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Assessing Critical Factors Affecting the Mass Adoption of IoT in Bangladesh

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ABSTRACT
Internet of Things (IoT) is a system in which objects can exchange data among themselves by being interconnected with the help of the internet over a wireless connection without human intervention. IoT is a buzz word in the modern era. A developing country like Bangladesh may face different problems while trying to adopt IoT due to the lack of technological knowledge, underdeveloped infrastructure and deficiency of relevant resources. But to stay apace with the fast-growing world, Bangladesh should also cast aside existing systems and accept IoT with open arms. This research aims to find out the most important factors which might be responsible for IoT adoption in Bangladesh keeping in mind about its socio-economic conditions. Some hypotheses were formed to create a questionnaire for the survey. Indicator variables found from the survey were grouped into 5 (five) factors using Exploratory Factor Analysis (EFA). A measurement model was created based on the hypotheses formed previously. Structural Equation Modelling (SEM) technique was used to find out the estimates of different factors associated with IoT adoption. From the structural model, it was found that Affordability and Ability had the highest regression weight. This suggests that in developing countries like Bangladesh people give priority to products being affordable rather than thinking about its usefulness or the positive changes it would bring to society. Besides a huge portion of people are not highly educated because of which they have expressed concerns over their ability to use IoT devices efficiently and safely. So all these factors were incorporated in this study which explains its significance and relevance.

Keywords: Internet of Things, Affordability, Adoption, Exploratory Factor Analysis, Structural Equation Modelling.

1. Introduction

Bangladesh is a densely populated developing country. Despite of all the obstacles Bangladesh is encountering, it has achieved nearly 8% gross domestic product (GDP) growth and is one of the fastest-growing economies in the world [1]. The basic fixing behind this development has been the savvy utilization of ICT in pretty much every sector. Its economy largely relies on the working-class people that are bereft of the basic needs of life. Bangladesh is focused to ensure 100% internet connectivity by 2021 and steps have been taken to ensure 5G network throughout the country for fastest speed [2]. It introduces the term 'IoT' (Internet of Things).

Internet of Things (IoT) has acquired outstanding attention within the last decade. This phenomenal innovation makes a new world where a good range of services are being offered by billions of smart, interacting gadgets to close and remote entities. Humans have been introduced as smart operators by IoT to regulate and supervise activities. IoT significantly expands productivity, lowers health costs, reduces carbon footprints, enlarges access to education in remote places and among underserved communities, improves transportation safety, encourages smart homes and cities and thus improves the standard of life [3]. IoT not only makes life easier and reduces the restrictions but also provides innovative changes for the lifestyle of people [4]. So IoT is a must for Bangladesh to realize its vision 'Digital Bangladesh'.

Firstly, there is a literature review of the previous works about the adoption of IoT in different countries. Then some hypotheses were developed based on which the survey would be performed. Next, the results were analyzed to know about the impact of different factors on IoT adoption in Bangladesh. Lastly, the conclusion recapitulates the importance of the research and advises future research prospects.

2. Literature Review

In recent years a lot of work has been done regarding the smooth transition of IoT from the existing market leaders for mass people in different countries. Roy, Zalzala and Kumar (2016) experimented on the acceptance of IoT among the urban poor in India and developed a model to facilitate the IoT adoption process among them. They observed the lifestyle of the urban poor to identify possible sectors in which IoT can be adopted [5]. Hernandez (2019) observed the constraints which restrain the poor people from accessing digital services in Bangladesh. He singled out availability, awareness, affordability, ability, agency and gender as the key barriers for adoption in Bangladesh [6]. AlHogail and AlShahrani (2019) developed a conceptual model based on the Technology Acceptance Model (TAM) and identified trust as the key component responsible for the

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adoption of IoT and emphasized on building trust [7]. Wireko, Hiran and Doshi (2018) in their research discussed about the cultural and social bias as the main hindrance in IoT acceptance in Ethiopia. The Unified Theory of Acceptance and Use of Technology (UTAUT) was used in their study to analyze the response from the participants [8]. Gao and Bai (2014) considered the impact of technology factors, social context factors and individual user characteristics to build an integrated model on the IoT adoption in China [9]. Luqman and Belle explored the non-technical factors associated with acceptance of IoT in rural areas and considered basic needs, skepticism, care for the community, safety and security as the main factors [10]. Hsu and Yeh (2016) used the TOE model to develop a base model for assessment and the DEMATEL method to evaluate the cause and effects of the factors of the base model [11]. Hsu and Lin (2016) examined the relationship between benefits and sacrifices made to the adoption of IoT. They applied the SEM technique to analyze the results of the survey [12]. Kamble et.al (2019) depicted the inter-relation between barriers using a two-staged integrated ISM and DEMATEL methodology in a food-retail supply chain [13]. Atayero, Oluwatobi and Alege (2016) compared the readiness of IoT adoption of Sub-Saharan Africa with other parts of the world using the Global Innovation Index, Global Competitiveness Index and Knowledge Economic Index [14]. Shafique, Ali and Salman (2019) mentioned about the needs of implementation of IoT for the reduction of poverty in the rural areas of Pakistan [15]. Swami and Bhargava (2019) explained the importance of digital security and the need to protect data from hackers while adopting digital services [16]. Hopalı and Vayvay (2018) explored the usability challenges of IoT in developing countries. They described lack of standardization, underdeveloped infrastructure, security issues etc. as the main hurdles for a developing country [4]. Kautsarina and Kusumawati (2018) used PRISMA protocol to understand the various uses of IoT in the rural areas of Indonesia and studied the potential implications of IoT adoption in that region [17]. AlHogail (2018) investigated on product-related factors, social influence related factors and security-related factors in building trust which in turn increases the tendency to adopt IoT [18]. Sharma et.al (2020) applied TISM approach, the Fuzzy MICMAC model, and the DEMATEL method to analyze the 15 IoT adoption barriers that were identified for waste management in developing economies [19]. Janssen et.al (2019) pointed out the challenges of adopting and implementing IoT in smart cities and analyzed them using integrated MICMAC-ISM approach [20].

Most of the previous studies done in this area of research concentrated on building a conceptual framework of the barriers by using either technical or non-technical factors. The prior studies have been conducted in different parts of the world but no such work has been done in Bangladesh in the past where IoT is relatively a new word. As sooner or later Bangladesh has to adopt IoT to achieve its agenda of 'Digital Bangladesh', so this research aims to find out the barriers of IoT adoption in the context of Bangladesh where a large section of people lack technological knowledge. The factors which are most relevant in relation to Bangladesh were considered for getting accurate estimates.

3. Hypothesis Development

It should be considered that nearly 20% of the people in Bangladesh live below the poverty line when speaking about mass adoption [21]. Around 26% of the adult do not know how to read and write [22]. So keeping these in mind, some critical factors for mass adoption of IoT were taken into account.

3.1 Affordability and Ability (A.A):

Almost 24% of the population of the country do not have access to electricity and a lot of people do not even have a stable 4g internet connection. Besides the cost of the internet is too high for people living hand to mouth. Most of the places do not have free public Wi-Fi though the use of IoT technologies require continuous connection to the internet [6].

Lack of content in Bengali creates great problems in communication for people having less acquaintance with English. Besides the use of IoT requires a significant level of technological knowledge.

3.2 Awareness and Trust (A.T):

Almost 67% of the people of Bangladesh lack awareness about the process of using the internet [6]. They don't know what IoT is and wouldn't even recommend their known ones to change their prevalent lifestyle.

Less educated people in Bangladesh believe that sharing their data in the IoT cloud will make them vulnerable both financially and personally [7]. Because of the great level of IT involvement people feel a source of greater uncertainty [9].

3.3 Usefulness (U):

People tend to underestimate the usefulness of IoT as the impacts are intangible. They tend to neglect the benefits of using IoT in the long run. IoT can increase the efficiency of a system by multiple folds. Consumers are only interested in adopting IoT if it provides a distinct advantage than existing systems almost immediately. Usefulness can play a significant role in the tendency to adopt IoT [9].

3.4 Ease of Use (E.U):

Ease of use refers to giving minimal effort required to satisfactorily use a product. Convenience in use can lead to an increased tendency to use a technology [7].

For people to adopt IoT, they need to have a sense of feeling that they can use it comfortably [9].

So it can be assumed that all the factors mentioned from 3.1-3.4 have a strong positive impact on consumer tendency for Adoption of IoT (A). To test the hypotheses a survey was performed and based on the result it was decided whether to accept or reject the hypotheses.

4. Methodology

Data Collection:

The survey was conducted over people from different classes, income groups and different age groups in Bangladesh over the course of 4 weeks. Participants of the study were provided with sufficient information and a description of how IoT devices work in general so that they could form a perspective about their use of IoT technology in the future. This approach was taken so that the participants could avoid any unclear understanding of IoT devices due to the lack of technological knowledge that could lead to faulty data collection. Then the respondents were asked to fill the questionnaire on a Likert scale ranging from strongly disagree (1) to strongly agree (5).

Among the 400 questionnaires distributed 380 were used for empirical analysis. 20 questionnaires were discarded due to invalid responses or missing data. Concerning the age group of the participants, 29.3 percent were between 20 and 25 years old, 36.8 percent were aged between 26-35 years, 17.7 percent between 36-45 years, 8.9 percent between 46 to 55 and the rest above 56 years of age.

With the help of Structural Equation Modelling (SEM), the results obtained from the survey were analyzed.

5. Result Analysis and Discussion

The results obtained were analyzed in three parts. Firstly, an Exploratory Factor Analysis was performed to reduce the redundant factors associated with the measurement model. Then the validity and reliability of the measurement model were tested. Lastly, the structural model was examined to find the impact of the residual factors on the Adoption of IoT and to find the model fitness.

5.1 Exploratory Factor Analysis:

5.1.1 Measuring Sampling Adequacy:

First, the sampling adequacy was examined to determine the appropriateness of factor analysis using the Kaiser Meyer Olkin (KMO) and Bartlett's Test measure.

Table 1 KMO and Bartlett's Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.905
Bartlett's Test of Sphericity	Approx. Chi-Square	7087.298
	df	276
	Sig.	0.000

If KMO > 0.5, the sample is adequate. Here, KMO = 0.905 which indicates that the sample data is adequate and the factor analysis can proceed. Taking a 95% level of significance, $\alpha = 0.05$, the p-value (Sig.) is 0.000. The p-value is significant as it should be less than 0.05. Therefore the Factor Analysis is valid [23].

5.1.2 Factor reduction:

Initially, 24 variables were used in Factor Analysis. However, not all of 24 variables were retained. Variances of the factors are represented by Eigenvalues. The first factor always has the highest variance and hence the highest Eigenvalue. Factors with Eigenvalue greater than 1 should be considered for the study [23]. The cumulative percentage gives the summation of the percentage of variance accounted by preceding factors and the present one. In this case study, the first 5 factors explain almost 75% of the variance.

Table 2 Total Variance.

Factor	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	9.188	38.284	38.284
2	3.042	12.674	50.958
3	2.331	9.714	60.672
4	1.710	7.126	67.798
5	1.643	6.847	**74.645**
6	0.948	3.949	78.593
7	0.535	2.231	80.825
8	0.483	2.013	82.837
9	0.460	1.915	84.753
10	0.422	1.757	86.510
11	0.370	1.542	88.052
12	0.366	1.526	89.577
13	0.314	1.309	90.886
14	0.297	1.240	92.126
15	0.282	1.174	93.299
16	0.248	1.035	94.334
17	0.212	0.884	95.218
18	0.201	0.836	96.054
19	0.196	0.818	96.873
20	0.185	0.770	97.643
21	0.169	0.704	98.347
22	0.157	0.653	99.000
23	0.144	0.599	99.600
24	0.096	0.400	100.000

Based on Promax Rotation with Kaiser Normalization, 5 (five) factors have been extracted by maximum likelihood. The percentage of non-redundant

residuals is 4% which is considered good as the percentage should be less than 5% [23]. 19 variables were clubbed into 5 (five) factors. These 5 (five) extracted factors explain 74.645% of the total variability.

5.2 Measurement Model:

Overall, the measurement model produces an excellent fit with Minimum Discrepancy = 2.051, GFI = 0.956, CFI = 0.972, TLI = 0.963, NFI = 0.948, RMSEA = 0.053, P-value = 0.000 [12, 24].

5.2.1 Measuring Convergent Validity:

As displayed in the Table 3 below, to assess Convergent Validity the Average Variance Extracted (AVE) was examined from the standardized loadings of the indicator variables. All the standardized loadings are greater than 0.7 and all AVEs exceed 0.5. Thus the model has good convergent validity [9].

5.2.2 Measuring Discriminant Validity:

Discriminant validity was calculated by the square root of AVEs. From Table 4 it can be seen that the square root of AVEs ranging between 0.776 and 0.891 is consistently greater than the off-diagonal entries (co-relation between latent variables) which are in the range 0.239 to 0.653. This shows good discriminant validity [12].

5.2.3 Measuring Composite Reliability:

Table 3 shows the value of Composite Reliability (CR). All the CRs exceed 0.7. This indicates that there is good internal consistency reliability between the respective latent and indicator variables [9, 12].

Table 3 Table for Measuring Convergent Validity and Composite Reliability.

Ind. Variables	Latent Variables	Std. Loadings	AVE	CR
Q5	E.U	0.905	0.694	0.900
Q4	E.U	0.881		
Q2	E.U	0.731		
Q1	E.U	0.804		
Q13	U	0.814	0.794	0.939
Q12	U	0.948		
Q11	U	0.929		
Q10	U	0.868		
Q18	A.T	0.822	0.718	0.927
Q17	A.T	0.808		
Q16	A.T	0.887		
Q15	A.T	0.843		
Q14	A.T	0.873		
Q8	A.A	0.725	0.712	0.880
Q7	A.A	0.907		
Q6	A.A	0.887		
Q22	A	0.821	0.603	0.820
Q23	A	0.750		
Q24	A	0.756		

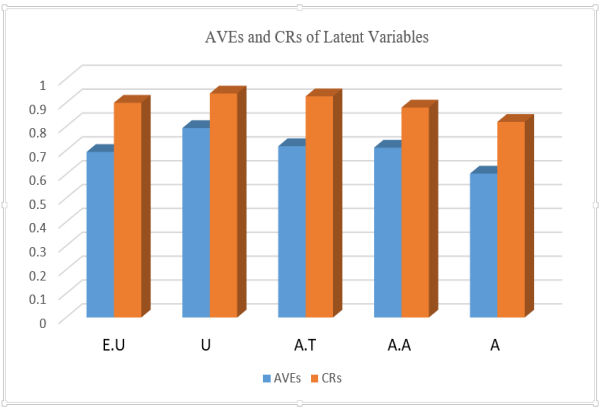

Fig.1 Values of AVEs and CRs of Latent Variables

Fig.1 is the graphical representation of Table 3 where each latent variable has AVEs greater 0.5. And the values of CRs exceed 0.7.

Table 4 Table for Measuring Discriminant Validity.

Latent Variable	U	E.U	A.T	A.A	A
U	**0.891**				
E.U	0.335	**0.833**			
A.T	0.476	0.497	**0.847**		
A.A	0.520	0.239	0.358	**0.844**	
A	0.544	0.371	0.523	0.653	**0.776**

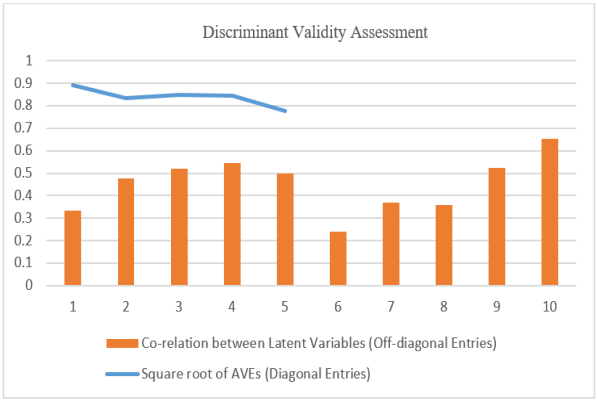

Fig.2 Assessment of Discriminant Validity

Discriminant validity can be clearly observed from Fig.2 as we can see that the diagonal entries (Square root of AVEs) from Table 4 are far greater than the off-diagonal (Co-relation between Latent Variables) ones.

5.3 Structural Model:

To measure the impact of the antecedent factors on the adoption of IoT technologies in Bangladesh the Structural Equation Modelling (SEM) technique was used. The SEM model displayed an absolute fit as P-value = 0.000, GFI = 0.945, RMSEA = 0.072 were within the acceptable range. The model also had an incremental fit as the value of CFI (0.948), NFI (0.923)

and TLI (0.932) all exceeded 0.9 and parsimonious fit as Minimum Discrepancy (2.950) was less than 5 [25]. Fig.3 shows the structural model in which we can see the impact of different factors on IoT adoption.

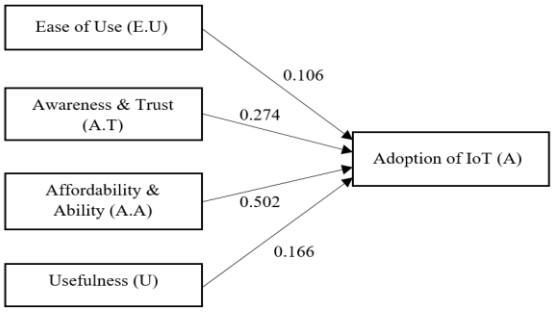

Fig.3 Structural Model.

Table 5 shows that Ease of use (E = 0.106 and p-value = 0.030), Awareness & Trust (E = 0.274 and p-value = 0.000), Usefulness (E = 0.166 and p-value = 0.006) and Affordability & Ability (E = 0.502 and p-value = 0.000) all have a positive influence on the Adoption of IoT technologies in Bangladesh**.**

Table 5 Standardized Regression Weights.

			Estimate(E)	P-value
A	<---	E.U	0.106	0.030
A	<---	A.T	0.274	0.000
A	<---	U	0.166	0.006
A	<---	A.A	0.502	0.000

However, Affordability & Ability is the factor that strongly influences the IoT adoption and Ease of use has the lowest impact on Adoption. So, it can be concluded that the overall SEM model was significant in identifying the impact of different factors on the Acceptance of IoT.

6 Conclusion

This study tried to incorporate different non-technical aspects of IoT adoption such as Affordability and Ability, Awareness and Trust which cannot be ignored because of the background of Bangladesh. These factors needed attention thinking of the socio-economic condition of Bangladesh. As these factors were taken into consideration, the results obtained were also significant enough to suggest that the study was relevant. It was found that Affordability and Ability had the highest estimate of 0.502 and Ease of Use had the lowest impact in the lot with an estimate of 0.106. All the other factors too had a positive impact on IoT adoption in Bangladesh which reinstates the assumptions made in the study. Practitioners and researchers have acknowledged the importance of IoT adoption as a key element for social and economic development in developing countries. This study serves as a theoretical base for understanding the implications of IoT adoption in Bangladesh. The factors found in the study can be taken into consideration to ensure participation of mass people in practical applications of IoT in Bangladesh in the near future. However, this research has some limitations. Firstly, the study was based on only Bangladesh though it intended to be more consistent with respect to the context of other developing countries. As other countries might have different IT regulations and socio-economic conditions, this research should enlarge its boundaries in the future. Secondly, a generalized survey was created describing the unique characteristics of IoT to the consumers. In future, the survey might be narrowed down to a particular product or IoT product category to improve the rigor of the study. Thirdly, the survey was based on the tendency to use IoT in the future rather than asking for customer experience about using IoT devices in personal. In future researches, user experience should be taken into account so that other factors may be considered which might not have been used in this study. Still, this research provides a good understanding of the Adoption of IoT in Bangladesh and provides an incentive for future researches.

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