Exploring the Landscape of Open Access Fibre Optic Cable Network in Sierra Leone

1st Fred Konneh Songa Monson, 2nd Alimamy Thomas Momodu

[1]PhD Candidate,[2] M Sc Student Telecommunications Management and Administration

[1]School of International Studies, [2]School of Technology

[1] Capital University of Economics and Business, Beijing, China, [2]Njala University, Freetown, Sierra Leone

Abstract - The goal of this study is to provide insightful information to the current discussion about how technology, development, and connectivity intersect in the global south with evidence from Sierra Leone. This paper surveyed 129 information technology professionals using a probability sampling method. Data was collected through a structured questionnaire, and analyzed using SMART PLS 4 and SPSS 21 to identify patterns and structure of the open-access fibre optic model. The SEM PLS approach was applied.

The study found significant positive relationships between economic benefits and user adoption benefits, technological advantages and user adoption benefits, but no significant relationship between technological challenges and user adoption benefits.

The study highlights the significant role of technological advantages and economic benefits in user adoption, emphasizing the need to consider organizational, technological, and environmental factors, but not technological challenges. The study emphasizes the need for targeted policies to support open-access fibre optic networks, focusing on regulatory frameworks, market structures, and technology infrastructure, fostering technological innovation and socio-economic development in developing nations.

Index Terms - Open access, fibre optic cable, network infrastructure, Sierra Leone, connectivity, telecommunications, prospects, challenges, comprehensive analysis.

I. INTRODUCTION

Millions of lives are changing as a result of high-speed internet [1]. According to Srivastava and Mukherjee [1], broadband has the power to fundamentally alter the economy and have a big impact on social and economic advancement. According to Kelly and Rossotto [2], the advantages of broadband can go beyond the ICT industry itself, having a ripple effect on the whole economy and acting as an essential component for every other industry, including finance, energy, transportation, health, and education. The introduction of high-speed broadband Internet services has resulted in modifications to the character and form of innovations inside the digital sphere [3]. By bringing people and local businesses together across geographic boundaries, the internet is transforming the fundamental nature of global business due to its capacity to connect global markets [4]. Developed and developing countries have recognized the potential of broadband and investing in building broadband infrastructure within the framework of their national agenda including Sierra Leone [1]. However, According to Kelly and Rossotto's [2] theory, there is still a broadband divide between developed and developing countries. Weir [5] established that when considering switching to a fibre-optic network, it's important to understand how it works, so that you can determine if it will work for you.

In the modern Sierra Leone, the deployment of open-access fibre optic cable networks marks a turning point in the country's technological development. The present study aims to conduct a thorough analysis of the advantages and difficulties associated with the application of this transformative model. Through the open-access fibre optic infrastructure, Sierra Leone can use the potential to promote sustainable development and close digital gaps as the digital era transforms international communication. This study intends to shed light on the opportunities and challenges this technological paradigm poses within the specific social and technological context of Sierra Leone by investigating its many facets.

The goal of the article is to advance our appreciation of the open-access fibre optic cable networks by adding to the group of literature already established. By carefully analyzing the opportunities and drawbacks of Sierra Leone's open access fibre optic network model, this paper provides practitioners and policymakers with important information that helps them make well informed decisions. By joining the Technological Organizational Environmental Framework (TOE) with the Perceived E-readiness model, new views and insights will be conveyed to bear on theoretical frameworks as well as real-world applications. Moreover, the logical methodology to data examination used in this study was Structural Equation Modeling on Partial Least Square Method (SEM PLS) using SMART PLS 4 and Statistical Package for the Social Sciences (SPSS 21) presents a systematic way for conducting rigorous research in the field and serves as a replicable guide for scholars.

The study's primary goal is to comprehend the dynamics of the economic benefits, technological advantages and technological challenges linked to user adoption of the open-access fibre optic network model in Sierra Leone. To shed light on the user-centric aspects of the model, the paper sought to do a thorough investigation of how people and communities interact with and benefit from this technological advancement. This paper sought to examine three dimensional relationships with the user adoption benefits of the open access fibre optic network model in Sierra Leone. The first aim of the research is to investigate the economic gains that result from the establishment of an open-access fibre optic network in Sierra Leone. It involves a thorough examination of how the model promotes entrepreneurship, boosts economic growth, and creates job opportunities in the nation. Next, the study explores the advantages of open-access fibre optic networks from a technological standpoint. By focusing on the user centric perception the study pursue to examine how users leverage the technological advancements facilitated by the model. Including assessments of the impact on a daily actions, innovation and overall quality of life for users. Finally, in finding solutions towards the technological challenges, the objective aims to investigate possible problems faced by users in Sierra Leone when adopting the open access fibre optic network model. It is vital to take a user-centric approach to understand the specific difficulties users encounter in terms of their anticipations. Through an analysis of the possible obstacles related to the open-access fibre optic network model's implementation in Sierra Leone, this investigation pursues to suggest significant insights into areas that might need attention, improvement, or creative results in order to promise the model's fruitful incorporation.

This study will seek to address three main questions arising from the objectives of the research. Including the following: What are the level of relationships based on economic benefits for the open-access fibre optic network model users in Sierra Leone? What technological advantages does Sierra Leone's open-access fibre optic network model offer its users? What technological obstacles does Sierra Leone's open-access fibre optic network model users face?

The absence of sufficient research on the application of the open-access fibre optic network model in Sierra Leone impedes the development of well-informed policies and decision making. The dearth of empirical data in the context of Sierra Leone emphasizes the necessity of conducting a thorough investigation into the complex effects of open-access fibre optic networks, which will benefit scholars and decision-makers alike. With unique evidence suited to the Sierra Leonean environment, this study aims to close this gap. Furthermore, the investigation of opportunities and difficulties related to the open-access fibre optic network concept in Sierra Leone holds significant potential for providing useful information for policymakers and operational implementation. By combining the Technological Organisational Environmental Framework (TOE) with the Perceived E-readiness model, this study seeks to offer new insights for theoretical frameworks and real-world implementations. Finally, the methodological technique used in data analysis provides academics with a systematic manual, which improves the prospects for next research projects.

This paper's structure is made up of six distinct sections. Section One is the Introduction, which set the stage for the study by outlining its importance and the reasons behind looking at the advantages and difficulties of putting an open-access fibre optic cable network model into practice in Sierra Leone. Subsequently, section two will conduct an extensive literature review, examining current understanding and perspectives pertinent to the study. Section three presents the theoretical framework and hypothesis development which will also include a conceptual exposition of the study and the formulation of hypotheses derived from well-established models. Section four focuses on the research methodology that presents the selected techniques and steps used in the gathering and examination of data. In the fifth section, the findings and their implications were systematically investigated through the presentation of results and discussions. To summarize the paper, the important findings were summarized in section six, conclusions, along with their theoretical and practical implications and an acknowledgement of any research limitations that were experienced.

II. LITERATURE REVIEW

The internet still has an impact on all facets of life, including businesses, healthcare, and education [1]. In order to provide faster data transfer rates, fibre-optic services are growing in popularity and networks are spreading to cover more ground [5]. The importance of broadband access has led to the government and business community prioritizing the development of its infrastructure [1]. An industry-wide paradigm shift in the telecommunications sector has occurred with the adoption of open access fibre optic networks, which promote diversity and equitable access. This model encourages fair competition and reduces barriers to entry for new entrants by permitting multiple service providers to share the physical fibre optic infrastructure. Weir [5] found that in order to determine whether fibre-optic networks are a good fit for your needs, it's important to understand how they operate.

Lee and Shin [6] claim that in order to provide telecommunication and broadcasting services, operators need to share their infrastructure with others who do not. According to Wu [7] enforcing open access has the potential to be counterproductive because broadband operators will endeavour, with the help of internet service providers, to prevent the provision of quality of service. Hogendorn [8] asserts that the open access model cannot promote content access and, as a result, cannot take the place of network neutrality. Consequently, the open access model becomes instrumental in democratizing connectivity and guaranteeing that a wider range of users can take advantage of the advantages of high-speed internet.

In recent times, major progress has been made on the subject of fibre optic and the open access network. For example Qiang's [9] study on information and communication for development illustrates the global trend in the direction of democratizing connectivity and promoting digital inclusion, with the open access fibre optic network model emerging as a powerful tool for extending reach and increasing impact in developing regions.

Srivastava & Mukherjee [1] examined the costs and benefits of connecting rural households to the national Optic fibre network in Rajasthan, India. They focused on calculating large costs and benefits of connecting rural households to the National Optical Fibre Network (NOFN), revealing a favourable cost benefit of 10 at the 5% level when using wired infrastructure to connect households. Oki1& Lawrence [10] reveal that the deployment of fibre optic networks, while promising, is mired by considerable costs, primarily attributed to the expenses related to drilling and trenching. Their study emphasized that addressing this cost challenge requires a collaborative approach among network operators, advocating for a customized pricing model that facilitates cost-sharing and provides shared benefits for both operators and rural internet users. Kelly and Rossotto [2] proposed that there is still a broadband divide between developed and developing nations.

The growing significance of broadband access and the deployment of open access fibre optic networks in Sierra Leone have resulted in a knowledge vacuum concerning the certain prospects and challenges that are particular to the country. There is a lack of research specifically designed to address the unique circumstances of Sierra Leone, despite the fact that previous studies like Qiang's [9] investigation of information and communication for development underline the worldwide trend toward democratizing connectivity. By offering distinctive evidence appropriate for the Sierra Leonean context, this study aims to close this gap and provide practitioners and policymakers with insightful information. Moreover, the combination of the Perceived E-readiness model and the Technological Organizational Environmental Framework (TOE) gives theoretical frameworks in the context of open-access fibre optic networks a fresh perspective that advances both theory and practice.

III. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

(1)Theoretical framework

A strong framework for investigating the deployment of an open-access fibre optic cable network model in Sierra Leone was anchored on two main models that formed the theoretical basis of this study: the Technological Organisational Environmental Framework (TOE) and the Perceived E-readiness model.

According to Tornatzky & Fleischer's [11] TOE framework, three factors; technological, organizational, and external environmental dimensions have an impact on technological innovation in organizations. Previous studies indicated that decision makers should consider these complex factors when considering technological innovation within their organizations [11; 12]. They provide an extensive understanding of the organizational context, which includes both informal and formal methods, communication processes, and organizational size [11]. The environmental context, which includes factors like market structure, government regulation, and technology infrastructure, and the technological context, which involves the availability and features of the technology [11; 12; 13].

The Perceived E-Readiness approach (PERM) is a more beneficial approach when applied to underdeveloped nations [12]. Molla and Licker [14] contended that a multi-perspective assessment that takes into account managerial, internal organisational, and external contextual elements is necessary for a thorough evaluation of the adoption of internet commerce in developing nations. Molla and Licker [14] postulated that the model includes two essential constructs for assessing factors that are both internal and external. Perceived Organization E-Readiness (POER), an internal factor, includes manager commitment, organizational readiness for e-commerce adoption, and organizational perception. The organization's evaluation and assessment of external factors, such as market forces, government support, and industry readiness for e-commerce adoption, are all covered in the external factor known as Perceived Environmental E-Readiness (PEER). During the model's development, a single validation test was done in South Africa. Moreover, important aspects indicators like sector, firm size, and employee educational background were not included [12; 14; 15; 16]

These models work in concert to produce a strong theoretical framework that allows for a comprehensive analysis of the complex dynamics underlying the installation of an open-access fibre optic cable network in Sierra Leone. While the Perceived E-readiness model illuminates the subjective aspects crucial to the effective application of technological advancements, the TOE model pledges a comprehensive evaluation of contextual factors.

(2) Hypothesis development

The study has the following hypothesis;

i. H1: Economic benefits of open access fibre optic network model in Sierra Leone is associated with the user adoption benefits.
ii. H2: Technological advantages of open access fibre optic network model in Sierra Leone is associated with the user adoption benefits.
iii. H3: Technological challenges of open access fibre optic network model in Sierra Leone is associated with the user adoption benefits.

(3) Research Model

The Study's model is given below:

Figure 1: *Showing the study's research model*
Source: Research (2024) compilation based on review of literature

IV. RESEARCH METHODOLOGY

(1) Study area

The study area is Sierra Leone, West Africa.

(2)Sampling technique

In order to choose study participants within the study area, this paper employs the probability sampling method. The best practice for sampling methodology and ensuring that study findings can be applied to the intended audience is to use probability samples [12].

(3)Data collection

Data was collected within the period September 2023 to November 2023. A structured questionnaire with a 7-point Likert scale, ranging from 1 (very poor) to 7 (excellent), was used to collect data for this study from 129 respondents. The purpose of the questionnaire was to determine respondents' opinions of the advantages and difficulties of Sierra Leone's open-access fibre optic model. The researcher selected online surveys using Google Forms as the method of choice, highlighting surveys as the best means of gathering information from a wide range of respondents. Information Technology practitioners from all regions of Sierra Leone, including students in ICT programs, lecturers, and ICT technicians employed by the public and private sectors, were included in the sample by random selection [12].

(4)Data Analysis

This paper utilized Structural Equation Modeling on Partial Least Square Method (SEM PLS) using SMART PLS 4 and Statistical Package for the Social Sciences (SPSS 21) to provide a comprehensive overview of the significant variables, descriptive and inferential statistics. Exploratory factor analysis using path analysis was used to uncover underlying patterns and structures in the data. According to Pituch & Stevens [17] exploratory factor analysis is frequently employed in the preliminary phases of a study to learn more about the relationships between a group of variables and is also used to verify dimensionality. PLS bootstrapping technique was used to assess the structure of the model.

This methodology enables a thorough understanding of the benefits and challenges associated with the implementation of an open-access fibre optic cable network model in Sierra Leone. By using these analytical methods, the chosen research topic will be supported in a thorough and insightful analysis.

V. RESULT AND DISCUSSIONS

In order to analyze the data, this study used the Partial Least Squire (PLS) approach to structural equation modeling (SEM), which was created by Wold [18] and has undergone multiple modifications. According to Henseler et al. [19], the tool was created for high dimensional data analysis in a low-structure setting. Initially, SPSS21 was used to analyze the respondents' demographic data. Second, exploratory factor analysis (EFA) was conducted using SMART PLS 4, in which the construct validity and reliability were evaluated as well as the underlying factors of the observable items investigated [20]. Ultimately, the PLS bootstrapping technique was used to analyze the model's structure.

The PLS-SEM approach was selected in accordance with Mseti's [20] recommendation, which emphasized that PLS is the best method for managing multiple latent variables, just like the research model in this article. Second, compared to the conventional ordinary least square regression technique, PLS has a lower sample requirement, according to Mseti [20]. Finally, PLS-SEM will have greater statistical power and converges quickly handling much larger and complex models [21]

(1) Demographic statistics of the respondents

Below is the demographic profile providing a comprehensive overview of the sample gender, age, qualifications, experience and regional locations.

Gender

The sample consist of 129 respondents, with 93 (72.1%) identified as male and 36 (27.9%) as female.

Age

In terms of the age distribution, the majority of respondents fall within the age range of 26 – 35 years, (45%), followed by 35-45years (31.8%), 46-60 years (17.1%), 16-25 years (5.4%), and 61 years and above (0.8%).

Qualification of the respondents

Regarding the educational qualifications, 51.2% of the respondents hold a bachelor's degree, 34.9% have a master's degree, 5.4% possess diploma, 16% holds a PhD and 7% indicated other qualifications.

Experience of respondents

The frequency distribution of respondents based on work experience within fibre optic environment reveals that 25.6% have less than 1 year of experience, 17.8% have 1- 5years , 27.1% have 6-10years, 17.8% have 11-15years, and 11.6% have 16years and above.

Regional locality of respondents

Based on table 5.1, the majority of the respondents (57.4%) are located in the Western area, followed by the Southern provience (21.7%), Eastern provience (10.1%), Northern Province (5.4%), and north western province (5.4%).

Table 1: Demographic profile of the respondents

Category	Variable	Frequency (N)	Percentage
Gender	Female	36	27.9
	Male	93	72.1
	Total	129	100
Age	16 - 25yrs	7	5.4
	26 – 35yrs	58	45.0
	36 – 45yrs	41	31.8
	46 – 60yrs	22	17.1
	61 years and above	1	.8
	Total	129	100.0
Qualifications of respondents	Bachelors	66	51.2
	Diploma	7	5.4
	Masters	45	34.9
	PhD	9	1.6
	Other	2	7.0
	Total	129	100.0
Experience of respondents	Less than 1 year	33	25.6
	1-5 years	23	17.8
	6-10 years	35	27.1
	11-15 years	23	17.8
	16 and above	15	11.6
	Total	129	100.0
Regional locality of respondents	Eastern province	13	10.1
	North Western province	7	5.4
	Northern Province	7	5.4
	Southern Province	28	21.7
	Western Area	74	57.4
	Total	129	100.0

Source: Field work (2024)

(2) *Measurement model*

Janadari et al [21] postulated that the first step is to assess the measurement model in PLS SEM analysis. According to Ho [22] the assessment of the measurement model that follows focused on ascertaining the reliability, validity, and internal consistency of the constructs that were measured with a range of articles.

(2.1) Exploratory factorial analysis

According to Tabachnick and Fidell [21], factor analysis is a multivariate statistical technique that can be used on a single set of variables to identify which variables form logical subsets that are reasonably independent of one another.

In this study, factor loadings were evaluated to explore the connection between the latent constructs and the corresponding items. Strong factor loadings for the economic benefits construct were shown by items EB1 (0.860), EB2 (0.887), EB3 (0.847), EB4 (0.872), and EB5 (0.889), indicating a strong correlation between the items and the overall construct. Item TA1 (0.858), TA2 (0.796), TA3 (0.830), TA4 (0.857), and TA5 (0.788) similarly showed significant factor loadings for technological advantages, indicating a significant correlation with the latent construct. Technological challenges factor loadings (TC1: 0.836, TC2: 0.852, TC3: 0.864, TC4: 0.835, TC5: 0.869) show a strong correlation between the construct and the items. Lastly, significant factor loadings were shown by items UAB1 (0.856), UAB2 (0.800), UBA3 (0.792), UBA4 (0.821), and UBA5 (0.889) in the user adoption benefits construct, demonstrating a strong correlation between the items and the overall construct. These results show that the measurement model is valid and that the chosen items accurately reflect the corresponding constructs.

(2.2) Assessment of construct reliability

According to Kline [24] a construct's reliability is measured by the degree of correlation between its indicators. The extent to which a variable or set of variables is consistent in what it is meant to measure is what Hair et al. [25] define as reliability. The reliability of a questionnaire is examined with Cronbach's alpha [26]. Cronbach's alpha, which ranges between 0 and 1, is considered acceptable when its value exceeds 0.7, indicating a high correlation among the items in the test [27]. The study's data shows a high level of internal consistency among the items within each construct, as evidenced by the high Cronbach's alpha scores for the various constructs. The economic benefits ($\alpha = 0.921$), technological advantages ($\alpha = 0.884$), technological challenges ($\alpha = 0.905$), and user adoption benefits ($\alpha = 0.888$) were the specific Cronbach's alpha scores. These alpha values significantly surpass the 0.7 cutoff, in accordance with the suggestion of Lavrakas [27] indicating a strong degree of reliability for the scales. As a result, the measurement tools used in this research have demonstrated strong internal consistency.

Composite reliability is a measure of internal consistency in scale items [28]. As with other reliability measures, the composite reliability cutoff is equal to 0.7, and a score of 0.6 to 0.7 is a good representation of construct reliability [29]. The internal consistency and reliability of the constructs were also evaluated by computing the composite reliability scores for the measurement scales. High composite reliability was found across the various constructs in the results, suggesting a high level of internal consistency for each latent variable. The economic benefits (CR = 0.940), technological advantages (CR = 0.915), technological challenges (CR = 0.929), and user adoption benefits (CR = 0.918) were the specific composite reliability scores. These values show the robustness and reliability of the measurement instruments used in this study, surpassing the suggested threshold of 0.70 [29]. The high composite reliability scores support the constructs' consistency and boost trust in the accuracy and stability of the study's scales.

Further Assessment of the construct reliability using the Rho_A coefficient, and the results were satisfactory. All latent constructs showed respectable degrees of internal consistency. The recommended threshold of 0.70 was exceeded by the Rho_A values for economic benefits (Rho_A = 0.759), technological advantages (Rho_A = 0.683), technological challenges (Rho_A = 0.725), and user adoption benefits (Rho_A = 0.693). These results imply that the measurement scales used in the research have strong internal consistency, supporting the consistency of the observed relationships within the model and enhancing the constructs' reliability.

(2.3) Assessment of construct validity

Validity concerns the soundness of the accuracy of a measure or the extent to which a score truthfully represents a concept [30]. According to Fornell and Larcker [31], the Average Variance Extracted (AVE) is a measure of the amount of variance a construct takes on relative to the amount of variance caused by measurement error. AVE is more than or equal to 0.5 confirms the convergent validity [26]. However, Fornell and Larcker [31] state that the construct's convergent validity is still sufficient if the AVE is less than 0.5 and the composite reliability is greater than 0.6.

In this study, the convergent validity of the constructs in this study was evaluated by computing the Average Variance Extracted (AVE) values for the measurement scales. The findings showed that every latent variable exceeded the suggested cutoff of 0.50 [26], including economic benefits (AVE = 0.759), technological advantages (AVE = 0.683), technological challenges (AVE = 0.725), and user adoption benefits (AVE = 0.693). These results imply that the constructs have a significant amount of shared variance that is represented by each of their indicators, indicating strong convergent validity. The convergent validity of the scales used in this study is supported by the strong AVE values, which validate the measurement tools' capacity to precisely measure the intended latent constructs.

The Heterotrait-Monotrait Ratio of Correlation (HTMT) was introduced by the recent research done by the Henseler,Ringle and Sarstedt [32] based on their Monte Carlo Simulation. According to Henseler et al., [33] in order to achieve discriminant validity the HTMT score should be between confidence interval value -1 and 1.

In accordance with the standards established by Henseler et al. [33], the Heterotrait-Monotrait Ratio of Correlation (HTMT) scores for the construct relationships showed a high level of discriminant validity. The HTMT scores for were significantly lower than the suggested upper limit of 1. According to these findings, the latent constructs in the model demonstrate adequate discriminant validity, proving that they capture different facets of the underlying constructs. The conclusion that the measurement model successfully discriminates between the various latent constructs is supported by the HTMT analysis, which gives confidence in the validity of the study's findings [33]. See table 3 for the HTMT scores.

Table 2: Showing Pattern mattrix, construct reliability and validity

Pattern mattrix , construct reliability and validity							
Main Construct	**Question number**	**Item code** (coded question)	**Factor loading**	**Cronbach's alpha**	**Rho_A**	**Composite reliability**	**Average variance extracted (AVE)**
Economic benefits	q1	EB1	0.860	0.921	0.922	0.940	0.759
	q2	EB2	0.887				
	q3	EB3	0.847				
	q4	EB4	0.872				
	q10	EB5	0.889				
Technological advantages	q11	TA1	0.858	0.884	0.888	0.915	0.683
	q12	TA2	0.796				
	q13	TA3	0.830				
	q14	TA4	0.857				
	q15	TA5	0.788				
Technological challenges	q16	TC1	0.836	0.905	0.907	0.929	0.725
	q17	TC2	0.852				
	q18	TC3	0.864				
	q19	TC4	0.835				
	q20	TC5	0.869				
User adoption benefits	q1	UAB1	0.856	0.888	0.892	0.918	0.693
	q2	UAB2	0.800				
	q3	UBA3	0.792				
	q4	UBA4	0.821				
	q5	UBA5	0.889				

Source: Field work (2024)

Table 3: Showing Heterotrait-Monotrait Ratio of Correlation (HTMT) scores for the construct

	Economic Benefits	Technological Advantages	Technological Challenges
Economic Benefits			
Technological Advantages	0.963		
Technological Challenges	0.876	0.937	
User Adoption Benefits	0.900	0.931	0.811

Source: Field work (2024)

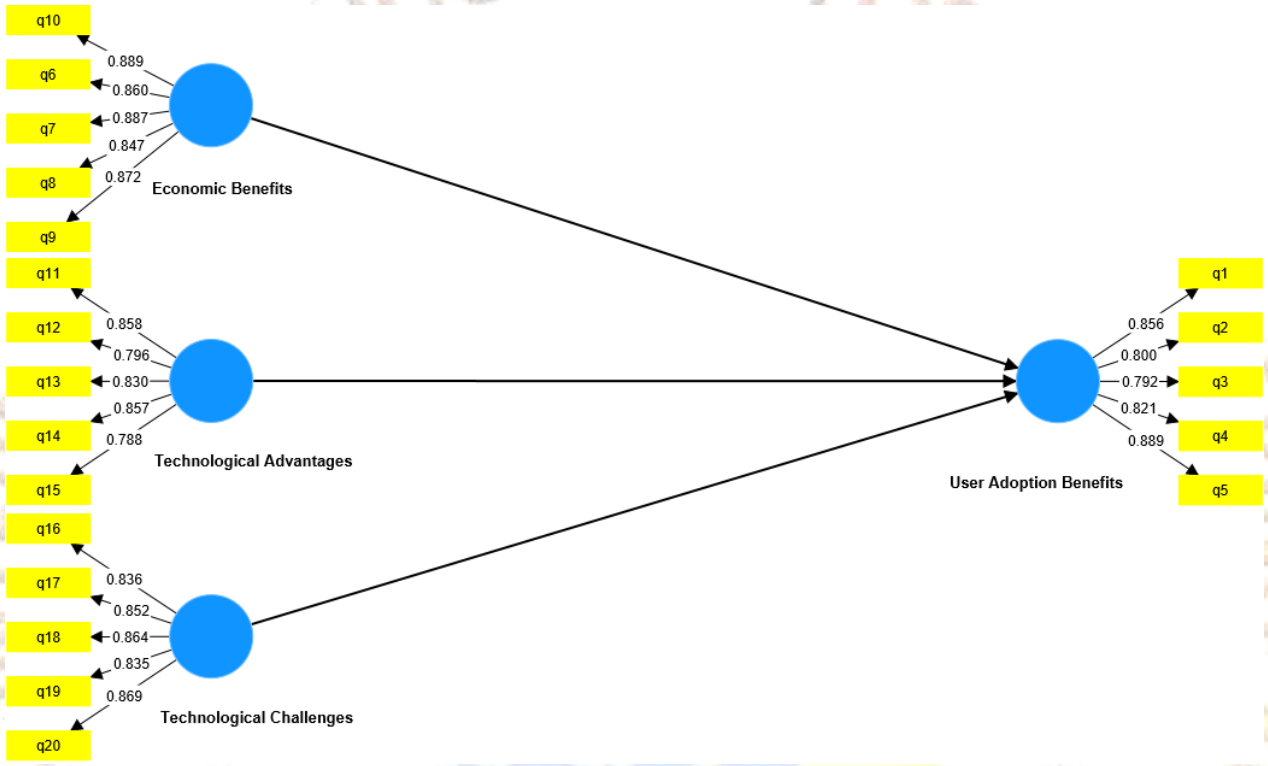

Figure 2 showing the outer loadings on the research model
Source: Field work (2024)

(2.4) Model fit

In order to prevent model misspecification, Henseler et al. [34] introduced the SRMR as a goodness of fit metric for PLS-SEM. According to Heseler et al. [34], a recent simulation study demonstrates that even fully correctly specified models can produce SRMR values of 0.06 and higher. According to Hu and Bentler [35], values of less than 0.08 are regarded as a good fit for the SRMR, which is defined as the difference between the observed correlation and the model implied correlation matrix. A good fit to the data was indicated by the Structural Model Root Mean Square Residual (SRMR) values of 0.066 for both the saturated and estimated models [34]. Furthermore, both models had the same other fit indices, d_ULS and d_G, at 0.919 and 0.943, respectively. For both the estimated and saturated models, the Chi-square value was 648.413. For both models, the Normed Fit Index (NFI) was 0.748. Overall, these findings point to a good fit between the estimated model and the data, matching the suggested PLS-SEM thresholds for a good model fit [34; 35].

Table 4: Showing model fit

Indicator	Saturated model	Estimated model
SRMR	0.066	0.066
d_ULS	0.919	0.919
d_G	0.943	0.943
Chi-square	648.413	648.413
NFI	0.748	0.748

Source: Field work (2024)

*(3) **Assessment of the structural model***

This study adopted the suggestion of Hair et al. [36] in assessing the structural model including, assessment of collinearity, path co efficient, level of R2, effect size f2 and the predictive relevance Q2.

(3.1) Assessment of the structural model for collinearity

Both outer and inner models were assessed for collinearity issues using the variance inflation factor (VIF). Significant multicollinearity concerns are indicated by a tolerance below 0.10 or a VIF greater than 10, according to Kline [37] and Myers [38]. The VIF values for each item in the outer model ranged from 1.942 to 3.554, which is significantly less than the critical threshold of 10. This suggests that there are no serious problems with multicollinearity [39; 40].

The constructs technological challenges, technological advantages, and economic benefits VIF values in the inner model were below the stricter threshold of 10 proposed by Myers [38]and Kline [37]. These values are 4.427, 5.317, and 3.603, respectively. Consequently, the VIF results show that the inner model does not have a serious multicollinearity problem.

Table 5: Showing outer model variance inflation factor

Outer model variance inflation factor	
Item	**variance inflation factor**
UAB1	2.445
UAB2	2.010
UAB3	2.737
UAB4	2.370
UAB5	3.554
EB1	2.817
EB2	2.988
EB3	2.499
EB4	3.049
EB5	3.052
TA1	2.457
TA2	2.005
TA3	2.312
TA4	2.458
TA6	1.942
TC1	2.725
TC2	3.164
TC3	2.845
TC4	3.17
TC5	2.632

Source: Field work (2024)

Table 6: Showing inner model variance inflation factor

Inner model variance inflation factor	
Main Construct	**variance inflation factor**
Economic benefits	4.427
Technological advantages	5.317
Technological challenges	3.603

Source: Field work (2024)

(3.2) Hypothesis testing

A statistically significant positive relationship was found along the structural path from economic benefits to user adoption benefits (β=0.388,t=2.757,p=0.006). This suggests that there is a direct correlation between rising economic benefits and rising user adoption benefits. The positive coefficient indicates that users are likely to see increased adoption benefits as long as entities in Sierra Leone benefit economically from the open-access fibre optic network. This result is consistent with the expectedly favourable effect of financial gains on user adoption in the context of the model under study.

In a similar vein, a strong positive correlation was found along the structural path that led from technological advantages to user adoption benefits (β =0.467,t=3.355,p=0.001). This suggests that a rise in the benefits associated with user adoption is correlated with an improvement in technological advantages. With the open-access fibre optic network making technological features and advancements more accessible, users in Sierra Leone should benefit from increased adoption. This is consistent with the more general understanding that improvements in technology have a positive impact on the adoption of users in the telecommunications industry.

In contrast, there was no statistically significant relationship observed in the structural path from technological challenges to user adoption benefits (β=0.029, t=0.290, p=0.772). This suggests that, generally speaking, technological challenges have no statistically significant effect on user adoption benefits in the model. This finding implies that, despite possible obstacles to technology adoption, these obstacles do not appreciably reduce the advantages of adoption that users in Sierra Leone enjoy. This result emphasizes how adaptable or resilient users are, as well as how well the open-access fibre optic network mitigates any potential negatives.

To summarize, the structural model of the study shows that in Sierra Leone, technological advantages and economic benefits both significantly increase user adoption benefits. However, in the context of the model under examination, technological challenges do not show a statistically significant impact on adoption benefits.

On the other hand, the model's coefficient of determination (R^2) is 0.725, indicating that the combined effects of technological advantages, technological challenges, and economic benefits can account for roughly 72.5% of the variability in the user adoption benefits. This high R2 value suggests that the model has a strong capacity to explain the variance in the benefits of user adoption that has been observed. The number of predictors in the model is taken into consideration by the adjusted R^2 of 0.718. In this instance, it implies that, after controlling for the number of predictors in the model, the predictors account for roughly 71.8% of the variance in the benefits of user adoption.

The selected predictors (technological challenges, technological advantages, and economic benefits) collectively contribute significantly to explaining the variations in user adoption benefits in the Sierra Leonean context. Overall, the $R^2$and adjusted R^2 values indicate a strong model fit. This shows that the model effectively captures the underlying relationships among the variables and has a significant amount of explanatory power.

Table 7: Showing Path coefficients, Sample mean, standard deviations, T-Statistics and P Values

Main constructs	Path coefficients	Sample mean (M)	Standard deviation	T statistics	P values
Economic benefits -> user adoption benefits	0.388	0.372	0.141	2.757	0.006
Technological advantages -> user adoption benefits	0.467	0.471	0.139	3.355	0.001
Technological challenges -> user adoption benefits	0.029	0.043	0.1	0.29	0.772
R^2 = 0.725, Adjusted R^2 = 0.718					

Source: Field work (2024)

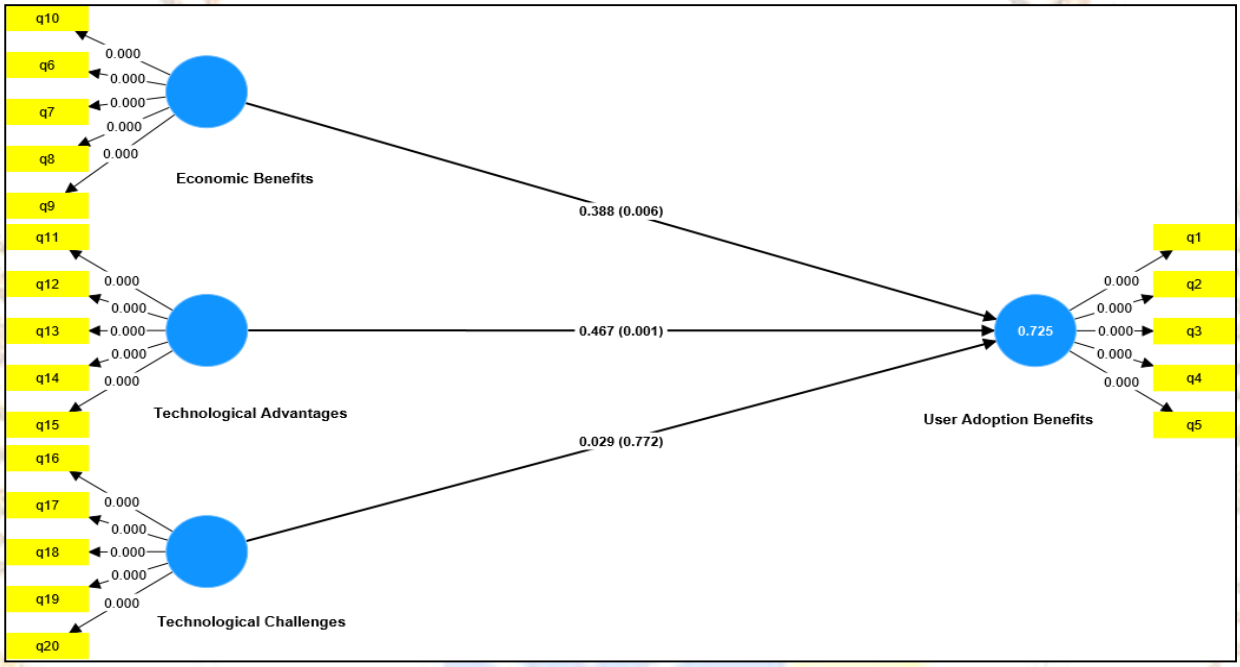

Figure 3: Showing the path coefficients and p values of the inner model the research model
Source: Field work (2024)

(3.3) Predictive relevance and effect size

The predictive relevance of the study model can be assessed through the Stone Geisser nonparametric test ([41; 42; 43; 44]. To evaluate the model's predictive ability, the Q^2predict values were in conjunction with an examination of PLS-SEM_RMSE and PLS-SEM_MAE comparison to the naïve LM benchmark. The Q^2predict values for the User Adoption Benefits (UAB) indicators were found to be between 0.384 and 0.547 indicating good prediction power. Then, the PLS-SEM_RMSE and PLS-SEM_MAE values were compared to the naïve LM benchmark values for each indicator. PLS-SEM_RMSE and PLS-SEM_MAE for UAB1, UAB3 and UBA4 were lower than their corresponding LM benchmarks demonstrating strong predictive power. As opposed to LM benchmarks, UAB2 and UAB5 showed slightly a greater PLS-SEM_RMSE and PLS-SEM_MAE values, indicating a medium degree of predictive power as suggested by Shmueli et al [45].

Furthermore, the Cohen's [46] framework emphasizes the significance of f^2 values in determining the significance of effect size. According to Cohen's [46] criteria, f^2 values above 0.35, 0.15, and 0.02 are considered strong, moderate, and weak, respectively.

The findings from the studied model, where technological advantages exhibit a moderate effect size (f^2 = 0.149) signifying their significant role in elucidating the variation observed in user adoption benefits, are particularly insightful. Additionally, the negligible impact of economic benefits, indicated by a weak effect size (f^2 = 0.123), and the minimal influence of technological challenges, represented by a small effect size (f^2 = 0.001), provide valuable insights into the varying levels of significance of predictor constructs in relation to user adoption benefits. These results are in agreement with the path coefficients, t-statistics and p-values of the study, hence demonstrating consistency in all result output.

Table 8: Showing the predictive relevance of the model

Indicators	Q^2predict	PLS-SEM_RMSE	PLS-SEM_MAE	LM_RMSE	LM_MAE

UAB1	0.547	1.486	1.149	1.599	1.168
UAB2	0.468	1.534	1.181	1.529	1.143
UAB3	0.384	1.609	1.237	1.674	1.28
UAB4	0.484	1.461	1.178	1.549	1.184
UAb5	0.533	1.448	1.139	1.422	1.032

Source: Field work (2024)

VI. CONCLUSIONS AND THEORETICAL CONTRIBUTIONS

(1) Conclusions

The study assessed the measurement model, construct reliability, construct validity, and model fit in Sierra Leone's open-access fibre optic network. It used exploratory factor analysis and found strong correlations between items and constructs, confirming the model's validity. High construct reliability scores indicated robust internal consistency. This paper established construct validity through AVE values exceeding the suggested threshold, confirming convergent validity and distinctiveness of latent constructs, and Heterotrait-Monotrait Ratio of Correlation scores below the superior boundary of 1.

The Structural Model Root Mean Square Residual (SRMR) and Variance Inflation Factor (VIF) were utilised to evaluate model fit, yielding values below 0.08 for good fit and no significant multicollinearity issues, as per Hu and Bentler [35]. The study found significant positive relationships between economic benefits and user adoption benefits, technological advantages and user adoption benefits, but no significant relationship between technological challenges and user adoption benefits.

The assessment of measurement and structural models, construct reliability, validity, and predictive capability in the study established strong effectiveness in explaining and foreseeing user adoption benefits within the open-access fibre optic network environment of Sierra Leone.

(2)Theoretical contribution

This work has numerous theoretical implications. First off, the inclusion and expansion of the Perceived E-readiness model (PERM) and the Technological Organizational Environmental Framework (TOE) into the examination of Sierra Leone's open-access fibre optic network deployment provide a fresh viewpoint. By showcasing these frameworks' adaptability and relevance outside of their original settings, their application in the context of developing nations enhances the body of literature.

Secondly, the study makes a methodological contribution by using the PLS-SEM approach, which is designed for low-structure, complex settings. The application of PLS-SEM offers a strong analytical framework for investigating the variables influencing technology adoption in Sierra Leone and is in line with the complexities of the study context.

Thirdly, a comprehensive methodology is showcased through the utilization of bootstrapping, exploratory factor analysis (EFA), and demographic analysis within the PLS-SEM framework. This highlights the study's dedication to thorough analysis and adds to the toolkit of methodological resources available to researchers looking into related contexts.

Finally, the research enriches our comprehension of TOE and PERM in Sierra Leone through the analysis of market structure, government backing, and communication channels, thereby adding depth to the theoretical framework for the uptake of technological advancements in developing nations.

(3)Implications for practice

The study suggests that Sierra Leone and other developing nations should prioritize creating an environment that encourages technological innovation, including economic development, addressing technological challenges, and enhancing organizational readiness for open access fibre optic networks. Government initiatives should focus on market structures, regulatory frameworks, and technology infrastructure to create a conducive ecosystem for successful network deployment.

The study highlights the importance of governments in promoting open access fibre optic networks. By aligning policies with findings, governments can stimulate economic benefits, enhance technological advantages, and address challenges. Policymakers should collaborate with industry stakeholders to develop regulations for efficient network use. Government support for user adoption initiatives can enhance the success and sustainability of open access fibre optic projects.

For the mobile and telecommunication sectors, the study underscores the importance of technological advantages in influencing user adoption benefits. Mobile and telecommunication companies should invest in advancing their technological capabilities, ensuring that they remain at the forefront of innovation. Concerted partnerships with fibre optic companies can improve the industry's preparedness for embracing open-access networks, resulting in enhanced services and advantages for users.

The study suggests that fibre optic enterprises can use the findings to improve their strategies and offerings, emphasizing the economic benefits of open-access networks. Addressing technological challenges through research and development can improve network reliability and effectiveness, promoting greater user adoption.

The study suggests a cooperative strategy involving governments, mobile and telecommunication industries, fibre optic businesses, and policymakers to ensure successful deployment of open-access fibre optic networks in Sierra Leone. This method tackles economic, technological, and organizational elements to maximize the socio-economic benefits of improved telecommunications infrastructure in developing nations.

(4) Limitations of the study

It is important to recognize that this study has certain limitations. Firstly, the assumptions drawn are specific to the unique context of Sierra Leone, which may limit their generalizability to other regions. The results may not be applicable to other areas due to the nation's specific socio-political and economic circumstances. Second, there's a chance of response bias because the study relies on self-reported data from questionnaires. The precision of the data may be affected by participants giving socially acceptable answers to particular questions. Furthermore, the cross-sectional research design employed has its own limitations. A more comprehensive understanding of the dynamic nature of open-access fibre optic network models may be provided by longitudinal studies. Nevertheless, the study offers insightful perspectives into the Sierra Leonean context and lays the groundwork for future investigations in this nascent field.

Acknowledgement

The authors express their sincere gratitude to the Capital University of Economics and Business's School of International Studies and Njala University's School of Technology for providing a supportive atmosphere for the research.

VII. REFERENCES

[1] Srivastava, R. & Mukherjee, E. (2018) Costs and Benefits of Connecting Rural Households to the National Optic Fibre Network in Rajasthan, Rajasthan Priorities, Copenhagen Consensus Center.
[2] Kelly, T. and Rossotto, C., M., (2012) Broadband Strategies Handbook, International Bank for Reconstruction and Development / International Development Association.
[3] Rao, B. (2001). Broadband innovation and the customer experience imperative. International Journal on Media Management.
[4] Sprano, E. &. (2000). E-commerce capable: Competitive advantage for countries in the new world e-conomy: Competitiveness review: An international business journal incorporating Journal of Global Competitiveness.
[5] Weir, M. (2021) A guide to fibre optics, and how fibre-optic networks are improving data transfer, https://www.businessinsider.com/guides/tech/fibre-optic (Retrieved on 16th January 2024)
[6] Lee, D. and Shin, D.-H. (2016), "The effects of network neutrality on the incentive to discriminate, invest, and innovate: a literature review", info, Vol. 18 No. 3, pp. 42-57. https://doi.org/10.1108/info-12-2015-0053.
[7] Wu, T. (2003). Network neutrality, broadband discrimination. Journal of Telecommunications and High Technology Law, 2, 141-178.
[8] Hogendorn, C. (2007). "Broadband Internet: Net neutrality versus open access," IEEP 4: 185-208.
[9] Qiang, C. Z. (2009). Economic impacts of broadband. Information and communications for development 2009: Extending reach and increasing impact.
[10] Oki1, O., & Lawrence, M., O. (2022) the cost-effectiveness of fibre optic technology deployment in rural area: a case study of Mdantsane, http://dx.doi.org/10.23925/2179-3565.2022v13i2p111-123
[11] Tornatzky, L.G., & Fleischer, M. (1990). The processes of technological innovation. Lanham, MD: Lexington Books.
[12] Idris, A. (2015), Assessing a Theoretically-Derived E-Readiness Framework for E-Commerce in a Nigerian SME, University of Sunderland,https://www.researchgate.net/publication/282817022_Assessing_a_Theoretically-Derived_E-Readiness_Framework_for_E-Commerce_in_a_Nigerian_SME.
[13] Nazir M., A., (2019) Factors Affecting E-commerce Adoption Among SMEs. A Case Study Investigation of a Developing Economy Pakistan, a doctoral thesis of Teesside University Business School Teesside University Middlesbrough, United Kingdom.
[14] Molla, A., & Licker, P.S. (2005a) 'E - Commerce adoption in developing countries: a model and Instrument', Information & Management, Vol.42, pp. 877 – 899.
[15] Molla, A., & Licker, P.S. (2005b) 'Perceived E-Readiness factors in E Commerce adoption: an empirical investigation in a developing country', International Journal of Electronic Commerce, Vol.10 No.1, pp. 83–110.
[16] Tan, J., Tyler, K., & Manica, A. (2007) 'Business-to-business adoption of e-commerce in China', Information & Management, Vol.44, pp. 332-351.
[17] Pituch, K. A. and Stevens, J.,(2016) Applied multivariate statistics for the social sciences: Analyses with SAS and IBM's SPSS (6th ed.), Taylor & Francis, New York.
[18] Wold, H. (1974). Causal flows with latent variables: partings of the ways in the light of NIPALS modeling. European Economic Review (5:1), 67-86.
[19] Henseler, J., Ringle, C., & Sinkovics, R. (2009). The use of partial least squares path modeling in international marketing, in: Advances in International Marketing. Emerald Group Publishing Limited, Bingley, UK , 277-319
[20] Mseti S.T. (2020) The role of Innovation and Managerial Capability in the Relationship between Intellectual Capital and Sustainable Competitive advantage, PhD Dissertation, Capital University of Economics and Business, Beijing, China.
[21] Janadari, N., Subramaniam, S., Ramalu, S.S., & Wei, C. (2018) Evaluation of Measurement and Structural Model of the Reflective Model Constructs in PLS –SEM https://www.researchgate.net/publication/327572183
[22] Ho, R. (2013). Handbook of Univariate and Multivariate Data Analysis and Interpretation with IBM SPSS. Abingdon-on-Thames Oxfordshire. UK: Taylor & Francis.
[23] Tabachnick, B.G. and Fidell, L.S.,(2013) Using multivariate statistics (6th ed.), Pearson, 2013.
[24] Kline, R.B. (2011) Principles and Practice of Structural Equation Modeling. Guilford Press, New York.
[25] Hair, J. F., JR., Black, W. C., Babin, B. J., & Andersen, R. E., (2010). Mutilvariate data analysis (7th ed.). Upper Saddle River, NJ: Pearson Prentice Hall. 280
[26] Shrestha, N (2021) Factor Analysis as a Tool for Survey Analysis, American Journal of Applied Mathematics and Statistics, 2021, Vol. 9, No. 1, 4-11.
[27] Lavrakas, P.J., (2008) Encyclopedia of survey research methods. SAGE Publications, Thousand Oaks.
[28] Netemeyer, R. G., Bearden, W. O. and Sharma, S., (2003) Scaling procedures: Issues and applications, Sage Publications, Thousand Oaks, Calif.
[29] Henseler, J. & Sarstedt M. (2013) Goodness-of-fit indices for partial least squares path modeling, Computational Statistics, Vol. 28 No. 2, pp. 565-580.
[30] Zikmund, W.G., Babin, B. J., Carr, J.C., Grinffin, M., (2013). Business Research Methods (9th Edition).Nelson Education Ltd. Canada.
[31] Fornell, C., & Larcker, D. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. Journal of Marketing Research, 18(1), 39– 50
[32] Henseler, J., Ringle, C.M., & Sarstedt, M. (2015). A newcriterion for assessing discriminant validity in variance-based structural equation modeling. Journal of the Academy of Marketing Science, 43(1), 115–135.
[33] Henseler, J., Houbona G., Ray P.A. (2016)Using PLS path modeling in new technology research:updated guidelines Industrial Management & Data Systems, Vol. 116 Iss 1 pp. 2 – 20
[34] Henseler, J., Dijkstra, T.K., Sarstedt, M., Ringle, C.M., Diamantopoulos, A., Straub, D.W., Ketchen, D.J. Jr, Hair, J.F., Hult, G.T.M. and Calantone, R.J. (2014), "Common beliefs and reality about PLS: comments on Rönkkö & Evermann (2013)", Organizational Research Methods, Vol. 17 No. 2, pp. 182-209.
[35] Hu, L. and Bentler, P.M. (1998), "Fit indices in covariance structure modeling: sensitivity to underparameterized model misspecification", Psychological Methods, Vol. 3 No. 4, pp. 424-453.

[36] Hair, J. F., Hult, G. T.M., Ringle, C.M., & Sarstedt, M. (2014). A primer on partial least squares structural equation modeling (PLS-SEM) (1 ed.). Thousand Oaks, CA: Sage.
[37] Kline, R. B. (2005). Principles and Practice of Structural Equation Modeling. New York: The Guilford Press.
[38] Myers, R.H. (1990) Classical and Modern Regression with Applications. Boston: PWS-KENT, 1990.
[39] Field, A. (2013). Discovering statistics using IBM SPSS Statistics: and sex and drugs and rock 'n' roll. 4th ed. London: Sage.
[40] Zhao, Li , Detlor, B & Connelly, C. E. (2016) Sharing Knowledge in Social Q&A Sites: The Unintended Consequences of Extrinsic Motivation, Journal of Management Information Systems, 33:1, 70-100, DOI: 10.1080/07421222.2016.1172459
[41] Chin, W. W. (1998). Commentary: Issues and opinion on structural equation modeling: JSTOR.
[42] Fornell, C., & Cha, J. (1994). Partial Least Squares (PLS), unpublished working paper. Ann Arbor: University of Michigan Business School.
[43] Geisser, S. (1975). The predictive sample reuse method with applications. Journal of the American Statistical Association, 70(350), 320-328.
[44] Stone, M. (1974). Cross-validatory choice and assessment of statistical predictions. Journal of the Royal Statistical Society. Series B (Methodological), 111-147
[45] Shmueli, G., Sarstedt, M., Hair, J.F., Cheah, J.-H., Ting, H., Vaithilingam, S. and Ringle, C.M. (2019), "Predictive model assessment in PLS-SEM: guidelines for using PLSpredict", European Journal of Marketing, Vol. 53 No. 11, pp. 2322-2347. https://doi.org/10.1108/EJM-02-2019-0189.
[46] Cohen, J. (1988), Statistical Power Analysis for the Behavioral Sciences, Lawrence Erlbaum, Mahwah, NJ.