Research on Factors Impacting the Adoption of Internet of Things (IoT) by Indian Enterprises

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Abstract: Internet of Things (IoT) technology promises to offer tremendous opportunities for all industry sectors. It is a big source of innovative business models for industries, which results in improved productivity and increase in revenue, thereby reducing the operational cost and enabling better control over business. This research aims to investigate the factors influencing IoT adoption by Indian enterprises and endeavours to develop and test the conceptual model based on a Technology-Organization-Environment (TOE) framework. Structural Equation Modeling (SEM) has been used to analyse the data collected from industry professionals. The results have shown that IoT- expertise, Perceived- usefulness, Level of Awareness, Funding and Government Support are not significant factors that impact IoT adoption. From a supporting factor perspective, Standardisation and interoperability, Infrastructural Challenges, Level of Preparedness, Top management support, Willingness to change and Supporting Industries have exhibited a significant and positive impact on IoT adoption. This research may help the top management and policy makers of industries in their decision making process on IoT adoption.

Index Term **- IoT, Indian Enterprises, IoT Adoption, SEM, TOE**

I. INTRODUCTION

Every industry sector: manufacturing [1] [2], Service industries, retail, transportation or medical, has been adopting Internet of Things (IoT) innovations, because it creates better efficiencies for their business [3] [4]. They have better control over costs as more meaningful analysis of data can be done [5]. What is driving this need to implement connected devices over assets and things, is insights and analysis, improved productivity, reduced costs, better profitability and increase in ROI [6].

Previous studies on IoT have mostly focused on IoT acceptance by consumers using TAM, UTAUT [7] [8] [9] [10] and other frameworks and very few studies have examined adoption of IoT technology by industries. Consequently, this paper aims to develop a TOE framework [11] [12] to identify the impact of factors that influence IoT adoption by industries in India. This research applies the structural equation modeling (SEM) approach, using SPSS AMOS software [13] [14] [15], to assess the empirical strength of the relationships between the factors identified in the proposed model. The framework will help the organizations to enhance the implementation of IoT in their business process.

The next section reviews the factors impacting IoT adoption. Third section presents the proposed conceptual framework along with the research hypotheses. The fourth section details out the methodology. The fifth section discusses results of data analysis and the sixth section highlights the key findings of the research work and section seven concludes the paper.

II. REVIEW OF FACTORS IMPACTING IoT ADOPTION

Previous studies on IoT adoption are built on technology, organisation and environment (TOE) and decision-making trial and evaluation laboratory (DEMATEL) models [16] . Grey Relational Analysis (GRA) and Analytical Hierarchy Process (AHP) methodologies [17] also have been used to identify the key challenges in IoT implementation.

This study examines 11 factors contributing to IoT adoption using a research model based on TOE framework. These factors are further validated by conducting online field survey of IoT users in India. Table 1 below detail these identified factors.

Table 1 IoT Adoption Factors

Factor	Description	Sources
Top Management Support	Top Management's Support towards innovation in the area of IoT.	[11] [16]
Perceived Usefulness	Perceived benefits like Performance Monitoring, Revenue Expansion, and Reduction in Operational Expenses that IoT offers.	[18] [11] [19] [16]
Funding	Annual investment budget committed to IoT based projects.	[6] [20]
Standardization and Interoperability	Standardization and Interoperability issues in integrating IoT solutions with legacy systems and also for forward and backward compatibility of products and services.	[18] [21]

Level of Awareness	Knowledge of potential business advantages of IoT driven innovations.	[22] [21]
Infrastructural Challenges	Technical and infrastructural Challenges such as Hardware/ Software/ Storage/ Analytics/ Security/ Privacy which may inhibit IoT's growth.	[6] [21]
Government Support	Government Support in regulating IoT use.	[11] [16]
IoT Expertise	In-house IoT talent and skills to manage IoT complexity and huge amount of data generated from sensors.	[23] [20]
Level of Preparedness	Extent of organisation's readiness to manage the business model disruption by IoT.	[20]
Supporting Industries	Third party partners for Hardware/ Software/ Cloud/ Telecom needs.	[18]
Willingness to Change	Employees' agreement in supporting IoT adoption.	[11]

III. CONCEPTUAL FRAMEWORK AND RESEARCH HYPOTHESES

Factors influencing the adoption of IoT technology are categorised according to TOE model (Technical, Organizational and Environmental). Table 2 shows these factors

Table 2 Factors for TOE Model

Technical factors	**Organizational factors**	**Environmental factors**
IoT Expertise	Level of Awareness	Government Support
Perceived Usefulness	Level of Preparedness	Supporting Industries
Standardization and Interoperability	Top Management Support	
Infrastructural Challenges	Funding	
	Willingness to Change	

Fig. 1 shows the conceptual model (developed using AMOS software) with these factors and their effect on the adoption of IoT by Indian enterprises.

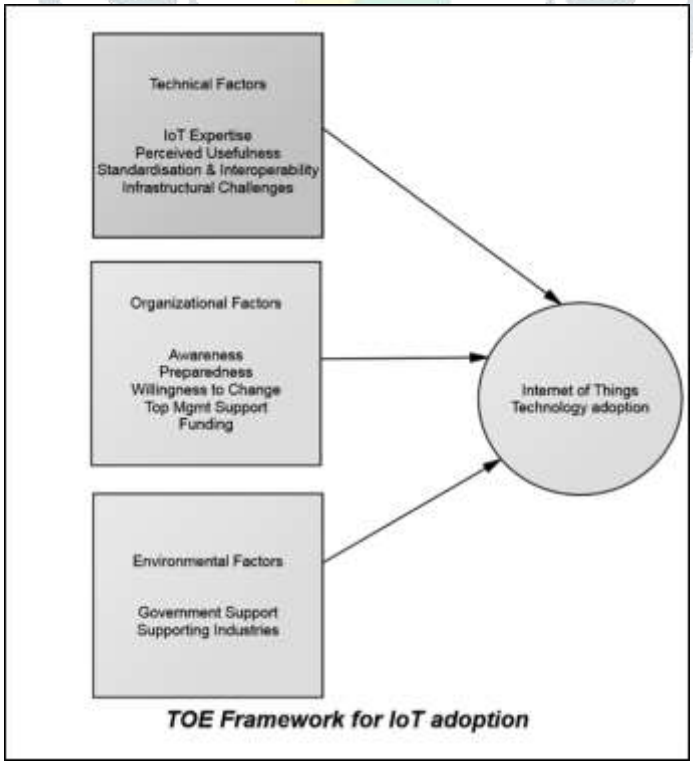

Fig 1 TOE framework for IoT adoption

Research hypotheses

Research hypotheses used for this study is shown in Table 3 below.

Table 3 Research Hypotheses

H1	There is a positive and significant impact of IoT Expertise on IoT adoption
H2	There is a positive and significant impact of Perceived Usefulness on IoT adoption
H3	There is a positive and significant impact of Standardization and Interoperability on IoT adoption
H4	There is a positive and significant impact of Infrastructural Challenges on IoT adoption
H5	There is a positive and significant impact of Level of Awareness on IoT adoption
H6	There is a positive and significant impact of Level of Preparedness on IoT adoption
H7	There is a positive and significant impact of Top Management Support on IoT adoption
H8	There is a positive and significant impact of Funding on IoT adoption
H9	There is a positive and significant impact of Willingness to Change on IoT adoption
H10	There is a positive and significant impact of Government Support on IoT adoption
H11	There is a positive and significant impact of Supporting Industries on IoT adoption

IV. METHODOLOGY

A survey was conducted among the technology professionals in the Auto industry/ IT industry /Start-ups having linkages with information about the IoT initiatives. The survey was investigative in nature assessing the levels of awareness, preparedness and interest of organisations in IoT. It further delved into the organisations experience on IoT, meeting and overcoming challenges and barriers faced when adopting IoT technology.

Table 4 below gives the summary of Research Methodology [24] used.

Table 4 Research Methodology

Research Design	Exploratory cum Descriptive
Sampling Design	Cluster sampling – Area sampling
Survey	Sample Survey
Population	Auto industry, IT industry and Start-ups
Scaling	Likert scale
Data Collection	Questionnaire, Personal Interview
Data Analysis	Descriptive, Inferential Analysis and SEM- Structural Equation Modeling

The data for this study was collected using questionnaires from 150 IoT professionals. **Structural Equation Modeling (SEM)** is used to investigate the effects of these factors on IoT adoption. Structural equation modeling is a multivariate statistical analysis technique [14] [15] that is used to analyse structural relationships. This technique is the combination of factor analysis and multiple regression analysis, and it is used to analyse the structural relationship between measured variables and latent constructs.

Fig. 2 shows the framework along with the covariances among the individual factors.

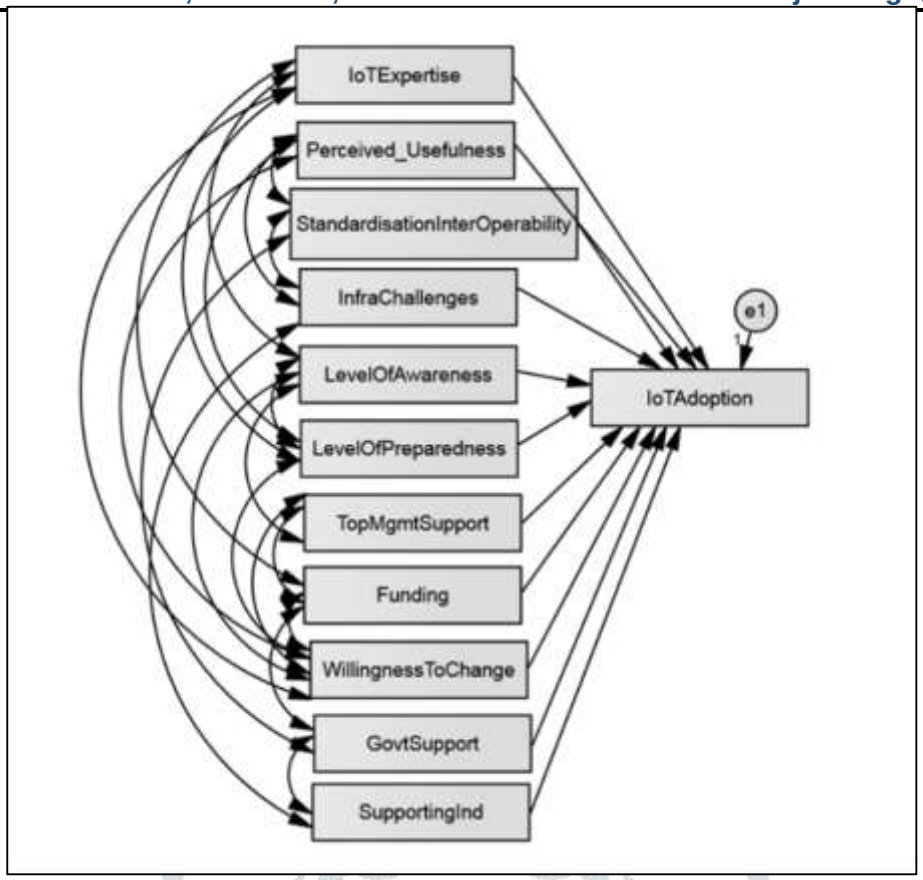

Fig 2 TOE framework with covariances

The summary of items of questionnaire is shown in Table 5. The final questionnaire contained total 31 questions, including respondents and company's profile and research instrument.

Table 5 Summary of Final Questionnaire Designed for Survey

Halves	**Contents**		**Number of Questions**
First half: Profile of Respondents and Company	Information about respondents and Company's Profile		11
Second Half: Research Instrument	Levels of Awareness and Preparedness	08	20
	IoT Challenges, Barriers and Risks	04	
	Project and Cost management	02	
	Requirements for smooth IoT integration	04	
	Feedback	02	
		TOTAL	31

V. RESULTS

Goodness of fit analysis and Confirmatory Factor Analysis (CFA) is carried out in SPSS AMOS [14] [15] to show how well the proposed model fits the set of observations.

Sample size 150

Model Identification-

Computation of degrees of freedom

Number of distinct sample moments: 78

Number of distinct parameters to be estimated: 43

Degrees of freedom (df) - (78 - 43): 35

Since degree of freedom is positive, above model is **Over Identified**

Model Fit- Goodness of Fit analysis is shown in the Table 6 below

Table 6 Goodness of Fit Analysis

Measurement index	**Ideal range**	**Tested value**
Chi-square (CMIN)	As small as possible	**167.538**
Probability level	<0.05	**0.00**
Minimum Discrepancy (CMIN/df)	<5.0	**4.787**
Goodness-of-fit Index (GFI)	>0.8	**0.837**
Comparative Fit Index (CFI)	>0.8	**0.8**
Root Mean Square Error of Approximation (RMSEA)	Relatively good if <0.1	**0.15**

From the table it can be concluded that the model is Absolute and Parsimonious Fit as fit indices are in the ideal acceptance ranges**.**

In addition, path analysis was conducted to compare the estimates and to validate the hypotheses. Table 7 shows this Confirmatory factor analysis and significance testing results.

Table 7 Confirmatory Factor Analysis and Significance Testing

Impact on IoT Adoption	**Estimate**	**S.E.**	**C.R.**	**P**	**Hypothesis**
IoTAdoption← IoTExpertise	0.092	0.068	1.355	0.175	Rejected
IoTAdoption← Perceived_Usefulness	-0.081	0.066	-1.227	0.220	Rejected
IoTAdoption← Standardisation InterOperability	0.134	0.047	2.798	0.042	Accepted
IoTAdoption← InfraChallenges	0.155	0.064	2.410	0.016	Accepted
IoTAdoption← LevelOfAwareness	0.055	0.071	0.774	0.439	Rejected
IoTAdoption← LevelOfPreparedness	0.448	0.073	6.121	***	Accepted
IoTAdoption← TopMgmtSupport	0.196	0.056	3.489	***	Accepted
IoTAdoption← Funding	-0.028	0.056	-0.501	0.616	Rejected
IoTAdoption← WillingnessToChange	-0.116	0.055	-2.122	0.034	Accepted
IoTAdoption← GovtSupport	0.053	0.060	0.879	0.380	Rejected
IoTAdoption← SupportingInd	-0.104	0.053	-1.971	0.049	Accepted

Note: *** → 0.00; Significance level = 0.05

The significance level is set as **0.05** to distinguish the significance of each hypothesis. Only when the p-value of any hypothesis is less than the set significance level, can the result of the hypothesis be recognized as reasonable and valid; otherwise, it is invalid.

VI. KEY RESEARCH FINDINGS AND OBSERVATIONS

Technical factors –

The results of analysis show that from Technical factors- relationship between standardisation and Interoperability (H3), Technical /infrastructural challenges (H4) and IoT adoption are positive and significant. On the other hand, IoT expertise (H1) and Perceived usefulness (H2) do not have a significant impact on IoT adoption.

From the above results, it can be observed that, Technical Challenges such as Hardware/ Software/ Data Storage/ Analytics/ Security are playing a significant role while integrating IoT in Organisation's business process. It is expected that industries would accelerate the IoT adoption in coming one or two years having completed the early evaluations of infrastructural models to understand how IoT adoption would leverage the existing technical infrastructure along with addressing the data security and storage issues.

With the complex array of IoT devices, enterprises have weighed Standardisation and Interoperability as an important catalyst in IoT adoption. This will smoothen the integration with legacy systems and also ensure future compatibility of products and services.

Organizational factors

Organizational factors depict a complex relationship with IoT adoption. Level of preparedness (H6) and Top Management support (H7) indicate positive and significant effect on IoT adoption, whereas, Willingness to change (H9) and IoT adoption are negatively related. Also, Level of awareness (H5) and Funding (H8) do not have a significant impact on IoT adoption.

Executives who participated in this study strongly feel that Indian enterprises are fully prepared to manage IoT disruptions in their business processes. This is further complemented with top management's full support in IoT initiatives. However, this study indicates that employees' willingness / resistance to change has a negative influence on IoT implementation. This implies that, industries should engage and integrate employees and policy makers to solicit feedback on the potential benefits so that there is a common agreement amongst all stakeholders involved.

Environmental factors

From Environmental factors, Government support (H10) does not have significant impact on IoT adoption, whereas, supporting industries (H11) has a significant impact, though there is a negative relationship with IoT adoption.

While Indian enterprises have showed strong interest in integrating IoT in their business process, the reality is that most enterprises rely on solution partners or system integrators or software platform companies to assist in evaluating the opportunities, to address the complexity of IoT implementation and integration of IoT with legacy systems and business platforms.

With regard to the factors which are not so significant in IoT adoption, 'IoT expertise' is in short supply i.e. not all enterprises have the required IoT talent. But this is being handled as companies seek third party assistance in the form of supporting industries. 'Perceived usefulness' and 'Level of awareness' too are not influencing IoT adoption, as almost all industry sectors are well aware of the strategic reasons for enterprise adoption of IoT such as product performance monitoring and analysis, product maintenance/service capabilities, expanding revenues, reducing operation expenses and gaining competitive advantage.

This survey also highlights that 'funding' for IoT projects is not impacting to a great extent, as the companies are fully convinced about how IoT implementation will improve the overall business processes with full support from top management and third party solution providers. Also, the cost of sensors has tremendously decreased, internet connectivity – which was very expensive couple of years back, today it is no longer an issue to consider. Cloud platforms are easily accessible for IoT based sensor data.

Between 'Government support' and 'Standardisation and Interoperability' factors, the latter has shown significant impact on IoT adoption. Government of India has taken several initiatives in the form of Digital India Program which aims at 'transforming India into digital empowered society and knowledge economy'. This is expected to provide the required impetus for development of the IoT industry ecosystem in the country. There are several international standardization bodies, however, there is no uniform definition adopted globally. The glue that allows infrastructures to link and operate efficiently is uniform and universally applicable standards as they make technologies interoperable and efficient.

VII. CONCLUSION AND FUTURE SCOPE

The key purpose of this research work was to investigate and analyse the challenges faced by Indian enterprises when adopting IoT in their business processes. 11 factors were identified through literature review and survey conducted. A framework based on TOE model is developed and Structure Equation Modelling is used in AMOS software to analyse the influence of these factors on IoT adoption. The results of this research could guide the policy makers in the decision making process and can smoothen

integration of IoT in their business process. In future research, some more factors may emerge which can be considered for IoT adoption. Further, requirements around integrating IoT with a view to achieve cost and quality arbitrage can be studied.

REFERENCES

[1] "IDC Manufacturing Insights:Transforming Manufactur ing wi th the Internet of Things," Sponsored by Cognizant, 2015.

[2] Simona Jankowski;James Covello;Heather Bellini;Joe Ritchie;Daniela Costa, "IoT primer The Internet of Things:Making sense of the next mega-trend," The Goldman Sachs Equity research, 2014.

[3] J. Gubbia, R. Buyya, S. Marusic and M. Palaniswami, "Internet of Things (IoT): A vision, architectural elements, and future directions," *Future Generation Computer Systems,* vol. 29, p. 1645–1660, 2013.

[4] D. S. I. member, G. Tripathi and A. J. J. I. member, "A survey of Internet-of-Things: Future Vision,Architecture, Challenges and Services," in *IEEE World Forum on Internet of Things (WF-IoT)*, 2014.

[5] "White Paper:What the Internet of Things (IoT) Needs to Become a Reality," Global Strategy and Business Development, Freescale and Emerging Technologies, ARM., 2014.

[6] Robert Parker, "IDC Manufacturing Insights: Internet of Things in Manufacturing: Driving Revenue and Improving Operations," Sponsored by: Tata Consultancy Services, 2014.

[7] A. M. Al-Momani, M. A. Mahmoud and M. Sharifuddin, "Modeling the adoption of internet of things services: A conceptual framework," *International Journal of Applied Research,* vol. 2, no. 5, pp. 361-367, 2016.

[8] J. Bradley, "The Technology Acceptance Model and Other User Acceptance Theories," IGI Global, 2009, pp. 277-294.

[9] P. Lai, "The Literature Review of Technology Adoption Models and Theories for the Novelty Technology," *Journal of Information Systems and Technology Management,* vol. 14, no. 1, pp. 21-38, 2017.

[10] L. G. X. Bai, "A unified perspective on the factors influencing consumer acceptance of internet of things technology," *Emerald Insight:Asia Pacific Journal of Marketing and Logistics,* vol. 26, no. 2, pp. 211-231, 2014.

[11] D. Lin, C. K. M. Lee and K. Lin, "Research on Effect Factors Evaluation of Internet of Things (IOT) Adoption in Chinese Agricultural Supply Chain," in *Proceedings of the 2016 IEEE IEEM*, 2016.

[12] F. J. Riggins and S. F. Wamba, "Research Directions on the Adoption, Usage and Impact of the Internet of Things through the Use of Big Data Analytics," in *The 48 Hawaii International Conferences on System Sciences (HICSS)*, Kauai, Hawaii,USA., 2015.

[13] A. Afthanorhan and A. N. Aimran, *Introduction to SPSS,* ResearchGate, 2015.

[14] "Structural Equation Modeling using AMOS An Introduction," Division of Statistics+Scientific Computation , The University of Texas at Austin, 2012.

[15] Z. Awang, "Structural Equation Modeling using AMOS".

[16] C.-W. Hsu and C.-C. Yeh, "Understanding the factors affecting the adoption of the Internet of Things," *Technology Analysis & Strategic Management- Routledge Taylor and Francis Group,* no. DOI: 10.1080/09537325.2016.1269160, 2016.

[17] S. Luthra, D. Garg, S. K. Mangla and Y. P. S. Berwal, "Analyzing challenges to Internet of Things (IoT) adoption and diffusion/; An Indian Context," *ScienceDirect,* vol. 125, p. 733–739, 2018.

[18] Andy Castonguay, "White paper Internet of Things Enterprise Survey Sponsored by Interdigital Telit," TIA Survey, 2016.

[19] C.-L. Hsu and J. C.-C. Lin, "Exploring Factors Affecting the Adoption of Internet of Things Services," *Journal of Computer Information Systems,* vol. DOI:10.1080/08874417.2016.1186524, 2016.

[20] A report from The Economist Intelligence Unit, "Assessing enterprise readiness for the IoT," Sponsored by SAMSUNG, 2016.

[21] S Ramachandran, "IDC Manufacturing Insights:Innovative Use Cases for the Adoption of Internet of Things in India Manufacturing," 2015.

[22] Fredrik Gunnarsson;Johan Williamson;Jerome Buvat;Roopa Nambiar;Ashish Bisht, "The Internet of Things: Are Organizations Ready For A Multi-Trillion Dollar Prize?," Capgemini Consulting Analysis, 2014.

[23] "KPMG-Internet of Things:An Indian Context," 2016.

[24] C. Kothari, Research Methodology Methods and Techniques, New Age International Publishers, 2004.