) occurred [15].

A variety of tests may be used to compare the survival functions among groups, but the log-rank test statistic is widely used in many studies in the management field. In the log-rank test, under the null hypothesis, the different groups have an equal chance of survival, so it has a chi-squared distribution.

The Kaplan-Meier estimator is useful for analyzing the duration or survival from the single point of view. However, to identify which factors influence the probability of survival, regression models are necessary which enable examining the multiple independent variables at the same time.

3.3 Cox proportional hazard regression model

Cox proportional hazard regression model is a semi-parametric method and the most general of the regression models because it is not based on any assumptions concerning the nature or shape of the survival distribution [23],[24]. Survival analysis typically examines the relationship of the survival distribution to covariates. Most commonly, this examination entails the specification of a linear-like model for the log hazard. The Cox proportional hazard model may be written as

$$h(t,x) = h_0(t)\exp(\beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k) \tag{1}$$

where x is the covariate vector, β is the unknown parameter vector estimated by using partial likelihood function and $h_0(t)$ is called the baseline hazard at time t. $h(t, x)$ denotes the resultant hazard, given the values of the covariates for the respective case and the respective survival time (t).

4. Analysis and results

We first briefly show the results of the log-rank test of survival functions between the group of independent firms (n = 152) and non-independent firms (n = 182). The result was significant (χ^2 (1) = 16.13, p = 0.00) and therefore the survival rates of two groups were not equal. In Figure 2, survival curves were depicted by Kaplan-Meier estimator method. We can find that the survival rate of the Ind. group is higher than that of the Non-ind. group. It is considered that the independent firms such as software vendors or houses face severe environment and suffer from the stress of market pressure, but these fact enables them to survive toughly. While, the non-independent firms such as subsidiaries are subject to the policy or control of their parent company, then disappearing from the *Data Book* does not always mean a bankruptcy.

Fig. 3 is shown for further discussion. These survival curves were drawn on the founded year basis. Because the *Data Book* also has information about the foundation year of each firm. It is the same for this result as mentioned above. That is to say, the result of the log-rank test was significant ($\chi^2(1)$ = 27.38, p = 0.00) and therefore the survival rates of two groups were not equal. The survival rate of the Ind. group is higher than that of the Non-Ind. group statistically in this attempt of analysis.

Next, we provide an overview of the regression analysis based on Cox proportional hazard model. The dependent variable is the hazard function which indicates the probability of event occurred in time (t). And eleven independent variables are used and examined which are each explained in detail below. Type of group (TYPE) is a dummy variable that takes the value 1 when a firm in sample is the non-independent firm and otherwise 0. Logarithmically transformed capital is used as a proxy for the firm size (SIZE). Then, a number of factors are relevant to the survival of firms, we address the two aspects: (1) economic structure and (2) technological capability in this study.

As a basis of economic structure, we prepare the three factors. Namely, sales per employee in log (SPE), sales profit ratio (SPFT), and sales ratio with main customers (SCUST). The rest of independent variables is related to the technological capability to perform by sales. These variables include system integration sales ratio (SI), software development sales ratio (SOFT), entrusted processing sales ratio (ENPRC), package software sales ratio (PACK), hardware sales ratio (HARD), and dispatching sales ratio (DISP).

System integration means the process or operation of creating a complex information system that may include designing or building a customized architecture or application, integrating it with new or existing hardware, packaged and custom software, networking, and storage products from multiple vendors. *Software development* is a business that is related to developing software for clients which works on a specific execution environment. *Entrusted processing* is a service providing entrusted with by customers about typical or routine data processing such as payroll calculation, ordering system and so on. *Package software*, also called *Packaged software* means a business to lay in stock of ready-made application software and sell it. Similarly, *Hardware* is about buying in stock of physical devices such as computer machine, storage, and so on from wholesalers, and selling them for wide end users. *Dispatching* is a service about temporary employee placement. It means a dispatch of a proper human resource according to the clients' requests.

The results of Cox proportional hazard regression analysis are shown in Table 1. The variable of TYPE was only introduced in Model 1. Variables considered in Model 2 were TYPE and groups of economic structure: SIZE, SPE, SPFT, SCUST. And we introduced all variables into Model 3 directly.

As shown in Model 1 through 3 of the Table, the coefficients of TYPE are positive and statistically significant. Also, the coefficients of SCUST are positive in Model 2 and 3. In contrast, the coefficients of SI, SOFT, and ENPRC are negative in Model 3. Therefore, the survival of the information service firms significantly depends on the degree of system integration sales ratio, software development sales ratio, and entrusted processing sales ratio. On the contrary, property of non-independent and high sales ratio with main customers have a negative effect on their own survivals.

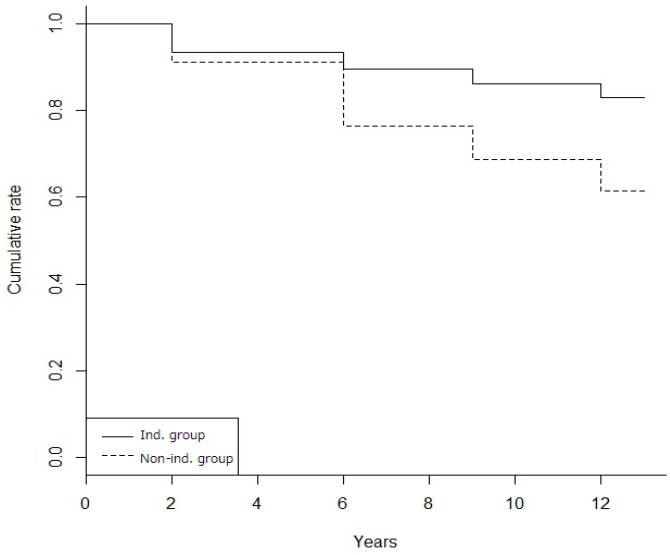

Fig. 2. Survival curves obtained from Kaplan-Meier estimator (starting from 1997)

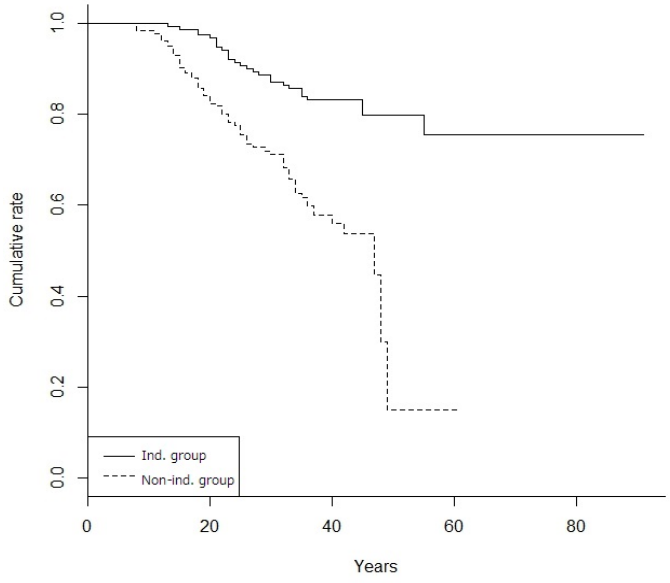

Fig. 3. Survival curves obtained from Kaplan-Meier estimator (starting from established year)

Table 1. Results of Cox proportional hazard regression analysis

Variable	Model 1	Model 2	Model 3
TYPE (0 = Ind.; 1 = Non-ind.)	0.894**	0.600*	0.662*
	(2.445)	(1.822)	(1.939)
SIZE	—	0.051	0.018
		(1.052)	(1.018)
SPE	—	0.139	0.128
		(1.149)	(1.136)
SPFT	—	0.025	0.015
		(1.025)	(1.015)
SCUST	—	0.017**	0.018**
		(1.017)	(1.018)
SI	—	—	-1.444*
			(0.236)
SOFT	—	—	-1.573*
			(0.207)
ENPRC	—	—	-2.823**
			(0.059)
PACK	—	—	-0.204
			(0.816)
HARD	—	—	-1.385
			(0.250)
DISP	—	—	-2.757
			(0.063)
Sample size	334	330	330
Number of events	96	95	95
$\chi 2$	16.166**	34.265**	47.803**

**, * Statistically significant respectively at 1% and 5% level.

Hazard ratios are in parentheses.

5. Conclusion

This paper analyzed the lifespan of the Japanese information service industry by using Kaplan-Meier estimator and Cox proportional hazard regression model on a sample of 344 firms. As a result, survival of the information service firms significantly depends on the degree of system integration sales ratio, software development sales ratio, and entrusted processing sales ratio. On the contrary, property of non-independent and high sales ratio with main customer have a negative influence on their survival rates.

We acknowledge there are some limitations in this study. First, our framework, especially the definition of the observation period of the survival analysis is not strictly elaborate. This is because of simplification but it is a main limitation. Second, location property which is one of the most important factors of any firm's survival is not taken into account in this study. And finally, our survival analysis do not identify between bankruptcy and temporary exits for

other reasons. Hence, future investigation, additional empirical analysis, is necessary. However, the results are potentially important because of providing useful information for practitioners. Many of founded significant factors depend on manager's choices, and, therefore, our results can help managers select optimal and/or successful strategies that increase their opportunities of survival.

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