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Article

Instrument Development Using Structural Equation Modelling for Successful Factors for IOT Adoption: An Indian Manufacturing Perspective

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Abstract: Businesses are anticipated to be greatly impacted by the Internet of Things (IOT), particularly in terms of how we view the manufacturing sector. However studies on the effective use of IOT in the Indian manufacturing industry are still scarce. Owing to the complex nature of IOT adoption in manufacturing sector and high failure rate, researchers are focusing on the successful factors that could lead to the successful adoption of IOT in manufacturing sector. The primary objective of this study is to develop a scale related to the success factors for IOT adoption in Indian Manufacturing sector. The items related to the success factors for IOT implementation were taken from the previous literature. Exploratory factor analysis was conducted on the collected data to find the constructs. Confirmatory factor analysis (CFA) was performed to validate the constructs and to finally check the model fitness of the measurement model. Hence, model fit indexes like comparative fit index (CFI), the goodness of fit index (GFI), normed fit index (NFI), and root mean square of error approximation (RMSEA) were used. In this study, we empirically identified and verified five dimensions of success factors for IOT adaptation in Indian Manufacturing sector. These dimensions are technical factor, Human factor, Ecosystem partnership factor, management factor and Institutional factor which contribute 73.35 % of CSF.
Keywords: IOT, Indian Manufacturing Sector, CFA, Exploratory Factor Analysis (EFA), and scale development, success factors

1. Introduction

These days, the term "Internet of Things" (IOT) is frequently used in the business and technology sectors. The concept of the Internet of Things is not new; it was initially described by Kevin Ashton, Executive Director of Auto-ID Labs at MIT, during a supply chain optimization presentation for Procter & Gamble [1]. Even before this the concept of IOT was used in early 1980s when it is used on a coca cola machine located at the Carnegie Melon University The programmers on the campus were connected by internet to the refrigerator application to check for the availability of drink and to check whether the drink is cold or not [2]. Although the idea of IOT has been around for a while, it has gained popularity in recent years due to a number of factors, including declining sensor costs, declining data collection and storage costs as a result of cloud solutions, widely expanding internet connectivity, rising processing power, and rising smartphone and tablet adoption.

Due to covid -19 and subsequent lockdown number of business sectors have shown a downward trend, however, there is a brighter scope for manufacturing and industrial sector as multinationals are seriously thinking about diversify their manufacturing locations. World is looking at India as an alternate manufacturing investment destination for China. Many foreign manufacturing companies in the field of textiles mobiles, medical devices and electronics are planning to shift their manufacturing base to India from China and recently Samsung has announced the shifting of electronics goods production to India. Manufacturing companies from the USA, Korea, and Japan are exploring partnerships, joint ventures, development management contracts to enter India. All this is going to benefit Indian in terms of sizable investments into the country in 2020-21 [3].

Manufacturing has become one of India's fastest-growing industries. By 2025, manufacturing is expected to contribute between 25% and 30% of GDP, up from 16% in 2017 [4]. By 2025, the income is expected to reach $1 trillion, and over 90 million human resources would be needed to support it [4]. The global Internet of Things market is expected to expand at a compound annual growth rate (CAGR) of 25.4% from $381.30 billion in 2021 to $1,854.76 billion in 2028 [5]. Ten years later, in 2025, an estimate of the value generated by IOT was included in a McKinsey report from 2015. According to the research, IOT may generate between $3.9 trillion and $11.1 trillion across the impacted industries [6].

The effective integration of IOT in manufacturing sector have many benefits in terms of reduced operation cost by 50 %, higher availability, utilization, and improved performance of critical assets. Automation in production process with IOT also results in improving the product quality also. Because of remarkable opportunities, there is a lot of attraction about IOT implementation. So, companies have invested lot in IOT implementation in order to stay ahead of their competitors. In addition to the benefits of IOT implementation in manufacturing sector, the complexities related to implementation makes IOT popular and notorious. More and more instance of abandoned and failed IOT implementation projects have put a question mark on the journey of digital transformation [7]. The report by cisco mentioned that the projects that were considered successful constituted of only 26% of IOT initiatives meaning that a majority of initiatives are, to some extent, failing. The failure rate of completed projects were at one third with no incremental benefits at all [8]. The estimation seems to be alarming, yet there is less clarity on the ways of successful implementation of IOT systems. A more significant issue is the rising number of failures that result in financial loss and, in certain situations, bankruptcy. Understanding and innovating the elements that would result in the successful deployment of IOT in the manufacturing industry is crucial. Organizations must research other people's experiences and take note of their best practices. In light of this, an empirical study was conducted to provide some light on the variables that might be crucial for the manufacturing sector's adoption of IOT.

This study's primary goal is to determine the critical factors that are essential for IOT adoption in the manufacturing industry and to develop and validate an instrument for successful adoption of IOT in Indian manufacturing sector.

The structure of this document is as follows. The literature assessment on IOT adoption critical factors in Indian manufacturing organizations is presented in Section 2. The methodology is covered in Section 3, data analysis and results are explained in Section 4, and discussion, consequences, and future research are covered in Section 5.

2. Literature

Manufacturing is one of the many areas where the Internet of Things is transforming business practices. Up until now, technology has largely been used to manage industrial operations, run businesses, automate processes, and gather data related to assembly activities. However, integrating IOT solutions in a company can be difficult since it involves careful preparation in areas such as designing the IOT architecture, data collecting strategy, choosing the correct IOT platform to interface with existing technologies, security, data, and so on. Having the proper understanding of the factors may help to develop and implement IOT solutions in a business more effectively, resulting in faster business value realization.

The human factor is considered as one of the vital factors for IOT adoption. The survey was conducted by Cisco involving 1,845 IT and business decision-makers in the UK, United States and India and 49% of respondents attributed that top-down leadership and executive sponsorship is the key factor. The industries covered were from manufacturing, local government, retail/hospitality/sports, energy (utilities/oil & gas/mining), transportation, and health care [8]. Leadership with a technology-focused culture plays an important role in implementing the new technology in an organization [9], [10]. The implementation of IOT in an organization is a resource demanding and time consuming which becomes very comprehensive and incur lot of cost. This is not possible without the support of top management. Top management should be willing to allocate valuable resources to the implementation team at the right time [11], [12].

For tackling the complexity of IOT implementation projects, the team plays a crucial role. The Team should be a dedicated cross-functional team consisting of the best people from internal staffs and external partnership and they should have both technical and business competencies so that they are able to support major business process [6], [8], [12]. In order to surpass silos and functions a team should be balanced mix of different skills like analytical, technical, creative and business process [13]. The team involved should be a cross functional team including technology, data science, users, finance and business. If any one of these is missing, the IOT implementation will have a negative impact on IOT implementation [14]. In order to have a highly qualified talented team, vocational education and training programs should be encouraged [15].

The IOT implementations and adaptation in manufacturing sector involve all the aspects of system integration from a hardware platform to its application; thus, adding to the complexity of the IOT projects. For avoiding the complications, the organizations should leverage ecosystem partnership. The partners should be involved in all phases from planning to data analytics after rollout. [8]. Monopolistic do-it-yourself approach does not work for IOT application as there are still the dearth of data and application platform along with standard interfaces. The only way to overcome this is to create an ecosystem in collaboration with individual players having common goal [16]. The lack of communication within the organization, different stakeholders from no of companies and between government and industry is a very big concerning issue [17]. For manufacturing sector to deliver value after implementation of IOT, a connected ecosystem is required [13]. IOT implementation involves number of technology stack so it will be extremely difficult for single organization to overcome all the challenges. This can be solved by building and using the partner ecosystem [18]. For faster deployment of IOT technology there should be collaboration between all stakeholders like service providers, private and public industry and academia [15].

According to [12], strategy should be placed at top as far as IOT adoption is considered. The company should clearly define the business plan, business model and vision; the identified clear short- and long-term objectives; the working model of the organization; project schedules along with milestone; critical paths and boundaries; needful resources; incurred cost; and risk associated with the project. Project planning enables organizations to plan and coordinate various activities in the different phases of effective implementation. Strategic alignment which means aligning the IOT initiatives with business and technology plays an important role in IOT adoption in an organization. Technology strategy can be characterized in terms of the limitations of the selected solution, whereas business strategy can be stated in terms of goals [11], [12], and [19]. Top management should make data-driven decisions and align the organization with the new business model in order to maximize the benefits of IOT implementation [19]. The strategy for IOT implementation projects should be aligned with technology and operations and also take expected output into consideration. The strategy defined at the beginning need to be revisited underway [20]. The company should be clear about the goal they want to achieve through implementing IOT in manufacturing. Problem statement and success criteria should be clearly defined [13]. For IOT implementation to be successful, company should have a clear vision and strategy and that can be achieved by understanding the pain area in manufacturing [21]. The important factor for IOT to be successful is that it should not be lead with technology but with strategy and investment should be made keeping strategy and goal into consideration [18].

The IOT implementation and adaptation should be looked as change management initiatives rather than IT initiatives. The IOT implementation team should formally prepare change management strategies for effective implementation of the IOT system. The change management should be carried out by a team which is led by top management. The main aim of change management is generally related to balancing the forces in favor over the resistant forces. Uncontrolled or poorly managed changes can result into low quality system, which may lead to poor decision and can finally deteriorates profitability and productivity [20]. Change management should be given equal attention if not more as technology in case of IOT implementation [18]. AS IOT implementation includes working in an ecosystem, so change management is very important in dealing with this change [14]. The IOT implementation can result in operating model change. Depending upon how comprehensive the change is, the employees will have to acquire new knowledge and skills. New skills can be acquired through focused educational and training programs to be given to all employees affected by new technology. Training and education play a crucial role in the successful implementation of any system and provides the user with the logic and overall concepts of the systems [19], [20]. As IOT implementation and adoption is a new technology concept so there is a possibility that professionals will resist with these kinds of changes. This resistance can be overcome by top management by explaining the positive effect of the technology and also by providing proper training and guidelines [10]. For successful development of IOT application involvement and education of people is must [16]. In less digitally mature companies, the lack of technology often complicates the implementation process [22]. For successful implementation of digital manufacturing, not only training is required but also constant technical support is important [23]. IOT implementation may disrupt the current practices and give rise to new products and processes, so training is very much required to get used to new processes [13]. Manufacturing industry is still heavily dependent on manual labor in production unit, so there can be lot of resistance towards IOT implementation [21], [24]. IOT implementation in manufacturing may result in decline of routine jobs and demand for higher skills like programming and repairing of robotics functions [25]

Operating model in manufacturing organization is complex, so IOT compatibility with the existing process and existing information systems plays an important factor as far as success of IOT implementation in an organization is considered. The organization should look in for the product from the vendor which supports end to end integration to other business processes [19]. If there is no inter-operability between the existing system and the new technology, the implementation of new technology will be hindered [10]. In order to achieve the full value of IOT, the IOT and other devices in the organization should be able to able to communicate and this can be achieved using open standards [6]. To improve the chance of success for IOT implementation interoperability, open standards play a very important role [13]. Inter-operability is important in IOT implementation as it makes possible for the seamless communication between system and application [14]. In most of the organizations IOT is developed as an independent solution and then integrated into the manufacturing process. Hence there is a lock of synchronization and inter-operability between IT and OT [5]. Consumers don't adopt the system which are fragmented and which don't support interoperability [25].

McKinsey's has highlighted that security and privacy plays an important role in IOT implementation. As more and more IOT devices are connected by web, security poses a major challenge and this can be overcome by using "security by design" strategy for IOT projects [6]. For manufacturing sector end to end security is a major concern as most of the machines on "the floor" are connected through internet. "Security by design" should be considered for IOT implementation in manufacturing sector [19]. According to Siemens report cyber security risk is big for IOT projects so emphasizes on the cybersecurity should be considered as top most priority in all stages of implementation [20]. The biggest inhibitor of IOT deployment is because of lack of trust and that is related to security and privacy [16]. Attack on IOT in manufacturing sector can have more impact as compared to non IIOT breaches. These security and privacy trust can be handled when these issues are addressed by government [17]. Security should be an important part of system design and the main focus should be on prevention, detection and response as integration of IOT into the manufacturing connects the enterprise to the eco system which poses a security threat [7]. IOT security guidelines, cyber security and data integrity should be given more focus as far as IOT implementation is considered [15]. The major thing that should be addressed as for as IOT implementation is concerned is the security issue as number of smart technologies are interconnected and there is no comprehensive cyber solution available as of now [26]. The security risk with respect to IOT should not be considered in isolation but should be taken into broader sense [15].

The IOT implementation should be carried out in an iterative manner where key to success is gradual learning [27]. According to siemens report the implementation should be carried out in an iteratively and pragmatic manner [20]. One of the main reasons for the failure of IOT projects remains as scaling. So, scale by Design plays an important role for successful implementation and it should not be limited to technology but include business operations and external partners also [7]. Scalability poses new unforeseen challenges as far as IOT implementation is considered [14].

In construction industry according to author the size of the company influences the way new technology is implemented. Large organizations have advantage in terms of budget and also the nature of projects handled require the utilization of IOT as compared to small organizations [10]. Larger companies have the well-defined existing infrastructure, large labor, internal process and culture. If IOT is to be implemented in such organizations, the companies will face harder time [21].

Based on the review of the literature, it is clear that IOT implementation is not discussed by lot of researchers, and there has been little attempt to find out the success factors for IOT implementation and adaptation in Indian manufacturing sector and validate those factors statistically. So, we have developed a scale for measuring factors for IOT implementation in Indian manufacturing sector.

3. Research methodology

For developing a new scale, there is need for building sound conceptual specifications about the subject. The development of scale [28] [29] uses both qualitative and quantitative methods and is a step-by-step process. The process is broadly classified into three steps. The first step also known as the qualitative step deals with the generation of items and purification of items. The second step also known as the quantitative step deals with the data collection method along with checking the appropriateness of the collected data. The third step also known as the result analysis step deals with checking the validity and reliability of the constructs using the statistical methods like EFA and CFA. The step-by-step approach for developing the instrument has been influenced by [30] and the properties of the model are also assessed.

3.1 Qualitative study phase

3.1.1 Item pool Generation

Qualitative analysis deals with finding the items related to CSF, which are to be included in the scale [29]. Literature review and expert judges serve as the primary source of getting the initial list of items [29]. In this study, most of the items were generated using the secondary method of data collection. The secondary source consists of journals from IEEE, EMERALD, ACM, SCIENCE DIRECT, etc., white paper, article and we considered both the conceptual and empirical papers. The main focus of this research was the articles published from 2010 to 2021. However, some references were also taken from earlier studies to have a clear understanding of the basic knowledge of the success factors influencing IOT implementation. From the literature review, 27 CSF items were identified.

The generation of items is a very difficult task and specific guidelines need to be followed while generating the items. The language of the item should be simple, short, and clear; and respondents should be able to easily read and respond to those items. In this stage, the item pool can be very large like four to five times of the final scale [29]. Our main source of item generation being from the secondary source, the refinement of item is required [31]. Initial refinement and correctness of item is done with content validity.

3.1.2 Content validity

Content validity is used to measure the item of interest and it can state about the relevance of the items used for measuring the targeted construct/model for a particular purpose open ended questionnaires were designed in accordance with the item pool generated from the literature review and from experts. The questionnaire was submitted to the focus group for checking the quality of question formation and for providing profound opinion on the topic. The primary objective of discussion with the focus group [32], [33] was to gauge clarity of the tasks, assess the capability of the instrument in capturing the desired phenomena, i.e., items related to success factors, ensure omission of important aspects, evaluate clarity of words, assess the likelihood of the target audience related to answering the questions, and limited time for task completion. Therefore, at this stage, modification, deletion, and addition of items are considered.

The 17 participants in the focus group were chosen to determine the content validity of the items. They included the project lead (6 people), top management (3 people), consultants (5 people) involved in IOT implementation, and academicians (3 people) involved in teaching IOT implementation practices. This made it easier for us to understand the viewpoints of academics and business management. The "complete decision rule" [34], which requires each focus group member to define the item's validity in respect to CSF, was applied. The validity was represented using a scale of 1 and 0, where 1 denotes full representation of the item and 0 denotes no representation. This helped in deeply exploring the respondents' point of view, feelings, and perspectives [35].

These discussions with the focus group and feedback from them helped in item modification before the final data collection [36]. Some minor changes were suggested by the focus group, mainly textual in nature, which include the language of the items and the questionnaires with IOT systems environment [37]. The comments and suggestions of the focus groups helped us in enhancing the clarity of the items.

3.2 Quantitative study phase

3.2.1 Questionnaire development and evaluation

Questionnaire development and survey is considered as the best method for data collection. The responses were gathered through web survey which is becoming very popular now a day [38], [39]. The design method for different types of survey methods (mail, telephonic, internet and mixed mode survey) is distinctive; hence, customized method should be used for each study [40]. So, we used the mixed mode survey through telephone and google form survey. The mixed mode augments the chance of getting relevant information as well as help in getting good response rate at minimum cost [40].

3.2.2 Pilot study performance

The items were screened using a pilot test based on Cronbach's alpha and item-to-total correlation [28]. This test aids in determining the significance and comprehensiveness of each instrument item. Based on their experiences implementing IOT in the manufacturing sector, 43 respondents—23 project managers, 9 senior consultants, 7 team members, and 4 IT professors—were chosen for this stage. Respondents were asked to rate the significance of each CSF for IOT implementation in the Indian manufacturing sector using closed-ended questionnaires.

The respondents were asked to evaluate the significance of each CSF for IOT implementation in the Indian manufacturing sector using closed-ended questions. Each item was rated on a five-point scale, with "1" being extremely low, "2" being low, "3" being medium, "4" being moderate, and "5" being very high. The first reliability was determined using SPSS 20, and the reliability for the pilot research was found to be 0.931, with each item passing the 0.7 criterion. Conceptually, reliability is used to find out that the items actually measure an attribute and have good fitness [41] [42]. It is also used to assess the quality of the construct measure. A statistically reliable instrument provides consistent and stable measures of a construct. The value of Cronbach alpha < 0.6 is considered as the unsatisfactory internal consistency, and the value > 0.7 is considered as satisfactory internal consistency. For validation of the instrument, the item-to-total correlation measures the correlation of each of the items and the total scale should be > 0.35. In our case the item-to-total correlation of each item is more than 0.35.

3.2.3 Sample and data collection

The endeavor is to collect the data for evaluating the factor structure of the measure and validating the measurement model. The size of respondents plays an important role, though there is no fixed rule regarding the sample size. Some researchers suggested that the sample size should be large [29], and some suggested that the item-to-response ratio should be 1:10 [43]. Selecting the initial sample size (ISS) and the minimum necessary sample size (MRSS) are two important criteria since selecting the sample size is a challenging process for data collecting [44], [45]. The minimum necessary usable sample should be between 100 and 200 because this study employed AMOS 20 for CFA and SPSS 20 for EFA [46]. Previous research has also indicated that a sample size of 200 can be used for a variety of statistical tests and analyses [47].

As there is always a chance that responders will not complete the questionnaire, the ISS should always be higher than the MRSS [44]. [46] states that the minimum sample size should be five times the number of independent variables, and the maximum should be fifteen times. The initial sample size was 713 (about 25 times the number of independent variables) in order to have an MRSS of at least 200 and to prevent selection bias. Therefore, the total sample size is 509, which is around 19 times the number of independent variables, taking into account the independent variable size of 27. As a result, both the MRSS and ISS requirements are met by the final response, and the item-to-response ratio is valid for analysis.

The questionnaire was given to the real IOT implementers in the manufacturing sectors, who made up the sample size. Data about a broader range of stakeholders would be helpful for the study's objectives. The responses were gathered in a variety of ways in order to develop the notion and hypothesis of the CSF items for this study. The online survey form using Google Docs, personal phone calls, and mailer responses were the most widely used methods. 27 questionnaires were sent to individuals involved in the IOT deployment in the Indian manufacturing sector in order to gather data for this study. The survey's respondents included senior management, project heads, consultants, users, and the head of the IT department. The demographic profile of the respondent is shown in Tab. 1. 57.3% of the 713 respondents were between the ages of 25 and 45. The 15–19 age group, which makes up 35% of the total, is given the highest weight due to their expertise in the manufacturing industry. According to the poll, 27% of participants were in senior management, 23% were project managers, 21% were team members, 17% were consultants, and 12% held other positions. The targeted businesses covered a variety of manufacturing verticals, including consumer electronics, computer hardware, automotive products, medical instruments, telecom instruments, hand and machine tools, air conditioning, and household appliances. The production firms selected were mostly from private sector with national or multinational origin and included both large organizations.

Table 1: Demography of respondents

Variable	Categories	Responses (%)

Age group	25 to 35 years	57.3
	45 to 55 years	42.7
Education	B. Tech	55.1
	MBA	23.2
	Bachelors	21.7
Respondent's role	Senior management	27
	Project head	23
	Part of project team	21
	Consultant	17
	Others	12
Total year of experience in manufacturing sector	1 to 5	9
	6 to 10	24
	11 to 15	26
	16 to 20	14
	20+	27

Tab. 2 summaries the cluster of selected companies and the percentage of companies under each cluster.

Table 2: Cluster of companies selected and % of each cluster

Industry selected for research	Percentage(%age)
Automobile	63
Electronics and electrical equipment	19
Computer peripherals	7
Consumer products	11

Out of 713 respondents, we received responses from 519 participants (73%). The population under study is represented by the extremely high response rate. To find out the missing data, individual responses were analyzed using the option of count blank in excel. Responses having missing value count greater than 5% were considered for deletion. The standard deviation of each individual's response for the set of questions was assessed in order to determine whether or not the respondents were engaged during the response process. Every record that had a standard deviation greater than 0.5 was kept. The records were then visually examined to determine the response variation. After then, the responses were examined to identify any anomalies. Since every response fell between 1 and 5, there were no outliers in this study. To do analysis, missing data was substituted with the closest median value. 509 replies were deemed complete for analysis following data purification. The reliability of the development model was demonstrated by the Cronbach's alpha value, which was determined to be 0.923 for the independent variable overall and greater than 0.7 for each item [46].

4. Data analysis and results

4.1 Factor Analysis

A statistical technique called factor analysis is used to identify a set of latent variables that can explain the covariance between a large number of observed variables. The data gathered from the survey was processed for factor analysis using the statistical program SPSS 20. The KMO sampling adequacy test was run on the CSF items to make sure that a sufficient sample size was obtained for factor analysis. The first analysis's KMO of 0.874 satisfied the sufficient requirement to be taken into account for factor analysis. EFA was then used to determine which factors, under maximum likelihood conditions, best reproduced the variables. It is data driven and is used to explore and summarize the underlying correlation structure for a data set. There is no restriction on the pattern of relationships observed between the unobserved and observed variables.

The factors retained were having the Eigenvalue cut off as 1. On the first run of EFA, the total variance of the factors was 73.35%, which means that the common factors explain more than 50% of the variance [48], [49]. The commonalities of the items on the CSF were > 0.5. Five factors had Eigenvalue ≥ 1. According to [46], for practical significance, the items having factor loading ±0.3 are of minimal importance, items with factor loading ±0.4 are of average importance, and items with factor loading ±0.5 are considered to be important. According to these guidelines, the items having factor loading ≤0.5 were eliminated. The pattern matrix was analyzed to find out cross loaded variables, and it was observed that no item has overloading of two or more factors. The five-factor solutions with 27 items accounted for 73.35%. After factor extraction and rotation, the factors were named as: Technical factor, Human factor, Institutional factor, Ecosystem partnership factor, and Management factor.

4.2 Assessment of measurement Model

The measurement model is tested using CFA, and correlations between the latent and observed variables were found using the hypotheses factor model. CFA is a theory-testing process in which a precise factor model is predetermined. The fit of that specific model is next assessed after the variables are compelled to load only specific factors that are identified by EFA. A latent construct's unidimensionality, validity, and reliability are evaluated using the CFA approach.In order to determine the behavior of a specific item inside the block of intended items for measuring the single construct, the first step in improving the measurement model is to assess the convergent validity and item reliability. Before utilizing these constructs for model construction, it is crucial to have a suitable level of validity, reliability, and unidimensionality [50]. Any factor with R2 less than 0.4 and factor loading less than 0.6 was eliminated. The final measurement model is displayed in Figure 1. The technical factor, human factor, ecosystem partnership factor, management factor, and institutional factors—the five constructs of the model—were represented by seven, two, four, three, and four items, respectively. Thus, 20 items are used to measure the five-construct model.In our model, the uni-dimensionality is achieved as all measuring items have factor loading ≥ 0.6.

When the measurement model has discriminant validity, all of the latent variables discriminate among themselves and there are no redundant items [46]. To determine if a latent variable explains more variance in the observable variables than other constructs or measurement error, discriminant validity is utilized.This is an essential prerequisite for determining the validity of each particular indication; without it, the construct's existence is in doubt [50]. There are two ways to access discriminant validity. According to the first approach, there shouldn't be a high correlation between various constructs, which implies that different constructs shouldn't correlate too strongly with instruments that have similar but different properties [51].The correlation between exogenous construct should not exceed 0.85, and if it exceeds then there is a serious problem of multicollinearity [52].

Fig. I show that the construct “Technical factor” has low positive correlation with “Human factor”, “Ecosystem partnership factor”, “Management factor”, and “Institutional factor” (0.39, 0.35, 0.37, and 0.21). Similarly, “Human factor” has low positive correlation with “Ecosystem partnership factor”, “Management factor”, and “Institutional factor” (0.43, 0.31, and -0.08).

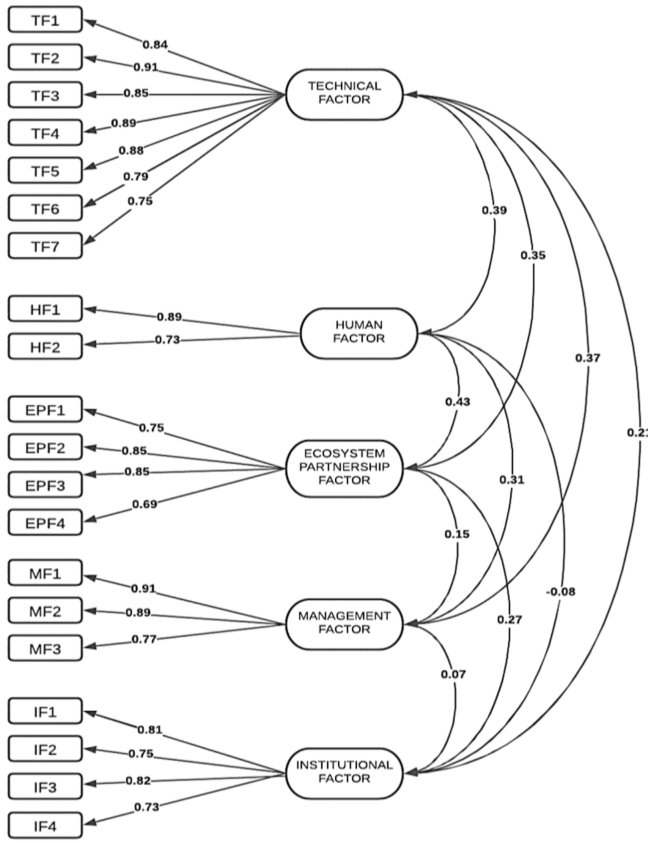

Figure 1: Measurement model

Likewise, “Ecosystem partnership factor” has low positive correlation with “Management factor”, and “Institutional factor” (0.15 and 0.27), and finally, “Management factor” has low positive correlation with “Institutional factor” (0.07). The measurement model's low correlation suggests that each construct is independent. In the second method for discriminant validity, Average Variances Extracted (AVE) of the individual constructs should be greater than Maximum Shared Variance (MSV), AVE of the individual constructs should be greater than the Average shared variances (ASV) among the constructs, and finally, the square root of AVE should be higher than the inter-construct correlations [46]. It is evident from Tab. 3 that the AVE of each individual construct is greater than both MSV and the ASVs among the constructs. The square roots of the AVEs are shown in bold (Tab. 4) along the diagonal, which are greater than the off-diagonal elements in the respective rows.

It is evident from Tab. 3 that the AVE of each individual construct is greater than both MSV and the ASVs among the constructs. The columns show amplification of the correlations between a particular construct, and the square roots of the AVEs along the diagonal are bolded (Tab. 4) and greater than the off-diagonal elements in the corresponding rows. This demonstrates unequivocally that the constructions, as opposed to other constructs in the measurement model, are able to explain more variance in the observed variables.

TABLE 3: Reliability and item loading

Construct	Items	Description	Standard factor loading	Cronbach α	Composite Reliability	Average Variance extracted AVE	Average Shared variance ASV	Maximum Shared Variance MSV
Technical factor	TF1	Infrastructure	0.84	0.947	0.945	0.687	0.11	0.153
	TF2	Data Management	0.91					
	TF3	Systems integration	0.85					
	TF4	Support and maintenance	0.89					
	TF5	Data security	0.88					
	TF6	Scalability	0.79					
	TF7	Interoperability and Standardization of IOT	0.75					
Human factor	HF1	Human capital	0.89	0.785	0.792	0.69	0.11	0.171
	HF2	Education and awareness	0.73					
Ecosystem partnership factor	EPF1	Partnerships between different sectors and parties	0.75	0.856	0.863	0.63	0.1	0.171
	EPF2	Partners with knowledge and experience	0.85					
	EPF3	Integration with external suppliers	0.85					
	EPF4	Greater customer focus	0.69					
Management factor	MF1	Composition of the project team	0.91	0.893	0.867	0.745	0.41	0.131
	MF2	Internal and external communication	0.89					
	MF3	Strategic direction	0.77					
Institutional factor	IF1	Decision-makers trained and authorized	0.81	0.855	0.859	0.615	0.41	0.085
	IF2	Support and continuous commitment of top management	0.75					
	IF3	Economic and profitability analysis	0.82					
	IF4	Training programs	0.73					

TABLE 4: Correlation matrix and roots of AVE's

	Ecosystem partnership factor	Technical factor	Management factor	Institutional factor	Human factor
Ecosystem partnership factor	**0.783**				
Technical factor	0.346	**0.837**			
Management factor	0.167	0.365	**0.861**		

Institutional factor	0.289	0.234	0.051	**0.775**	
Human factor	0.412	0.387	0.306	-0.075	**0.815**

The overall validity of the model was checked with the help of model fit indices like the goodness of fit index (GFI), comparative fit index (CFI), normed fit index (NFI), root mean square of error approximation (RMSEA), and Tucker-Lewis Index (TLI) [46]. For the measurement model, the goodness-of- fit indices is shown in Table 5. The respective values of $\chi2$/df, CFI, GFI, NFI, TLI and RSMEA are 1.472, 0.963, 0.885, 0.897, 0.955, and 0.053. Apart from the GFI and NFI, all the values are within the acceptable range. The acceptable values are $\chi2/df < 3$; CFI, GFI, NFI, and TLI > 0.9; CMIN/DF < 5; and the RMSEA<0.8 [53]. The values of GFI and NFI are below the threshold value of 0.90, but they are very close to the threshold value; hence, these values also represent an acceptable model fit. Tab. 5 clearly demonstrates that the measurement model posited a good fit with the collected data.

TABLE 5: Summary of goodness-of-fit indices for the measurement model

Model Fit Index	$\chi2$/df	CFI	GFI	NFI	TLI	RMSEA
Model Values	1.472	0.963	0.885	0.897	0.955	0.053

5. Discussion, implication and future research

Five constructs have been highlighted by the instrument development method used in this study—Technical factor, Human factor, Ecosystem partnership factor, Management factor and Institutional factors -that were indicated by seven, two, four, three, and four items, respectively. The factors account for 73.35% variability, which is considered as substantial variability. Every item that was retained had a factor loading of more than 0.6 and a Cronbach alpha of more than 0.8. From a theoretical viewpoint, this study verifies and validates the measurement model in terms of both the discriminant and convergent validity and also provided evidence of good internal consistency.

5.1 Implication for research

This study has a number of theoretical implications for the manufacturing sector's adoption of IOT. Researchers can use this study as a foundation to successfully implement IOT in the manufacturing industry. The current study is one of the first to examine the IOT implementation scenario in the Indian manufacturing sector, despite the fact that other studies have examined the factors that should be taken into account while adopting IOT. We use survey data from 519 respondents to give empirical support for the variables for IOT adoption in the Indian manufacturing industry, highlighting the significance of key aspects specifically connected to this sector.

5.2 Implication for practice

Because of efforts like 'Make in India,' IOT in the Indian manufacturing sector is expected to rise, bolstering the country's industrial capability, but there is no instrument developed for factors responsible for successful adoption of IOT in Indian manufacturing sector. Our research adds to the body of empirical data about adoption determinants in the context of the Indian manufacturing sector. Our study can assist IOT implementers in the Indian manufacturing sector in concentrating on the elements that will increase profitability, efficiency, and transparency in all business operations. Implementers can use this research as a foundation to successfully embrace IOT in the manufacturing industry. A conceptual model of IOT adoption determinants in the Indian industrial industry is defined and tested in this study. The model's constructions will assist implementers in concentrating on the elements that will support IOT adoption in India's manufacturing sector. The outcome of this research has revealed that Ecosystem partnership factor, technical factor, Management factor, Institutional factor and Human factor.

In Ecosystem partnership factor, company's solution will not be dependent on a single vendor or product; instead, all components must work together. As a result, partners in each field must be identified, and a clear plan for collaboration must be developed. The use of IOT is growing in India, but companies are having trouble with communication protocols, legacy systems, and the high costs of large-scale IOT deployment. IOT suppliers may help businesses with their digital transformation, including automation, by using their worldwide expertise and range of IOT products and services. Connectivity, awareness, a lack of compelling use-cases and viable business models, concerns with privacy and encryption, and India's current high cost of technology are the key challenges. The policies and strategies of government are the primary drivers of IOT technology research and adoption, and they will play a critical role in accelerating the paradigm shift toward smart manufacturing in the next decades. Many Indian government initiatives are currently encouraging Indian manufacturing sector to adopt smart manufacturing and stimulate economic growth.

In India, privacy has always been a key concern. Large amounts of personal data, including sensitive personal data in some situations, are shared through the use of IOT and connected devices. Data networks are delicate, and storage in data clouds is still in the early stages of development in India. As a result, data kept in a cloud service that is not sufficiently protected might lead to unwanted third-party access and information leaks, with the data being used and processed for unintended purposes. In the development and design stages of IOT devices, ensuring effective security measures is a must. Manufacturers in India have shifted their focus from ensuring device quality to creating more devices due to the increase in demand for IOT devices. As a result, low-cost, low-quality devices have been produced in large quantities, making their security weak and unsecure. The homogeneity raises the potential impact of any one security fault on all devices with the same security flaw because IOT arrangements also involve the development of similar devices.

In terms of technology, India is rapidly developing. However, the skill set required for Industrial Internet of Things (IIOT) technology acceptance and deployment is lacking. IOT demands a thorough understanding of hardware, software, and the network. Companies will need skilled workers to implement this new technology. India needs skilled labor in this new technology, and training and fully deploying the workforce for the numerous functionalities in the IOT environment should be the top most priority of top management.

Although a number of product manufacturers provide corporate IOT technologies to the Indian market, the growth of vertical solution providers and the System Integration channel is slower. This is mostly due to a lack of available data and information about the technology, the high cost of IOT hardware even during testing, and a lack of resources to scale up to the unique demands of enterprise customers. The solution is to select the proper IOT partner who can deliver the best results at the lowest cost and with the least amount of resources. To begin, solution providers should take small measures and gradually scale up.

Creating a clear vision and action plan of IOT adaptation is a huge challenge. Leaders must determine precisely what the organization intends to achieve with IOT. It's also critical that all corporate functions agree on the same vision and action plan. It's important to remember the primary goal of IOT implementation: to allow all of the company's physical and digital devices to communicate with one another. As a result, if various IOT-related decisions or action plans are made without taking into account business functions, the result could be a failure. Companies must have a clear vision of how they will use IOT to change their business model, increase operational efficiency, or improve product/service offerings.

5.3 Contribution, limitation and future direction of research

The primary contribution of this study is the definition of new constructs associated with success factors for IOT adoption in the Indian industrial sector. Additionally, this is the researcher's first attempt at creating a multi-measurement scale for these constructs. This study is significant because it looks at the elements that are thought to be essential for IOT adoption in the Indian manufacturing sector. By outlining the elements that organizations should concentrate on while implementing IOT, the study may help those that are open to doing so.

The main contribution of this research is that new constructs related to success factors for IOT adoption in Indian manufacturing sector has been defined. The development of multi-measurement scale for these constructs is also the first attempt carried out by researcher. This study is considered important as it examines the factors considered critical for successful adoption of IOT in Indian Manufacturing Sector. The research could assist the organizations that are willing to go in for IOT adoption by providing the factors which they should focus on while adopting the IOT. According to recent research, the "Ecosystem partnership factor," "Technical factor," "Management factor," "Institutional factor," and "Human factor" are thought to be crucial elements for the effective adoption of IOT in the Indian manufacturing sector. The findings can be used to better understand the elements that could contribute to the effective adoption of IOT across the majority of India's manufacturing sector. Decision-makers in the Indian manufacturing sector should find these findings useful before or during the adoption of IOT. The study presents an intriguing area for further investigation. These elements can be utilized to create a fictitious model that illustrates how these elements affect supply chain management.

Even though the results are helpful, there are certain drawbacks. The study is primarily quantitative, covers only the discrete manufacturing sector, and is limited to the Indian environment. Another restriction that may have impacted material validity is the limited size. These restrictions can be addressed by using a larger sample size and case studies from various organizations to better validate the findings. This would allow us to evaluate how important each component is to a successful IOT deployment.

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