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ADOPTION DETERMINANTS OF FOG COMPUTING IN SAUDI ARABIAN PUBLIC ORGANISATIONS: A MIXED-METHODS STUDY USING THE FCA-SAPO FRAMEWORK

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ABSTRACT

A new paradigm in information technology and enterprise computing, fog computing allows organisations to significantly boost efficiency and productivity. It is essential in developing countries where resource efficiency is key. However, research is scarce in Saudi Arabia regarding fog computing adoption, especially identifying key influencing factors, benefits, and challenges. To bridge this gap, this study examines the determinants of fog computing adoption in Saudi Arabian public organisations through a mixed-method research approach. Initially, semi-structured interviews were conducted with 15 IT managers to gain qualitative insights. From these discussions, complexity was identified as the only significant barrier to adoption. Subsequently, a large-scale quantitative analysis was carried out, involving 665 IT managers and employees. This phase validated the proposed framework and revealed that, out of 12 identified factors, privacy, complexity, awareness, and senior management support were not significantly associated with adoption intention. By integrating qualitative and quantitative findings, this research highlights the crucial role played by technical, organisational, environmental, and financial factors in influencing fog computing adoption. These insights provide IT managers in Saudi public sector organisations with a comprehensive and strategic understanding, enabling them to make well-informed decisions regarding its effective implementation. With a structured and holistic approach, organisations can maximise the benefits of fog computing while effectively addressing potential challenges, ensuring its successful adoption in the evolving technological landscape.

KEYWORDS

FCA-SAPO Framework, Fog Computing, Mixed-Method Research

1. INTRODUCTION

By focusing on the public sector in Saudi Arabia, Examining Critical Factors in FCA-SAPO Framework provides a detailed understanding of fog computing adoption, addressing the unique challenges and strategic needs of public IT employees. Fog computing, a transformative technology, allows users to access computing resources locally without depending on centralised data centres, facilitating real-time data processing across various geographical locations (Wöbker *et al.*, 2018; Donno and Dragoni, 2019). As technological advancements, particularly in AI, reshape daily life, fog computing stands out as a promising solution for regions where efficient resource utilisation is crucial. This study investigates fog computing adoption in Saudi Arabian public organisations, a setting where challenges like service efficiency, data security, and regulatory compliance are heightened, particularly in alignment with Saudi Arabia's Vision 2030 goals.

Fog computing extends cloud capabilities by decentralising data processing, bringing it closer to data sources. This architectural shift improves latency and allows real-time decision-making, making it highly suitable for IoT, autonomous vehicles, and smart cities (Chiang and Zhang, 2016). The demand for decentralised systems has grown significantly as IoT devices produce increasing amounts of data, which centralised cloud solutions struggle to process efficiently (Bonomi *et al.*, 2012). Despite fog computing's promise, it faces adoption challenges such as security, privacy, interoperability, and resource management (Stojmenovic and Wen, 2014; Yi, Qin and Li, 2015). In developing nations like Saudi Arabia, fog computing offers substantial potential for enhanced service delivery, yet organisations often face obstacles tied to organisational readiness, workforce technical skills, and compliance requirements (Alqahtani, 2016; Alfaifi, 2022). Research in Saudi Arabia on the adoption of fog computing and similar technologies has highlighted issues related to the cultural and regulatory contexts, which can slow technology uptake and complicate adoption frameworks (Al Mudawi, Beloff and White, 2022). Notably, few studies have developed adoption models for the Saudi public sector, leaving a gap in the understanding of factors that could drive or hinder fog computing implementation in this context. Addressing this gap, the present study introduces a framework proposed to Saudi Arabian public organisations—the fog computing Adoption in Saudi Arabian Public Organisations (FCA-SAPO) framework, first proposed by Alyami, Beloff and White (2023).

The primary objective of this research is to identify the key technical, organisational, environmental, and financial factors influencing fog computing adoption in Saudi Arabia's public sector and to validate the FCA-SAPO framework designed for this purpose. To explore these objectives, this study uses twelve hypotheses to test the significance of various factors, including Quality of Service, Security, Technology Readiness, and Compliance with Regulations, hypothesising that these factors positively influence adoption. It also explores the potential barrier posed by Privacy, alongside other variables such as Complexity, Awareness, and Senior Management Support.

The scope of this research is limited to public sector organisations in Saudi Arabia, focusing on their specific challenges and benefits in adopting fog computing. While this context provides valuable insights, it also limits the study's applicability to other countries or sectors. The use of a mixed-methods approach, combining qualitative interviews with IT managers and quantitative surveys with both IT managers and employees, allows for a comprehensive analysis. However, the reliance on data from Saudi Arabian public organisations may not fully capture the broader organisational dynamics present in other settings.

The structure of this paper is as follows: Section 2 outlines the related work on the adoption of fog computing. Section 3 details the mixed-methods research methodology used to test the framework. Section 4 presents qualitative results from interviews with IT managers, and the quantitative survey findings. Section 5 discusses the implications of the findings, then finally, Section 6 closes with concluding with recommendations and potential directions for future research.

2. RELATED WORK

Fog computing represents a transformative paradigm that enhances computational efficiency by reducing latency and facilitating real-time data processing closer to data sources (Bonomi *et al.*, 2012). Unlike conventional Cloud computing, which is reliant on centralised data centres, fog computing distributes computational resources across multiple layers positioned between the Cloud and end-user devices. This architecture supports faster data processing and decision-making at the network edge, essential for applications requiring low-latency responses, such as the Internet of Things (IoT), autonomous vehicles, and smart cities (Chiang and Zhang, 2016). The rise in IoT devices has amplified the need for decentralized computing infrastructures, highlighting the crucial role of fog computing in managing the significant amounts of real-time data produced (Gubbi *et al.*, 2013; Mahmood and Ramachandran, 2018). However, while fog computing offers several benefits, its adoption also presents challenges, including issues of security, privacy, interoperability, and resource management (Stojmenovic and Wen, 2014; Yi, Qin and Li, 2015; Roman, Lopez and Mambo, 2018).

In developing countries, including Saudi Arabia, the adoption of fog computing presents both promising opportunities and obstacles. While potential benefits include enhanced service delivery and reduced latency, barriers to adoption remain significant, including organisational readiness, staff technical expertise, and regulatory constraints (Al-Mashari, 2002; Alharthi *et al.*, 2015). Additionally, cultural considerations and resistance to change pose further challenges (Alfaifi, 2022). Currently, a lack of a cohesive model to guide fog computing adoption within Saudi Arabia's public sector further complicates its implementation. Although considerable research has explored the technical and operational aspects of fog computing, there remains a lack of focus on a comprehensive adoption framework designed to public sector needs in Saudi Arabia. Much of the literature addresses general barriers to fog computing without examining factors specific to the region, such as regulatory readiness and the particular organisational characteristics of Saudi public institutions. Moreover, previous studies have tended to overlook the importance of financial considerations in the adoption process, a gap that is increasingly relevant given the significant investments required for infrastructure and technical training.

This study adopts and expands upon the Technology-Organisation-Environment (TOE) framework proposed by Tornatzky and Fleischer (1990) to examine fog computing adoption within Saudi public organisations. The TOE framework is ideal for the FCA-SAPO framework due to limitations in other theories. UTAUT omits key factors like privacy and regulation, TRA focuses narrowly on attitudes and norms, TAM overlooks organisational concerns like finance and policy, and DOI fails to address trust and contextual differences. Thus, TOE's comprehensive focus on technology, organisation, and environment makes it more suitable. Building on the FCA-SAPO framework introduced by Alyami, Beloff and White (2023), which identified critical factors influencing the adoption process in the public sector, this research integrates a financial context into the TOE model to address the economic factors influencing adoption. This framework includes four contextual domains: Technical, Organisational, Environmental, and Financial, each with unique influencing factors tailored to the Saudi context. By refining the FCA-SAPO framework, this study seeks to support fog computing adoption in Saudi Arabia's public sector by providing a structured approach for understanding and managing these key contextual elements. This current research validates the expanded framework, aiming to address the identified barriers and promote fog computing adoption across Saudi public organisations.

3. METHODOLOGY

This study employed a mixed-methods approach to examine factors influencing the intention to adopt fog computing within the FCA-SAPO framework, where the dependent variable is Adoption Intention, and the independent variables include Quality of Service, Security, Privacy, Compatibility, Complexity, Awareness, Senior Management Support, Technology Readiness, Competitive Pressures, Compliance with Regulations, Cost, and Maintenance. Following established research methodologies (Creswell, 2013; Neuman, 2014; Ishtiaq, 2019), data were collected from 15 IT managers through semi-structured interviews and 383 IT employees through surveys, achieving a 95% confidence level and a 5% margin of error, with a total of 665 participants involved.

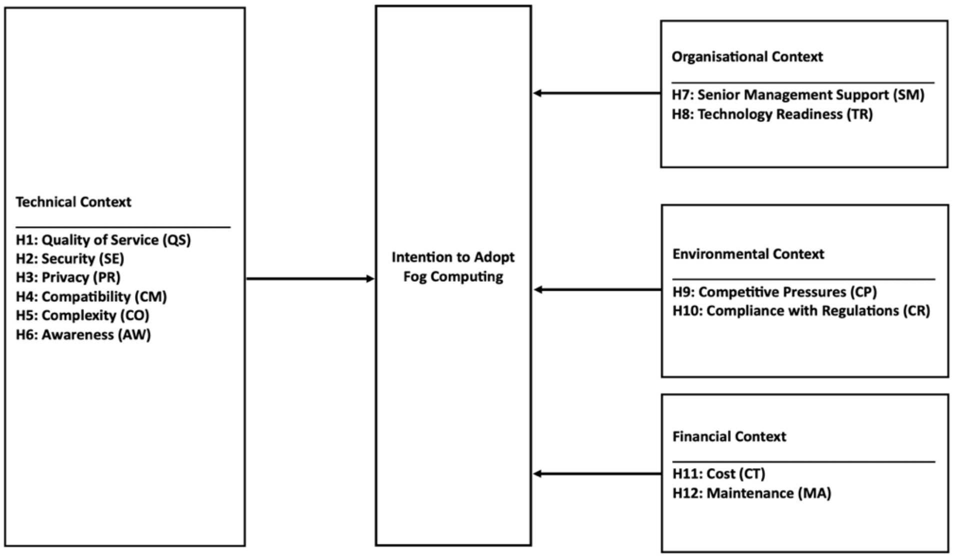

Figure 1. The conceptual research model of fog computing Adoption in Saudi Arabian Public Organisations (FCA-SAPO) (Alyami, Beloff and White, 2023)

To ensure a comprehensive understanding of fog computing adoption in Saudi Arabian public organisations, the qualitative phase used validated open-ended questions for descriptive insights, while the quantitative phase employed a structured survey based on FCA-SAPO's Technical, Organisational, Environmental, and Financial factors, using a 5-point Likert scale. Data analysis was conducted using SPSS and SmartPLS 3, with qualitative data securely stored under the University of Sussex's ethical guidelines (ER/MA2282/2).

4. RESULTS

The interviews with IT managers revealed nine main themes: enhancing service quality, security and privacy concerns, awareness initiatives, internal complexity, governmental challenges, organisational size variances, crucial compliance, financial complexity, and importance of considerations, see Figure 2. These themes highlight key factors for fog computing adoption, supporting the FCA-SAPO framework evaluation.

Quantitative analysis was conducted to understand fog computing adoption in Saudi Arabia's public organisations, surveying IT managers and employees via Qualtrics. Data were analysed with descriptive statistics (frequency, percentages, bar charts) and advanced statistical methods for model validation. Structural Equation Modeling (SEM) tested the FCA-SAPO framework's fit, and SPSS 26 and SmartPLS 3 were used for data analysis, ensuring normality, skewness, and other statistical prerequisites.

For technical factors, it includes quality of service (QS), security (SE), privacy (PR), compatibility (CM), complexity (CO), and awareness (AW). Organisational factors focus on senior management support (SM), and technology readiness (TR). Environmental factors are influenced by competitive pressures (CP) and compliance with regulations (CR). Financial factors cover cost (CT) and maintenance (MA).

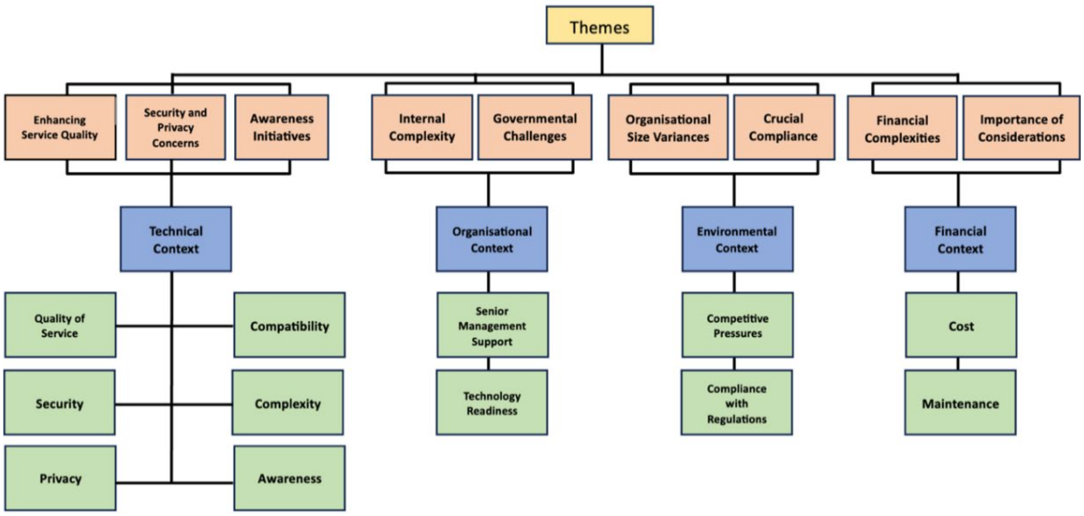

Figure 2. Identified themes from thematic analysis

4.1 Thematic Analysis

A comprehensive overview of the factors influencing the adoption of fog computing is provided in Figure 2 which illustrates the various factors that will be driving the adoption of fog computing in the context of the proposed framework (FCA-SAPO).

4.1.1 Quality of Service (QS)

QS is a fundamental driver of fog computing adoption, enhancing service efficiency and user experience. An IT director from KAU stated: *"The focus on quality of service represents an important aspect of adopting fog computing in government organisations, as care is taken to provide fast and responsive services, which enhances the user experience and improves performance."* This highlights the emphasis on efficiency and service improvement. Another interviewee from MOI highlighted: *"Fog computing is intended to provide a higher quality of service when retrieving data, reducing Internet slowness, slow support, and data analysis."* This demonstrates its role in addressing speed and performance issues. A senior IT manager from TVTC noted: *"Fog computing, which has the advantage that it is a local technology, will help solve the problems of system slowness and solve the problem of dependency on a single server and a single backup copy."* This suggests that local implementation enhances system stability. Collectively, these insights support the view that QS is a significant factor in fog computing adoption in Saudi Arabian public organisations, helping to overcome service inefficiencies and improve user satisfaction.

4.1.2 Security (SE)

The interview responses consistently highlight security as a critical factor. An IT director from KAU stressed: *"Organisations must take care of security and privacy concerns to ensure that data and information will be secure and properly protected while using this technology."* This underscores the necessity of security precautions. An IT manager from MOF stated: *"We need technology such as fog computing to ensure the confidentiality of data and also increase the security and encryption of data throughout the organisation."* This highlights its role in strengthening encryption and confidentiality. These findings indicate that SE plays a critical role in fog computing adoption, as strong security measures are essential to mitigate risks and maximise the technology's benefits.

4.1.3 Privacy (PR)

PR is crucial in protecting sensitive information. An IT manager from NEC noted: *"Privacy is very influential and useful; fog computing is important for protecting patient data and preventing unreliable access attempts."* This confirms its role in safeguarding personal data. An IT director from KAU added: *"Fog computing provides excellent privacy and efficiency for every organisation, with special controls implemented to protect employee and user information."* This illustrates the integration of privacy measures. PR is a key factor in ensuring the successful adoption of fog computing, as organisations must prioritise data protection to enhance efficiency and compliance.

4.1.4 Compatibility (CM)

CM is vital for seamless system integration. An IT director from NCA stated: *"The compatibility between new and old technology through networks and operating systems in the public sector* *is very important to make services fast and easy to use for system users."* This highlights the need for smooth technological integration. An interviewee from TVTC explained: *"Compatibility with legacy systems can be a challenge, but if compatibility requirements are defined, this challenge can be overcome. We have modern systems and keep them updated regularly, so there is no big problem regarding compatibility."* This suggests that proactive system updates can address compatibility issues. CM is a significant factor in fog computing adoption, requiring careful planning to integrate new technologies with existing infrastructures.

4.1.5 Complexity (CO)

CO can hinder adoption due to resistance to change. An IT manager from NEC pointed out: *"Complexity may be considered a negative aspect because fog computing is a new electronic services system and will often face resistance to change among the organisation's employees in the IT sector and other sectors."* This highlights the challenge of staff adaptation. An IT director from KAU stated: *"Fog computing may face technical complexities, but advance preparation and technical development make it possible to overcome these challenges, such as ensuring Internet speed and compatibility of the necessary devices and equipment."* This indicates that planning reduces complexity. Findings show that CO negatively impacts adoption, though proactive preparation can mitigate these challenges.

4.1.6 Awareness (AW)

AW is essential for successful adoption. An IT director from NCA stated: *"I think when adopting any technology, we will need workshops, which in turn raise awareness among fog computing users."* This highlights the role of training. An IT manager from NEC stressed: *"Employees must be aware of fog computing and its benefits and drawbacks before adopting it."* This confirms the importance of informed decision-making. AW is crucial for adoption, requiring organisations to invest in training programs and awareness campaigns.

4.1.7 Senior Management Support (SM)

SM influences adoption through policy and funding. An IT director from NCA noted: *"The support of senior management is very important, as they are responsible for enacting regulations and legislation to adopt any new technology."* This underscores leadership's role in policy-making. A participant from MOE stated: *"If organisations are not provided with the necessary support, it becomes very difficult to attract this new technology."* This highlights the need for managerial backing. SM is a critical factor in fog computing adoption, as leadership plays a key role in funding and implementation strategies.

4.1.8 Technology Readiness (TR)

TR ensures organisations have the infrastructure and skills needed for adoption. An IT director from MHRSD stated: *"It is worth noting that our technical readiness is there and there is no problem regarding compatibility, as we can successfully use fog computing without major problems."* This confirms the importance of existing IT infrastructure. An IT manager from KAU stressed: *"It is important for senior management and organisations to support and improve technology readiness to realise the full benefits of fog computing in government in Saudi Arabia."* This highlights the role of continuous improvement in IT capabilities. TR significantly affects adoption, requiring investment in infrastructure and IT expertise.

4.1.9 Competitive Pressures (CP)

CP pushes organisations to adopt fog computing in alignment with **Vision 2030**. An IT manager from MOF stated: *"Competitive pressure is crucial for keeping pace with Saudi Arabia's Vision 2023. Adopting fog computing ensures operational speed and security of user data."* This highlights competition as a motivator for adoption. An IT director from KAU added: *"When an industry witnesses successful implementation of fog computing in one organisation and it has not yet been adopted in other organisations, competitive pressure to adopt this technology to outperform and achieve superiority in performance and productivity may increase."* This suggests that adoption is driven by industry trends. CP has a positive impact on adoption, driving technological advancements and ensuring alignment with national objectives.

4.1.10 Compliance with Regulations (CR)

CR is necessary for legal and security standards. An IT director from KAU stated: *"Organisations with big number of employees must ensure that their use of fog computing complies with these regulations and laws."* This highlights the necessity of regulatory adherence. An IT manager from MOF explained: *"Senior management must identify work teams for the financial, regulatory and technical aspects after determining the regulations that must be implemented by them to ensure success when adopting new technologies."* This confirms the need for structured compliance teams. CR is a critical factor, ensuring legal compliance and security.

4.1.11 Cost (CT)

CT plays a crucial role in adoption, as financial planning and budget limitations influence implementation decisions. An IT manager from MOI noted: *"The cost of fog computing definitely requires financial statements and studying previous financial statements when implementing new technologies."* This highlights the importance of financial assessment before adoption. An IT administrator from JU explained: *"Government institutions with large numbers of users are the ones who receive financial support that enables them to attract new technologies such as fog computing. In contrast, technical cost will be an influential factor in Fog Computing in small government organisations due to the lack of financial capacity to pay for and maintain this new technical system through hardware, teams, and expertise."* This illustrates the financial gap between large and small organisations in adopting fog computing. CT is a key factor, with larger organisations having more resources for adoption, while smaller ones face financial constraints.

4.1.12 Maintenance (MA)

MA is essential for ensuring long-term system efficiency and reliability. An IT manager from MRM stated: *"Maintenance operations must be carefully considered, including determining its cost and allocating personnel and financial resources to it."* This highlights the importance of proper financial and workforce allocation. An IT director from MMRA reinforced this, saying: *"Maintenance for any technology is very important. A maintenance team must be provided to deal with all emergency or periodic cases of fog computing maintenance."* This stresses the need for dedicated personnel to manage upkeep. MA is crucial for sustainable fog computing adoption, requiring financial and human resource planning to prevent operational disruptions.

The main factors influencing fog computing adoption in Saudi public organisations include QS, SE, PR, CM, AW, SM, TR, CP, CR, CT, and MA. While CO may hinder adoption, training and support can help mitigate this. Adopting fog computing aligns with Vision 2030, enhancing service standards and operational security.

4.2 Descriptive Statistics

The FCA-SAPO framework, covering Technical, Organisational, Environmental, and Financial contexts, offers valuable insights. Table 1 summarises key demographic variables and their potential correlations with adoption factors across the four contexts. To enhance its practical relevance, exploring these correlations is significant. For instance, in the Technical Context, IT staff with different experience levels may perceive security or compatibility challenges differently. In the Organisational Context, technology readiness might vary by age group, revealing readiness gaps. Environmental factors, like compliance with regulations, could highlight differences in awareness across roles or sectors (e.g., education, finance, public health). Financially, cost perceptions may differ by organisational size, workforce, or education. These correlations can uncover group-specific patterns, offering actionable strategies to support fog computing adoption.

Table 1. Respondents' descriptive characteristics (N= 665)

Constructs	Categories	Number	Percentage
Gender	Male	553	83.2
	Female	112	16.8
Age	31-45 Years	471	70.8
	18-30 Years	178	26.8
	46-60 Years	16	2.4
Education level	Bachelor`s Degree	390	58.6
	Master`s Degree	272	40.9
	Diploma	2	0.3
	Doctorate Degree	1	0.2
Business nature of your organisation	Education	215	32.3
	Financial	163	24.5
	Public Health	142	21.4
	Other	117	17.6
	Retail	28	4.2
Number of employees in your organisation	10-49 Employees	412	62.0
	50-250 Employees	206	31.0
	More than 250 Employees	43	6.5
	1-9 Employees	4	0.6
Organisation's location	Southern Province	318	47.8
	Central Province	274	41.2
	Northern Province	73	11.0
Occupation in the organisation	IT Staff	489	73.5
	IT Director	158	23.8
	Director of the Governmental Organisation	10	1.5
	Other	8	1.2
Years of experience	Less than 10 Years	337	50.7
	More than 10 Years	223	33.5
	Less than 3 Years	104	15.6
	Less than 1 Year	1	0.2
Does your organisation adopt fog computing?	No	636	95.6
	Yes	29	4.4

Table 1 provides a detailed breakdown of the respondents' demographic characteristics, highlighting patterns that influence fog computing adoption. This analysis lays the foundation for understanding contextual factors.

4.3 Data Analysis and Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) was performed to validate the measurement model and test relationships between observed variables and latent constructs, following Hair et al. (2010). This approach confirmed the reliability of factors influencing fog computing adoption in Saudi Arabian public organisations, including Quality of Service (QS), Security (SE), Privacy (PR), Compatibility (CM), Complexity (CO), Awareness (AW), Senior Management Support (SM), Technology Readiness (TR), Competitive Pressures (CP), Compliance with Regulations (CR), Cost (CT), Maintenance (MA), and Adoption Intention (AI). The CFA findings support the robustness of these factors in the context of fog computing adoption.

4.4 Measures of the Model Validity

CFA, using SEM and SmartPLS 3, was applied to ensure unidimensionality, reliability, and discriminant validity. Constructs met the thresholds for Cronbach's Alpha (>0.7), Composite Reliability (>0.7), and AVE (>0.5), as shown in Table 2, ensuring model reliability and validity. Discriminant validity was established by AVE square roots exceeding inter-construct correlations, and all HTMT values were below 0.9, as recommended by Hair et al. (2010); Hair, Ringle and Sarstedt (2013). These results indicate that the model is statistically sound and valid for further analysis.

Table 2. Validity and reliability of constructs

Constructs	Cronbach's Alpha	Composite Reliability	AVE
Quality of Service	0.715	0.823	0.54
Security	0.743	0.834	0.557
Privacy	0.716	0.816	0.529
Compatibility	0.718	0.82	0.533
Complexity	0.713	0.75	0.500
Awareness	0.742	0.836	0.561
Senior Management Support	0.717	0.816	0.528
Technology Readiness	0.760	0.847	0.581
Competitive Pressures	0.747	0.838	0.565
Compliance with Regulations	0.803	0.871	0.628
Cost	0.762	0.847	0.582
Maintenance	0.814	0.878	0.643
Adoption Intention to fog computing	0.736	0.828	0.500

Table 2 presents the reliability and validity measures, ensuring that the constructs meet statistical requirements for further analysis. These findings reinforce the significance of the validated factors.

4.5 Model Good Fit

R-squared (R^2) analysis in Table 3, following Cohen (1988), showed an R^2 of 0.346 (33.4%) for (AI) which is greater than 0.25 reflecting a strong goodness of fit (based on R-square limits for SEM), indicating the model's substantial explanatory power for fog computing adoption intentions in Saudi public organisations, supporting its robustness (Hair, Ringle and Sarstedt, 2013). This R^2 value signifies that the model effectively explains a significant portion of the variance in adoption intentions.

Table 3. R-Square measure for goodness of fit

Dependent Variable	R Square	R Square Adjusted
Adoption Intention to fog computing	0.346	0.334

Table 3 demonstrates the explanatory power of the model, which provides a reliable foundation for the subsequent structural analysis.

4.6 Discriminant Validity

Discriminant validity ensures constructs are distinct, with low correlations among them. Using the Fornell-Larcker criterion and HTMT ratio, all values fell below 0.85, validating distinctness among constructs (Hair *et al.*, 2010; Hair, Ringle and Sarstedt, 2013). Table 4 summarises the HTMT matrix. The analysis confirms that each construct is unique and independent within the model.

Table 4. Hetero-Trait Mono-Trait (HTMT) for discriminant validity

Constructs	AI	AW	CM	CP	CO	CR	CT	MA	PR	QS	SE	SM	TR
AI													
AW	0.294												
CM	0.286	0.133											
CP	0.44	0.381	0.088										
CO	0.079	0.153	0.091	0.067									
CR	0.415	0.187	0.191	0.336	0.1								
CT	0.455	0.27	0.114	0.349	0.073	0.382							
MA	0.46	0.234	0.137	0.355	0.073	0.315	0.398						
PR	0.328	0.177	0.146	0.321	0.056	0.28	0.367	0.262					
QS	0.527	0.348	0.126	0.378	0.115	0.308	0.427	0.306	0.349				
SE	0.323	0.181	0.219	0.179	0.052	0.208	0.264	0.328	0.242	0.231			
SM	0.313	0.387	0.178	0.338	0.148	0.26	0.352	0.202	0.342	0.312	0.176		
TR	0.459	0.237	0.217	0.326	0.052	0.378	0.436	0.365	0.423	0.403	0.317	0.284	

Table 4 summarises the HTMT matrix. The analysis confirms that each construct is unique and independent within the model.

4.7 Structural Equation Model

SEM was utilised to assess the relationships within the FCA-SAPO model (Hair et al., 2010). Table 5 summarises results: significant predictors of (AI) included QS (β=0.205, p=0.0001), SE (β=0.067, p=0.017), CM (β=0.113, p=0.001), TR (β=0.09, p=0.008), CP (β=0.128, p=0.001), CR (β=0.102, p=0.006), CT (β=0.103, p=0.002), and MA (β=0.137, p=0.0001). Non-significant predictors were PR (β=0.027, p=0.424), CO (β=-0.003, p=0.957), AW (β=0.023, p=0.472), and SM (β=0.037, p=0.219), suggesting their limited role in fog computing adoption in the public sector. These results highlight key factors that are statistically significant in influencing Adoption Intention.

Table 5. Summary of hypotheses` results

Hypotheses	Paths	Coefficient	P-value	Results
H1	Quality of Service -> Adoption Intention to fog computing	0.205	0.0001	Supported
H2	Security -> Adoption Intention to fog computing	0.067	0.017	Supported
H3	Privacy -> Adoption Intention to fog computing	0.027	0.424	Rejected
H4	Compatibility -> Adoption Intention to fog computing	0.113	0.001	Supported
H5	Complexity -> Adoption Intention to fog computing	-0.003	0.957	Rejected
H6	Awareness -> Adoption Intention to fog computing	0.023	0.472	Rejected
H7	Senior Management Support -> Adoption Intention to fog computing	0.037	0.219	Rejected
H8	Technology Readiness -> Adoption Intention to fog computing	0.09	0.008	Supported
H9	Competitive Pressure -> Adoption Intention to fog computing	0.128	0.001	Supported
H10	Compliance with Regulations -> Adoption Intention to fog computing	0.102	0.006	Supported
H11	Cost -> Adoption Intention to fog computing	0.103	0.002	Supported
H12	Maintenance -> Adoption Intention to fog computing	0.137	0.0001	Supported

The results presented in this section provide a comprehensive analysis of the factors influencing fog computing adoption in Saudi public organisations. The findings validate the reliability and distinctiveness of the constructs and confirm the robustness of the FCA-SAPO framework. Furthermore, the structural model reveals the significant and non-significant predictors of Adoption Intention, offering actionable insights for practitioners and policymakers.

5. DISCUSSION

The **qualitative findings** showed that the adoption of fog computing in Saudi Arabian public organisations is influenced by a range of technical, organisational, environmental, and financial factors, each playing a crucial role in the decision-making process.

Technical Factors: The study identified several key technical aspects, including Quality of Service (QS), Security (SE), Privacy (PR), Compatibility (CM), Complexity (CO), and Awareness (AW). The implementation of fog computing was seen as a means to enhance service quality, improving data retrieval speeds and overall user experience. This technological advancement also significantly supported security and privacy measures, essential for protecting sensitive data and maintaining organisational trust. Compatibility issues were generally manageable, although some concerns arose regarding integration with existing legacy systems. The most notable challenge among the technical factors was Complexity (CO), where the introduction of new technologies encountered resistance, particularly due to a lack of familiarity and the perceived difficulty in adapting existing systems. This resistance underscored the need for thorough preparation and training to ease the transition to fog computing.

Organisational Factors: Senior Management Support (SM) and Technology Readiness (TR) emerged as critical organisational factors. The support from senior management was vital for providing the necessary strategic direction and resources, ensuring a smooth adoption process. The readiness of an organisation's technological infrastructure and the technical skills of its workforce were also crucial, with higher levels of readiness facilitating a more seamless integration of fog computing. The findings indicated that organisations with better-prepared infrastructure and knowledgeable staff were more likely to succeed in adopting this technology.

Environmental Factors: Competitive Pressures (CP) and Compliance with Regulations (CR) played significant roles as external influences. The competitive pressures, particularly within the context of Saudi Arabia's Vision 2030, encouraged organisations to adopt advanced technologies like fog computing to enhance their operational capabilities and maintain a competitive edge. This was especially relevant in the public sector, where technological advancements can lead to improved service delivery. Compliance with regulatory requirements was another critical factor, ensuring that the adoption of new technologies adhered to legal standards and protected sensitive data. This compliance not only mitigated potential legal risks but also ensured the security and privacy of information.

Financial Factors: Financial considerations, including Cost (CT) and Maintenance (MA), were pivotal in the decision-making process. The costs associated with implementing fog computing were a major concern, particularly for smaller organisations with limited budgets. The financial analysis revealed varying capacities among organisations to absorb these costs, with larger entities generally better positioned to manage the financial expense required for new technology. Effective planning for maintenance was highlighted as essential, as inadequate maintenance strategies could lead to increased costs and suboptimal use of the technology. Ensuring proper maintenance was crucial for sustaining the benefits of fog computing and preventing technical issues from escalating.

This section discusses the **quantitative analysis** of the updated framework in Figure 3 of fog computing Adoption in Saudi Arabian Public Organisations (FCA-SAPO), that examine the factors that influencing the adoption of fog computing in public organisations in Saudi Arabia. The analysis is based on path coefficients derived from statistical tests, supporting various hypotheses related to technical, organisational, environmental, and financial factors. Each finding is discussed with relevant supporting literature to validate the results.

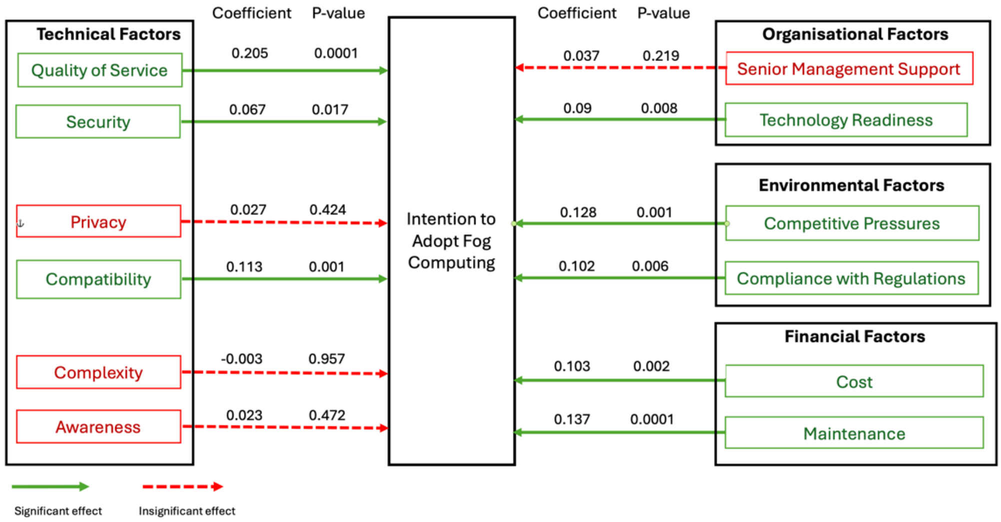

Figure 3. The updated FCA-SAPO framework

Technical Factors: In Quality of Service (QS), the analysis indicates a significant positive relationship between QS and the intention to adopt fog computing (AI), with a path coefficient of 0.205 (p = 0.0001). This supports the hypothesis (H1) that higher service quality enhances adoption intention. This finding is consistent with existing literature, where QS has been identified as a significant factor in the adoption of new technologies (Alkhater, Walters and Wills, 2018).

Security (SE) shows a modest but significant positive correlation with adoption intention (AI) (path coefficient = 0.067, p = 0.017), supporting hypothesis H2. Security has been emphasised in previous studies as one of the most important factors for the adoption of Cloud and fog computing technologies, affirming that enhanced security perceptions can drive adoption (Hashizume *et al.*, 2013).

For Privacy (PR), the path coefficient for privacy is 0.027, with a p-value of 0.424, indicating an insignificant relationship with adoption intention (AI). This leads to the rejection of hypothesis H3. This result aligns with some studies suggesting that privacy concerns, while important, may not be the primary determinant of technology adoption (Pearson, 2013). Some participants also reflected this, stating that while privacy is an essential feature, it may not be the critical factor driving adoption decisions: *"Privacy is important, but without other supporting factors like efficiency and data handling, it won't be enough to drive adoption alone."* [KAU].

Compatibility (CM) is significantly correlated with adoption intention (path coefficient = 0.113, p = 0.001), supporting hypothesis H4. The importance of compatibility with existing systems in facilitating technology adoption is well-documented in the literature (Rogers, Singhal and Quinlan, 2019).

Complexity (CO) and Awareness (AW) both were found to be insignificant, with path coefficients of -0.003 (p = 0.957) and 0.023 (p = 0.472), respectively. These findings reject hypotheses H5 and H6, suggesting that these factors do not significantly impact adoption intentions (AI). This is supported by research indicating that other factors may minimise complexity and awareness in the adoption decision process (Venkatesh and Bala, 2008; Alharbi, Atkins and Stanier, 2016). The participants' perspectives corroborate this result. For example, while some IT directors suggested that overcoming complexity was achievable through preparation, others acknowledged that *"I see the complexity of the technology affecting our ability to embrace fog computing in government."* [MHRSD] Similarly, though awareness was deemed important by some, other respondents pointed out that insufficient awareness among users, particularly in government settings, would decisively hinder adoption efforts [JU]. This emphasises the conclusion that complexity and awareness alone do not significantly drive adoption intentions.

Organisational Factors: In Senior Management Support (SM), the path coefficient for senior management support is 0.037 (p = 0.219), indicating an insignificant relationship with adoption intention, leading to the rejection of hypothesis H7. Additionally, one participant noted that *"the support of senior management is very important, as they are responsible for enacting regulations and legislation to adopt any new technology. But top management support is a challenge because of the long time it takes to legislate any new system."* [NCA] This reality further complicates the perceived significance of senior management support in technology adoption efforts. Theses finding contrast with some studies that emphasise the role of leadership in technology adoption by Thong et al. (Thong, 1999) but aligns with others suggesting variability depending on organisational context (Ifinedo, 2011). Research has shown that senior management support is a crucial factor in the successful adoption of new technologies, particularly because it provides the necessary resources, supports the technology with the organisation's strategic goals, and mitigates resistance to change (Chatterjee, Grewal and Sambamurthy, 2002). However, when the respondents are primarily technical staff, the perception of this support may be less significant, as they may not be directly involved in or aware of the strategic decision-making processes.

For Technology Readiness (TR), there is a positive and significant relationship between technology readiness and adoption intention (AI) (path coefficient = 0.09, p = 0.008), supporting hypothesis H8. In line with this, literature has shown that organisations that are technologically ready are more likely to adopt new technologies as compared to those that are not (Parasuraman and Colby, 2015).

Environmental Factors: Competitive Pressures (CP) have a strong positive and significant impact on adoption intention (AI) (path coefficient = 0.128, p = 0.001), supporting hypothesis H9. This finding is consistent with studies that identify competitive pressure as a key driver for technology adoption (Zhu and Kraemer, 2005).

For Compliance with Regulations (CR), the relationship between compliance with regulations and adoption intention is positive and significant (path coefficient = 0.102, p = 0.006), supporting hypothesis H10. Regulatory compliance is a critical factor in technology adoption, as highlighted in various studies (Mell and Grance, 2011).

Financial Factors: For Cost (CT), the cost factor shows a positive and significant influence on adoption intention (AI) (path coefficient = 0.103, p = 0.002), supporting hypothesis H11. This suggests that lower costs enhance the likelihood of adopting fog computing, aligning with findings from studies on cost considerations in technology adoption (Oliveira, Rosario Oliveira Martins and Fraga Martins, 2011).

Maintenance (MA) demonstrates a significant positive impact on adoption intention (AI) (path coefficient = 0.137, p = 0.0001), supporting hypothesis H12. Reduced maintenance requirements have been shown to facilitate technology adoption, as supported by existing literature (Thong, 1999).

6. CONCLUSION

This study has examined key factors influencing fog computing adoption in the Saudi Arabian public sector, an area requiring further exploration (Aazam, Zeadally and Harras, 2018; Brogi *et al.*, 2018). The findings highlight the importance of quality of service, security, privacy, compatibility, and awareness, while complexity remains a major barrier. Organisational factors such as senior management support and technology readiness play a crucial role, alongside external influences like regulatory compliance, competitive pressures, and financial considerations. Quantitative results confirmed these relationships, though privacy, complexity, awareness, and senior management support did not significantly impact adoption intentions.

By applying the FCA-SAPO framework, this study enhances understanding of technology adoption in developing regions, particularly within Saudi Arabia's public sector. To support fog computing adoption, IT managers and policymakers should focus on service quality, security, and compatibility while ensuring regulatory compliance. Allocating resources, simplifying complexity through training, and strengthening privacy measures can build trust and reduce resistance. Addressing cultural influences and incorporating diverse perspectives will further refine adoption strategies.

Future research should explore fog computing adoption in other developing regions, incorporating broader stakeholder perspectives for deeper insights. Additionally, integrating views from IT managers and employees in quantitative analyses will offer a more balanced perspective.

Finally, embedding cultural and social contexts into the FCA-SAPO model can clarify adoption factors, while longitudinal studies can track evolving challenges and enablers, refining the model over time.

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