ADOPTION OF SOFTWARE AS A SERVICE: A FUZZY APPROACH TO RANKING THE DETERMINANTS

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ABSTRACT

'Software as a Service' (SaaS) holds various benefits for organisations; however, SaaS solutions are not enjoying widespread adoption in South Africa. Hence, to improve the competitiveness of South African organisations, this study ranked SaaS adoption factors according to their influence on a SaaS adoption decision. This novel approach from a South African perspective implemented an integrated adoption model with the fuzzy analytic hierarchy process (AHP) with linguistic preference relations (LinPreRa). The top five adoption factors were found to be trust, relative advantage, security risk, complexity, and trialability. Implications for researchers, vendors, and end-users are also discussed.

OPSOMMING

Sagteware as 'n Diens (SanD) hou verskeie voordele vir organisasies in maar geniet egter nie wydverspreide aanvaarding in Suid Afrika nie. Om die mededingendheid van Suid Afrikaanse organisasies te verbeter, het hierdie studie SanD aanvaardingsfaktore gegradeer volgens hul invloed op 'n SanD aanvaardingsbesluit. Hierdie nuwe benadering vanuit 'n Suid Afrikaanse perspektief het 'n geïntegreerde aanvaardingsmodel geïmplementeer met die vae analitiese hierargie proses met taalkundige voorkeurverhoudinge. Die navorsingsresultate dui die top vyf aanvaardingsfaktore aan as vertroue, relatiewe voordeel, veiligheidsrisiko, kompleksiteit en beproefbaarheid. Implikasies vir navorsers, verskaffers en eindgebruikers word ook bespreek.

1. INTRODUCTION

1.1. The impact of SaaS

Dramatically reducing the total cost of ownership for software solutions can influence the accessibility of these solutions and impact the competitiveness of organisations, especially in developing countries such as South Africa. Cloud computing (CC) is a model that can enable this accessibility by allowing convenient, on-demand access to a shared pool of configurable resources that are made available with minimal management or vendor support (Lechesa, Seymour & Schuler, 2012). Commonly, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) are such CC models.

When considering IaaS, cloud service providers (CSPs) provide users with a combination of infrastructure-related services such as virtual servers, storage, and other fundamental computing resources that enable them to run their own operating systems, deploy their applications, and upload and download software or content into the cloud at the user's discretion (Senyo, Addae & Boateng, 2018). On the other hand, PaaS focuses on extending a platform to users to run and build applications through a programming interface that is made available and then supported by the CSP (Senyo et al., 2018).

In contrast, from a user perspective, the flexibility of the applications and infrastructure that are available on the cloud-based system is intentionally limited under the SaaS service offering. The functionality of an application is provided through 'Internet as a Service', which reduces the need to install and run the software on-premise on the user's hardware (Lee, Chae & Cho, 2013). This also implies, correctly, that the maintenance and development of the software remain the responsibility of the vendor (Oliveira, Martins, Sarker, Thomas & Popovič, 2019). Figure 1 summarises the various models, and indicates the degree of simplification available to the user.

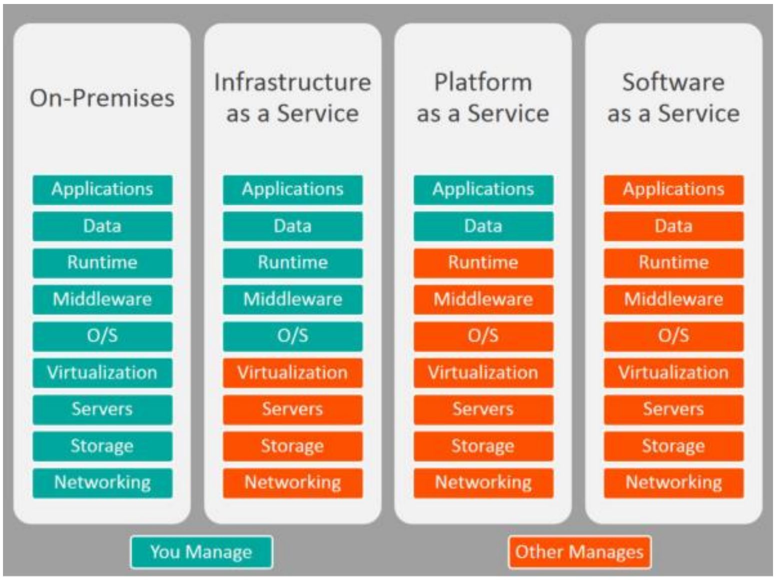

Figure 1: A visual representation of the various CC solutions (IaaS, PaaS, and SaaS), compared with traditional on-premise systems. Source: Watts (2019).

The SaaS model has the potential to increase technology accessibility, which is currently impeded by high costs and low technological maturity. This is driven by SaaS solutions offering businesses a low-cost alternative to on-premise software, thereby increasing the competitive nature of the organisation (Safari, Safari & Hasanzadeh, 2015).

This competitive advantage is a function of the associated SaaS benefits, including immediacy, pricing and total cost of ownership, superior information technology (IT) infrastructure, collaboration, ease of implementation, scalability/economies of scale, and related business benefits (Mokwena & Hlebela, 2018; Safari et al., 2015; Madisha & Van Belle, 2011). Because of the combination of these benefits and the ease of implementation, SaaS is considered the most advantageous cloud-based model (Yang, Sun, Zhang & Wang, 2015). For this reason, SaaS is the focus for this research.

Unfortunately, the above-mentioned benefits are offset by various challenges when adopting a SaaS solution. These include limited customisation, long-term sticker shock, integration problems, lack of open standards, perceived security concerns, business/organisational challenges, and barriers to entry in developing countries (Madisha & Van Belle, 2011; Lechesa et al., 2012; Senyo et al., 2018).

Even though SaaS solutions offer various benefits, a survey conducted by Lechesa et al. (2012:157) in South Africa proposes that the business impact and management of SaaS is unclear. This sentiment is further supported by the works of Mudzamba, Van Der Schyff and Renaud (2022) and Moonasar and Naicker (2018). This points to probable existing adoption constraints and inhibitors. The adoption rate in South Africa is also in strong contrast with that in other developing countries, such as Malaysia and Thailand, and their uptake of cloud-based solutions ((ACCA), 2020). This further validates the need to research SaaS adoption in a South African context, where adoption is lower than in its Brazilian, Russian, Indian, and Chinese counterparts. To adopt new technologies, organisations need to evaluate holistically the displacement of current solutions against the benefits of SaaS solutions (Cohen, Mou & Trope, 2014). To this end, it is important to identify the factors that would influence SaaS adoption in addressing the related SaaS adoption challenges that are emphasised in the literature.

1.2. Considering previous SaaS studies

To identify these factors, it is necessary to identify suitable technology adoption models that are used in the SaaS landscape. Senyo et al. (2018) identify the most common adoption models as technology, organisation, and environment (TOE), the technology acceptance model (TAM), and the resource-based view (RBV). An important distinction with TOE that is relevant to the conceptual model used in this study is the inclusion of the environmental effects, thus incorporating the internal and external contexts of an organisation.

Senyo et al. (2018:131-133) further mention the tendency to combine adoption models. Sharma, Gupta and Acharya (2020:12), in their study reviewing the available CC literature and its application in developing and developed countries, found that integrated models are among the most frequently used methods for assessing adoption. Van den Berg and Van der Lingen (2019) applied such a unifying approach by integrating various adoption models; and so this approach is also supported in the South African literature. Since the TOE model provides context to the various factors considered in adoption – technology, organisation, and environment – it is easily integrated with other models and theories. Two such theories that deserve mention are the diffusion of innovation (DOI) theory and the institutional (INT) theory.

DOI aims to define how, why, and at what rate any new idea or technology spreads at an individual or organisational level (Rogers, 2010). Therefore, DOI aims to explain how innovation is diffused within an organisation. From an organisational perspective, DOI defines the process of innovation adoption in five stages (Sharma, 2009). Chong and Chan (2012) suggest, however, that most studies focus on only three of these stages. These are the intention to adopt, adoption, and actual use or routinisation stages. Since the focus of this study is on adoption and not on continued use, only the first two stages will be considered. The common factors that form part of the DOI theory are relative advantage, compatibility, complexity, trialability, and observability (Martins, Oliveira & Thomas, 2016:21).

For its part, INT theory describes how organisations shape and influence the behaviour and intent of their employees (Chatterjee, Grewal & Sambamurth, 2002). INT implies that decision-making in an organisation might not be completely rational, but might also be based on social and cultural effects that impact it (DiMaggio & Powell, 1983). So organisations might adopt SaaS purely because they operate in an environment in which the level of SaaS adoption is high, or because the value of the technology is evident. To define effectively the scope of pressures impacting an organisation, the INT theory makes provision for the coercive, normative, and mimetic pressures influencing the organisation.

In discussing the DOI and INT theories, it should be clear that their use in combination with the TOE model provides clear benefits to this study. DOI lacks a structured breakdown of how the constructs impact organisations, and does not provide for any environmental considerations. INT theory increases the extensibility of the environmental construct of the TOE model. Integrating the DOI theory and the TOE model ensures a well-rounded research model with appropriate reach and with constructs that are relevant to research in the information systems fraternity.

Finally, to identify the adoption factors that influence a SaaS decision, the available literature was investigated. A summary of the research that was investigated, together with the included adoption factors, is given in Table 1 below.

Table 1: Summary of studies conducted that confirm SaaS adoption factors (bold indicates significance)

Author (year)	Adoption model	Country	Factors
Madisha and Van Belle (2011)	PERM	South Africa	Perceived organisational – **Awareness**, **human resources, technology resources**, commitment, governance. Perceived external – Government SaaS readiness, **market forces** SaaS readiness, support industry SaaS readiness. SaaS outsourcing – Application specificity, application uncertainty, the strategic value of SaaS, application inimitability.

Author (year)	**Adoption model**	**Country**	**Factors**
Mokwena and Hlebela (2018)	DOI	South Africa	Relative advantage, **complexity**, compatibility, **trialability**, awareness, **cost**.
Lechesa et al. (2012)	TOE	South Africa	Technology – Cost, customisation, application specificity. Organisation – Competitive advantage, organisation specificity. Environment – Network limitation, information and knowledge, security, regulation.
Cohen et al. (2014)	INT	South Africa	**Mimetic pressures**, normative pressures, **top management support**, **absorptive capacity**.
Alemeye and Getahun (2015)	TOE/DOI/ TAM/ Simulation	Ethiopia	Technology – Technological readiness, network connectivity. Organisation – Executive support and business case. Environment – Competitive pressure/ edge. Other – Perceived usefulness and perceived ease of use; Relative advantage, compatibility, trialability, and observable result.
Oliveira et al. (2019)	INT/TOE	Portugal	Technology – **Technology competence**. Organisation – **Top management support.** Environment – **Coercive pressures, normative pressures, mimetic pressures.**
Senyo, Effah and Addae (2016)	TOE	Ghana	Technology – **Relative advantage, security concern,** compatibility. Organisation – Firm size, firm scope, **Top management support, technology readiness**. Environment – **Competitive pressure, trading partner pressure,** regulatory support.
Sener, Gökalp and Eren (2016)	TOE (extended to AHP)	Literature study/ Turkey	Technology – **Relative advantage, trust, complexity, customisation, security and privacy.** Organisation – **Top management support, organisation size, business activity/cloud solution fit, organisation's IT resource**. Environment – **Competitive pressure, trading partner pressure, government policy and regulations, country-based infrastructure**.
Martins et al. (2016)	TOE/DOI	Portugal	Technology – **Relative advantage**, compatibility, **complexity**. Organisation – **Technology competence**, **top management support**. Environment – **Coercive pressures**, **normative pressures**, mimetic pressures.
Hsu and Lin (2015)	TOE	Taiwan	Technology – **Relative advantage**, ease of use, compatibility, trialability, **observability, security**. Organisation – Firm size, global scope, f**inancial costs**, **satisfaction with existing information systems**. Environment – **Competition intensity**, regulatory environment.

It is worth outlining the South African SaaS-related studies that are included in this research to sketch the existing South African SaaS research landscape. Madisha and Van Belle (2011) implemented the perceived e-readiness model (PERM) to investigate the factors that impact SaaS adoption and readiness in SMEs in South Africa. Key barriers to SaaS adoption included poor awareness, limited resources, expensive and poor internet infrastructure, and finally, security and privacy concerns. In contrast, the key enablers were good awareness, sufficient resources, affordable and reasonable internet infrastructure, guaranteed security and privacy, functionality, and business efficiency. In a related study, Mokwena and Hlebela (2018) expanded on the work done by Madisha and Van Belle (2011) by using the DOI to investigate the factors affecting SaaS adoption in SMEs.

Similar to the current study, Lechesa et al. (2012) chose to use the TOE model as a basis for model development. The findings of Lechesa et al. (2012) show that the environmental factors were key in impacting a SaaS adoption decision. Finally, in the study of Cohen et al. (2014), the proposed model references institutional theory in combination with DOI. Cohen et al. (2014) found that top management support had the most substantial impact on intended adoption, reinforcing the importance of managerial support.

The predominant research on SaaS relates to model development and hypothesis testing. This study is unique from a South African perspective, as it applies existing theories in a descriptive study.

1.3. Conceptual model

To build on the available literature, it is necessary to identify the factors with the most significant influence on a SaaS adoption decision. Furthermore, to emphasise this research's novel nature and to increase its social and scientific value, these adoption factors must be ranked by their impact on a SaaS decision. To this end, it is proposed that a multi-criteria decision-making (MCDM) methodology be followed. MCDM has been used in various studies in which the subjective evaluation of criteria is important (Zavadskas, Skibniewski & Antucheviciene, 2014). This is a fitting approach, since the ranking of adoption criteria is inherently subjective – as discussed in more depth in the research methods section.

To conclude the above discussion, the theoretical framework and the constructs mentioned are summarised and outlined in Figure 2, showing the conceptual model used in this study. The integration of the TOE, DOI, and INT models is shown, and reference is made to the weight (W) of the factors and how they influence adoption. The model forms the core of the study and of the approach to obtaining the relevant SaaS adoption weights.

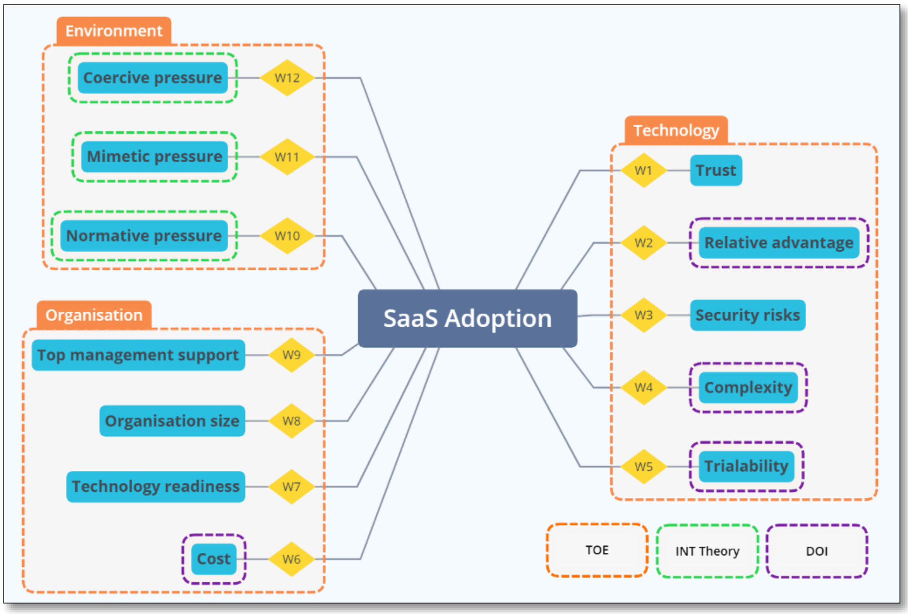

Figure 2: Conceptual model of this study (indicating the various models and weights)

The objective of this research is to define appropriate adoption models and adoption factors relating to SaaS in South Africa. This is emphasised in the conceptual model above. This research also aims to add social and scientific value by ranking these key adoption factors by way of MCDM to identify appropriately the importance of these factors during a SaaS adoption decision. Then the results are analysed, and recommendations are made to support vendors, organisations, and researchers in understanding the complexity of SaaS solutions and SaaS adoption better. With this approach and these insights, this research aims to improve the competitiveness of and access to SaaS technologies from a South African perspective.

2. RESEARCH METHODS AND DESIGN

Although a range of literature from a South African perspective provides clarity on the aspects that influence adoption, to the authors' knowledge, no research indicating the importance of these factors is available.

Applied research was conducted by using a quantitative method. This allowed the researcher to implement the available models and linkages between SaaS adoption factors and SaaS adoption by obtaining insights from various IT/CC practitioners. Furthermore, in combination with the MCDM technique, this quantitative methodology provided an opportunity to obtain subjective feedback from various experts to address the research objectives.

Since the descriptive research approach is concerned with describing current events and relates to what is being experienced, this was a fitting approach to investigate current SaaS adoption challenges in South Africa (Cohen, Manion & Morrison, 2013).

To capture the subjective opinion of the participants (the 'experts'), a survey was developed, distributed by making use of Qualtrics, and subsequently analysed to provide insights into the current SaaS adoption landscape. The survey required participants to evaluate a particular SaaS adoption factor over another in a pairwise comparison. This is the nature of the MCDM technique.

For this research to deliver valuable insights and to justify the use of MCDM techniques, it was required to assess the opinion of experts in the IT or CC fields. These individuals would need to be practitioners in the field and so have some intrinsic understanding of the benefits and challenges associated with SaaS solutions. These experts would also need to be in a position such that their insights and comments resembled an organisational adoption decision. For this reason, a selective sampling method was used to identify and target individuals with experience and knowledge of SaaS solutions. These included individuals fulfilling an IT/CC function and holding decision-making responsibility in an organisation (IT practitioners and managers, heads of IT, chief technology officers, etc.) and individuals with a keen understanding of the SaaS landscape (researchers, industry bodies, and trusted vendors). This selective sampling methodology was offset by a snowball sampling approach to increase the reach of the survey. An important consideration was that the quality of the results would be directly related to the quality of the expert opinion, and care needed to be taken to identify the experts accordingly. Pertinent demographic questions were therefore included in the survey.

Given the intended sample size, Fu and Chang (2016:1750) comment on the analytic hierarchy process (AHP) methodology by stating that the technique is not statistically based. This affects both how sample size is determined and how consistency is measured. Fu and Chang (2016:1750) also comment on the findings of various authors, including Herrera-Viedma, Herrera, Chiclana and Luque (2004), Duke and Aull-Hyde (2002), and Delbecq, Van de Ven and Gustafson (1975), who all confirm the suitability of smaller sample sizes, given the consideration that a homogeneous group of experts is used. Research practice has shown that a sample size of between ten and thirty participants is acceptable when using MCDM techniques to quantify experts' opinions (Fu & Chang, 2016:1750).

2.1. Applying the fuzzy LinPreRa methodology

To rank the adoption factors, MCDM methodologies were used. A common MCDM technique is AHP – a method that allows for the subjective judgement of an individual through pairwise matrix comparisons by constructing a ratio/weight scale that identifies the priorities from among the available alternatives (Saaty, 1980). One drawback of the conventional AHP technique is its ability to process data with inherent ambiguity. Since SaaS adoption in South Africa is reported in the literature to be low, it is expected that there will be ambiguity about the adoption factors.

For this reason, fuzzy logic was employed. Zadeh (1965) defines fuzzy logic as the process of making decisions when the problem is not well-defined. This is achieved by using fuzzy sets. These sets range from the inclusion of fuzzy triangular numbers in combination with the least-squares method to fuzzy trapezoidal numbers and geometric means in ranking the determinants (Van Laarhoven & Pedrycz, 1983; Buckley, 1985). However, these methods cannot guarantee the consistency of pairwise comparisons, and require a large number of items to be evaluated (Wang & Chen, 2008). Based on these findings, Wang and Chen (2008) propose the use of fuzzy linguistic preference relations (fuzzy LinPreRa).

The fuzzy LinPreRa technique replaces fuzzy triangular numbers with linguistic variables that indicate the preference for one construct over another, based on linguistic variables (very poor, poor, medium poor, medium, medium good, good, and very good) (Safari et al., 2015:406). This ensures consistency, increases accessibility, and improves the subjectivity of the ranking of the determinants – and was also the approach used in this research.

The fuzzy LinPreRa methodology is largely based on the work of Herrera-Viedma et al. (2004). Wang and Chen (2008) used this theoretical background to prove its application in the context of the fuzzy LinPreRa methodology. Therefore, based on the insights of Herrera-Viedma et al. (2004) and the implementation of Wang and Chen (2008), this approach has the following benefits:

- The number of evaluations (n) required by the participants is reduced from the traditional $\frac{n \times (n-1)}{2}$ to only $n-1$. This reduction in evaluations already increases consistency (fewer evaluations).
- Furthermore, by constructing a pairwise comparison matrix with additive reciprocal properties, consistency is mathematically included in the comparison.

The detailed mathematical proof of the fuzzy LinPreRa methodology and the use of linguistic transfer functions (TFNs) are outside the scope of this article. How the methodology is applied, however, is an important discussion.

To define the fuzzy LinPreRa reciprocal matrix, a decision will refer to an evaluation (P), based on the various set of alternatives $A = (a_1, a_2, \dots \dots .., a_n)$ and the membership function $P : A \times A \rightarrow [0,1]$ (Wang & Chen, 2008:3756). This translates into a fuzzy LinPreRa reciprocal matrix $\tilde{P} = (\tilde{p}_{ij})$ with dimensions $n \times n$. The various increments of this matrix $\tilde{P}$ are defined as $\tilde{p}_{ij} = (p_{ij}^L, p_{ij}^M, p_{ij}^R)$, as indicated in equation (1). This definition implements the TFN mapping, which shows the preference of aspect a_i over a_j based on linguistic preferences, as indicated in Table 2 (Wang & Chen, 2008:3759).

$$\boldsymbol{\tilde{P}} = \begin{bmatrix} \boldsymbol{\tilde{p}_{11} = (p_{11}^L, p_{11}^M, p_{11}^R)} & \cdots & \boldsymbol{\tilde{p}_{1n} = (p_{1n}^L, p_{1n}^M, p_{1n}^R)} \\ \vdots & \ddots & \vdots \\ \boldsymbol{\tilde{p}_{n1} = (p_{n1}^L, p_{n1}^M, p_{n1}^R)} & \cdots & \boldsymbol{\tilde{p}_{ij} = (p_{nn}^L, p_{nn}^M, p_{nn}^R)} \end{bmatrix} \tag{1}$$

Table 2: Fuzzy linguistic evaluation variables

Linguistic variables	Fuzzy numbers
Very poor (VP)	$(0, p_{VP}^M, p_{VP}^R)$
Medium (M)	$(p_M^L, 0.5, p_M^R)$
Very good (VG)	$(p_{VG}^L, p_{VG}^M, 1)$

Source: Wang and Chen (2008:3759)

To provide the discussed benefits, the fuzzy LinPreRa matrix needs to comply with certain conditions. Accordingly, the participants in this research would populate the $n-1$ cells of the matrix. The remaining cells would be mathematically calculated as indicated below.

- The matrix $\tilde{P} = (\tilde{p}_{ij})$ (where $\tilde{p}_{ij} \in [0,1]$) will be reciprocal when the following is true (Wang & Chen, 2008):

$$1) \quad p_{ij}^{L} + p_{ji}^{R} = 1 \forall i, j \in \{1, \dots, n\}$$

$$2) \quad p_{ij}^{M} + p_{ji}^{M} = 1 \forall i, j \in \{1, \dots, n\}$$

$$3) \quad p_{ij}^{R} + p_{ji}^{L} = 1 \forall i, j \in \{1, \dots, n\} \qquad (2)$$

- The matrix $\tilde{P} = (\tilde{p}_{ij})$ (where $\tilde{p}_{ij} \in [0,1]$) will be consistent when the following is true (Wang & Chen, 2008; Herrera-Viedma et al., 2004):

$$1) \quad p_{ij}^{L} + p_{jk}^{L} + p_{ki}^{R} = \frac{3}{2}, i < j < k$$

$$2) \quad p_{ij}^{M} + p_{jk}^{M} + p_{ki}^{M} = \frac{3}{2}, i < j < k$$

$$3) \quad p_{ii}^{R} + p_{ik}^{R} + p_{ki}^{L} = \frac{3}{2}, i < j < k$$

$$4) \quad p_{i(i+1)}^{L} + p_{(i+1)(i+2)}^{L} + \dots + p_{(j-1)j}^{L} + p_{ji}^{R} = \frac{j-i+1}{2} \forall, i < j$$

$$5) \quad p_{i(i+1)}^{M} + p_{(i+1)(i+2)}^{M} + \dots + p_{(j-1)j}^{M} + p_{ji}^{M} = \frac{j-i+1}{2} \forall, i < j$$

$$6) \quad p_{i(i+1)}^{R} + p_{(i+1)(i+2)}^{R} + \dots + p_{(j-1)j}^{R} + p_{ji}^{L} = \frac{j-i+1}{2} \forall, i < j \qquad (3)$$

With these conditions satisfied, the fuzzy LinPreRa matrix complied with the intended benefits, and was subsequently applied as an instrument in this research.

It was necessary also to consider how the methodology would be applied to rank the determinants of SaaS adoption. These steps were based on the approach by Herrera-Viedma et al. (2004), Wang and Chen (2008), and Safari et al. (2015).

- Step 1: The hierarchical structure of the problem to be evaluated is defined. In the case of this research, this refers to the adoption factors influencing SaaS adoption.

- Step 2: Evaluation takes place. The participants evaluate the alternatives as discussed, and start populating the incomplete fuzzy LinPreRa matrix $\tilde{P}$. This is achieved through the indicated $n-1$ number of evaluations to populate cells $\{p_{12,} p_{23}, \dots, p_{n-1,n}\}$. This serves as the evaluation by the experts.

- Step 3: For the fuzzy LinPreRa matrix to be valid and to comply with the reciprocity and consistency propositions, all the elements in the matrix have to be within $[0,1]$ (therefore $\tilde{p}_{ij} \in [0,1]$). Should any of the elements not fall within this criterion, the matrix will be transformed using the transformation function indicated below. In these equations, c is the maximum deviation within the elements from the $[0,1]$ goal.

$$1) \quad f(x^{L}) = \frac{x^{L}+c}{1+2c}$$

$$2) \quad f(x^{M}) = \frac{x^{M}+c}{1+2c}$$

$$3) \quad f(x^{R}) = \frac{x^{R}+c}{1+2c}. \qquad (4)$$

- Step 4: With the fuzzy LinPreRa matrix fully complete and meeting the requirements of reciprocity and consistency, it is required to determine the weights of the alternatives. This is achieved by using equation (5) to determine the average of each alternative, and then equation (6) to determine the weight (Wang & Chen, 2008).

$$\boldsymbol{A_i} = \frac{\mathbf{1}}{\boldsymbol{n}}\left(\sum\nolimits_{j=1}^{n} \boldsymbol{p_{ij}}\right) \tag{5}$$

$$\boldsymbol{W_i} = \boldsymbol{A_i}/\left(\sum\nolimits_{i=1}^{n} \boldsymbol{A_i}\right) \tag{6}$$

- Step 5: To rank the determinants according to their importance and impact, it is required to convert the fuzzy numbers back to crisp numbers. This can be done with the equation below, and the alternatives can then be ranked (Safari et al., 2015).

$$\boldsymbol{W_i} = \frac{\boldsymbol{w_i^L} + \boldsymbol{w_i^M} + \boldsymbol{w_i^R}}{\mathbf{3}} \tag{7}$$

3. RESULTS

From the distributed survey, sixty responses were received. A portion of the responses was disregarded owing to the demographic questions' evaluation and some responses being made autonomously. The latter is an unfortunate consequence of recruiting respondents through social media (Pozzar, Hammer, Underhill-Blazey, Wright, Tulsky, Hong, Gundersen & Berry, 2020). However, these responses did not influence the accuracy and integrity of the results. In total, thirty usable responses were received and incorporated into the analysis. This sample size was in line with other studies employing MCDM techniques (Fu & Chang, 2016:1750). To provide further context and insights, Table 3 summarises the expert participants and their associated demographics.

Table 3: Demography of the expert respondents

Measure	Description	Experts	
Industry	Academic	6	20
	Aerospace and defence	2	6.67
	Consumer products and retail	2	6.67
	Energy and utilities	5	16.67
	Industrial machinery and heavy equipment	2	6.67
	Insurance and financial	2	6.67
	Media and telecommunications	1	3.33
	Software development	10	33.33
Focus	Academic	5	16.67
	ICT consultant	2	6.67
	ICT decision-maker	12	40
	Service provider/developer	6	20
	Other	5	16.67

Measure	Description	Experts	
Company size	0 to 100	10	33.33
	101 to 1000	6	20
	1001 to 10000	6	20
	Greater than 10000	7	23.33
	Uncertain	1	3.33
SaaS adoption	Enterprise level	22	73.33
	Consumer level	5	16.67
	No adoption at the moment	3	10
Experience (years)	Less than 5	3	10
	6 to 10	5	16.67
	11 to 20	12	33.33
	Greater than 20	12	40

A key first step in the analysis process was to determine the simple numerical average value for the evaluations by the expert participants. This served as input values to the fuzzy LinPreRa matrix $\tilde{P}$ and populated cells $\{p_{12,} p_{23}, \dots, p_{n-1,n}\}$. With these inputs in place, equations (3) and (4) were used to fully populate the remainder of matrix $\tilde{P}$. The subsequent equations were implemented to ensure that the matrix entries were within the limits of $[0,1]$. This formed the basis for ranking the SaaS adoption factors.

Finally, with the completed fuzzy LinPreRa matrix $\tilde{P}$ in place, steps four and five above were implemented to rank the SaaS adoption factors. Then, by implementing equation (7), the fuzzy numbers were converted into crisp numbers, and, by following good mathematical practice, the weights were normalised. Finally, these normalised crisp numbers were used to rank the SaaS adoption factors. The associated result and the ranking for the SaaS adoption factors are indicated in Table 1Table 4.

Table 4: Ranking of the SaaS adoption factors with associated weights.

-	SaaS adoption factor	Overall rank	Weight	% difference from leading factor	Cumulative weight
Technology	Trust	1	0.1047	-	0.4683
	Relative advantage	2	0.0959	9.1424	
	Security risk	3	0.0933	12.1632	
	Complexity	4	0.0884	18.4001	
	Trialability	5	0.0860	21.7102	
Organisation	Cost	6	0.0836	25.1250	0.3151
	Technology readiness	7	0.0788	32.7979	
	Organisation size	8	0.0765	36.8260	
	Top management support	9	0.0762	37.3814	
Environment	Normative pressure	10	0.0728	43.7729	0.2166
	Coercive pressure	11	0.0721	45.1189	
	Mimetic pressure	12	0.0717	45.9957	

In addition, to rank the SaaS adoption factors, Table 4 showcases the percentage difference when the factors are compared with the weight of the most prominent (trust) factor and the cumulative weights of the elements associated with the TOE framework. This emphasises the importance of the technological (46.8%) context compared with the organisational (31.5%) and environmental (21.6%) contexts.

Finally, as a core element of this study, the updated conceptual model is shown in Figure 3. In addition, the relevant weight of the adoption factors is incorporated, and provides a clear graphical representation of the results.

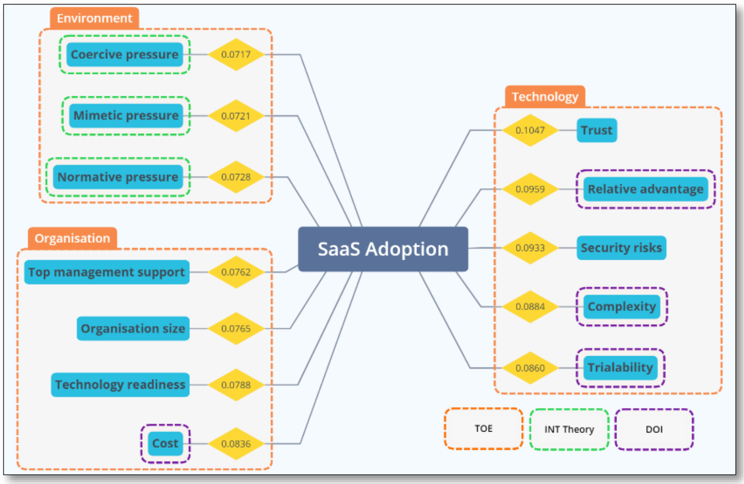

Figure 3: Updated conceptual model incorporating the weights of the SaaS adoption factors

4. DISCUSSION

4.1. Insights from South African SaaS adoption

The results clearly show that the technological and organisational contexts pertaining to a SaaS adoption decision receive preference, which supports the findings of Sener et al. (2016). Since the level of SaaS adoption in this study (indicated in Table 3) is relatively high, this does seem not to indicate a lack of awareness of SaaS solutions. Thus it is clear that decision-makers consider technological and organisational forces to be more important and relevant when considering SaaS solutions.

The five most significant factors are trust, relative advantage, security risk, complexity, and trialability. In other words, SaaS adopters value the extent to which a SaaS solution can deliver on its intended purpose and the extent to which a SaaS provider is trustworthy. This is in line with the findings of Faasen, Seymour and Schuler (2013). The high priority of the relative advantage factor further emphasises the importance of the benefits of a SaaS solution. This indicates a clear-headed decision-making approach, and demonstrates a good awareness of the associated benefits of SaaS solutions. This finding further validates the decreased importance of the environmental context, since adopters make decisions based on the benefits of a solution and not as a result of pressure from the organisational environment.

The ranking and associated importance of the security risk factor in this study supports the existing international literature in which MCDM techniques were applied, and emphasises the degree to which the integrity and security of a SaaS solution is a key adoption consideration. An important distinction, particularly relating to the work of Mokwena and Hlebela (2018), Lechesa et al. (2012), and Wessels and Jokonya (2022) is the contrasting finding that security risk is not ranked as the highest priority. This study thus differs from these past South African studies; and the ranking of security risk emphasises that vendors have succeeded in promoting the integrity and protection associated with SaaS solutions, and that the SaaS landscape in South Africa is increasingly mature.

The associated priority of the complexity factor indicates a healthy consideration by the decision-maker to evaluate the associated effort by implementing and using a SaaS solution. It is also comforting to note that complexity is not ranked as the most important factor, indicating increased maturity in the South African SaaS fraternity. Therefore, this finding seems to support the findings of Mokwena and Hlebela (2018) and to emphasise the importance of improving the ease of use of SaaS solutions by vendors.

Finally, trialability is an important consideration. From a South African perspective, this supports the findings of Madisha and Van Belle (2011). The importance of the trialability factor also supports the available SaaS literature.

A noteworthy finding to mention is the lower degree of importance of the cost factor. This ranking particularly supports the value tied to the benefits associated with SaaS solutions compared with the costs. This indicates rational decision-making on the part of the respondents, who did not base a decision purely on costs.

Considering the priority of top management support, this paper contrasts with some of the available literature – in particular, with the study by Cohen et al. (2014). Borrowing from the findings of Gutierrez, Boukrami and Lumsden (2015), however, the lower ranking of top management support seems to indicate an increased awareness of SaaS solutions and their benefits in the South African context. The driving factor behind such a statement arises from an apparent decrease in complexity and the lower risk associated with decision-making, thus decreasing the reliance on top management support.

4.2. Associated implications

This research has various implications. SaaS vendors should be sure to promote their status as a trusted partner; to make clear the associated relative advantages that are achievable with SaaS solutions; to guarantee that their solutions are secure; to reduce risk for the adopting organisation; to improve the ease of use of SaaS solutions; and finally, to ensure that the adopting organisation can easily experience solutions with trials as key activities.

From an organisational perspective, this research could guide the decision-maker when SaaS initiatives are considered – for example, focusing on the technological capabilities of the SaaS solution and its benefit to the organisation, rather than relying on pressures from the organisational environment or hoping that the relative advantage of the solution is clear enough. Finally, from a research perspective, by applying well-known adoption models with MCDM techniques, this study has built on the available local and international SaaS literature.

5. CONCLUSION

This study aimed to identify a suitable model for determining relevant SaaS adoption factors and to combine this with MCDM techniques to rank these factors in order of importance. Accordingly, appropriate recommendations can be made on how SaaS adoption decisions could be approached to increase the competitiveness of South African organisations.

To achieve the outlined objectives, a detailed literature review was conducted to identify relevant SaaS adoption factors and adoption models that have been shown to impact a SaaS adoption decision. Although various adoption models were considered, this research implemented the TOE model by integrating constructs from the DOI and INT models – a practice that is also supported in the literature (Sharma et al., 2020).

The constructs embedded in the conceptual model of this study needed to be evaluated to suitably rank the SaaS adoption factors in order of importance and to deliver on the objective of this research. To achieve this, fuzzy LinPreRa AHP was employed to obtain and evaluate the subjective opinion of experts in the ICT community. This approach was novel from a South African perspective.

The results emphasised the importance of the technological and organisational contexts of the TOE model. This correlates with the study by Sener et al. (2016), and indicates clearly that technological and organisational forces have the most substantial influence on SaaS decision-makers. Conversely, this indicates that the environmental context of a SaaS adoption decision could be assigned a lower priority.

The top SaaS adoption factors were identified as trust, relative advantage, security risk, complexity, and trialability. Analysing the positioning of these adoption factors, and comparing the results with findings from other international and South African studies, delivered valuable insights. In particular, the high importance assigned to relative advantage and the decreased importance of security risk and complexity indicated a maturing South African SaaS landscape.

This study has delivered unique insights, and is relevant from the perspective of SaaS vendors, SaaS adopters, and the research fraternity. Vendors could incorporate the insights provided and focus on the highest-ranking adoption factors to increase their competitive advantage and invest their organisational resources effectively. Similarly, organisations could use the findings of this study to reduce the complexity and uncertainty involved in making SaaS adoption decisions, and so streamline their decision-making. Finally, this study has added to the available SaaS literature in South Africa by not considering whether an adoption factor is significant, but rather by ranking the factors influencing SaaS adoption.

5.1. Future work

A qualitative study that obtains insights from SaaS decision-makers is a natural next step. This would provide the opportunity to discover, in greater depth, why the adoption factors included in this study were ranked in the manner indicated. Further investigation focusing on a specific demographic (industry, role in the organisation, organisation size, etc.) should also deliver valuable insights.

The challenges associated with a SaaS adoption decision were also not directly addressed by this study; thus this also offers an opportunity for future research. A similar methodology could also be followed to investigate IaaS and PaaS offerings.

Finally, this study and the format of its results are ideally positioned for studies that compare them with both future and past work.

5.2. Limitations

First and foremost, this study focused on South African organisations and the South African context. Also, from the context of CC technologies, this study considered SaaS solutions only, and therefore has no bearing on PaaS, IaaS, or other ‘as a Service’ solutions.

The focus of this study was also on experts in the ICT environment. To be more holistic, this study should reflect the opinion and concerns of the greater SaaS landscape; but no guarantee can be made as to the true general applicability of the results of this study without further investigation.

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