A Structural Equation Modeling Approach for Adoption of Big Data Analytics by SMEs in India

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Abstract Big data means a large volume of data used and stored by different firms in their day-to-day operations. It is a field that extracts and analyzes a complex, large volume of data. This research is conducted to study the adoption of big data in Indian SMEs using the TOE framework. This research created awareness for the adoption of big data software in Indian SMEs. For this, a structured literature review was conducted. Three independent variables, technological, organizational, and environmental perspectives, are identified. Survey is carried out in the SMEs with the help of questionnaires. The target population is IT managers, plant managers, owners, and directors. For data analysis, exploratory factor analysis using SPSS 20.0 software and structural equation modeling using AMOS 20.0 software is used. The developed model using three independent variables and one dependent variable showed a good fit.

Keywords Big data · TOE framework · Indian SMEs · Structural equation modeling · Exploratory factor analysis

1 Introduction

The information has begun to produce a massive volume in various fields throughout the most recent years. It has been typical that the data will expand to a great extent. It had been portrayed that big data (BD) is the dramatic development of complex information for a vast scope as an advancing term [1]. As per [2], "major information is the data resource portrayed by its volume, velocity, variety, variability, and volatility that requires explicit innovation and logical strategies for its change into esteem."

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Various government establishments just started adopting BD in their offices. Most researchers have found many advantages of using BD as it helps in handling massive information among many sectors [3]. However, many firms are not ready to adopt the latest technologies of BD due to the cost of installations and the cost of handling it [4]. The present circumstance features the requirement for another top to bottom examination to comprehend the inspirations driving the amazing cycle of huge information reception [5]. Indeed, even numerous analysts accepted that massive information appropriation could essentially upgrade firm execution [6].

In the light of digitalization, where everyone utilizes new computerized innovations, like cell phones and online media, design as far as raw data has become available principally to get a handle on, keep, examine, and use at a lowered cost [7, 8]. In this way, a pervasive and always expanding advanced record, commonly named considerable information, is getting produced by every person globally. However, notwithstanding the numerous advantages of BD, less exploration has occurred about how organizations can receive it and make business esteem from such an innovation [9]. Along these lines, there is an absence of comprehension of how organizations manage the cycle of BD, usage, and worth age [10]. Accordingly, the appropriation of creative advancements can deliver more business favorable circumstances and openings for huge companies and small and medium-sized enterprises (SMEs).

2 Literature Review

2.1 Big Data Analytics in Small and Medium Enterprises

SMEs go about as the principal component of economic development by making open positions and being creative and profitable [11–14]. BD is a recently arisen technique for SME's development, which empowers them to settle on better choices about the market and clients' requirements by depending on analytical instruments [15]. It will also help them expand their severe status on the lookout. SMEs can get an incentive from voluminous information by accepting the help of BD specialist organizations. The selection of BD in SMEs can be productive in handling the significant difficulties of organizations. Utilizing BD and its insightful methods are not just for enormous endeavors [16–18]. These days, independent companies likewise can use the favorable circumstances and shrouded estimations of the high measures of on the web and disconnected information to settle on dependable choices following their organizations' target [19, 20].

The intense feeling of rivalry among the SMEs in the market would compel them to grasp BD's appropriation to increment operative execution [21–24]. However, advancement among SMEs ought not to be downplayed. The more significant part of the current writing underscored BD's significance in huge organizations [25]. Be that as it may, most SMEs are hesitant to use BD, strategies in their organizations,

or they neglect to have useful utilization of BD ventures, which is essential because of an absence of comprehension and information about BD [26].

2.2 TOE Framework and Hypothesis Development

First proposed by Tornatzky et al. [27], the TOE system is a hypothetical structure at the association level that clarifies factors that influence the way toward receiving and rehearsing mechanical advancements from the innovative, hierarchical, and natural points of view, as opposed to factors identified with the attributes and feelings of people inside the association. Various investigations have checked the TOE structure's viability in selecting different data frameworks and innovations. Three independent variables are technological factors (TF), organizational factors (OF), and environmental factors (EF). One dependent variable is big data adoption (BDA).

2.2.1 Technological Factors (TF)

Alharbi et al. [28] have characterized the relative advantage (RA) "as how much a development is seen as being superior to the thought it overrides." Earlier research, for example Ahmadi et al. [29], recommends that RA is an essential component of the mechanical setting that is fit for empowering or debilitating innovation's reception. It had been characterized compatibility (COM) as "how much the development is seen as predictable with the current qualities, past encounters, and needs of the expected adopter" [30–32]. As per [33], complexity (COMP) is how much development is seen as moderately hard to comprehend and utilize. The innovative products would be less inclined to be executed if seen as the more aspiring and testing for actualizing. Trialability (TR) is the degree to which IT advancement is conceivable to attempt [34–37]. It has characterized TR "as how much a development might be explored different avenues regarding restricted premise."

H1: TF influences BDA in SMEs.

2.2.2 Organizational Factors (OF)

(Makena [38]) Characterizing top management support (TMS) refers to how many administrators grasp and grasp another innovation framework's innovative capacities. Likewise, Kuan and Chau [39] describe TMS as the uplifting demeanor of CEOs toward innovation reception. As indicated by Alsetoohy et al. [30], Queiroz, and Wamba [40], organizational readiness (ORN) is referred as the degree for which necessary hierarchical assets are accessible for use innovation BD [41–43]. For instance, organizations need skilled labor (SL), such as information researchers, information board specialists, and experts talented at working with huge scope data

when receiving and using BD and business investigation [44–46]. Financial investment competence (FIC) refers to how firms can put resources into presenting and working BD [47]. It takes a great deal of monetary venture to receive BD in firms, including gear, programming bundle, and counseling [48–50].

H2: OF influences BDA in SMEs.

2.2.3 Environmental Factors (EF)

(Abed [51], Stjepić et al. [52]) Competitive pressure (CP) is one of the transcendent precursors of IT advancements selection inside firms. Rivalry in an industry is generally seen to affect the reception of IS advancements positively [53–55]. The external support (ES) is re-evaluating had been shown as the primary drivers in the IT development achievement, which can undoubtedly impact IT advancement reception [56, 57]. Government regulations (GR) have been acknowledged as another essential component in advancement selection [58, 59].

H3: EF influences BDA in the SMEs.

3 Research Methodology

3.1 Sampling

The data is collected through a structured questionnaire. Qualified academicians and researchers checked the questionnaire. The questionnaire was sent to the employees working in SMEs across India. The target populations were plant managers, IT managers, directors, and owners. The sample is selected simple random method from each strata because it enables population harmony from the subpopulation [60]. Four hundred fifty-nine respondents received the questionnaires; however, only 288 respondents provided usable, insightful questionnaires. For avoiding the biasness of the data, few precautions are being taken. It is mentioned in the first page of the questionnaire that the survey is for research purpose and it will not be used for anything else. We used the Harman test to calculate the single factor after the data was collected. The first factor showed a percentage of 26.445 which is below the recommended threshold level of 50% [61]. So, we can say that the data collected is not biased.

3.2 Demographics of the Respondents

Table 1 shows the characteristics of the respondents for the survey. The firm in which a total number of employees are in the range 51–100 respondents' percentage was 18%, which is the highest. Followed by employees in the range 151–250, respondent's percentage was 17%. The rest are in the range 26–50 employee's respondent's percentage with 16%, the range 1–9 employee's respondent's percentage was 15%, the range 101–150 employee's respondent's percentage was 14%, the range 10–25 employee's respondent's percentage was 12%, and the range 251 and above employee's respondent's percentage was 8%. The percentages of respondents who are directors are 29%, which is the highest. The plant manager is 26%, the IT manager is 25%, and the owners are 20%. The percentages of respondents from the type of medium enterprises are 39%, which is the highest. Followed by microenterprises are 31%, and small enterprises are 30%.

Table 1 Characteristics of the respondents for the survey

	Characteristics	Percent
I. *Total number of employees*		
A	1–9 employees	15
B	10–25 employees	12
C	26–50 employees	16
D	51–100 employees	18
E	101–150 employees	14
F	151–250 employees	17
G	251 and above	8
II. *Respondents current position*		
A	Owner	20
B	Director	29
C	Plant manager	26
D	IT manager	25
III. *Type of firms*		
A	Microenterprises	31
B	Small enterprises	30
C	Medium enterprises	39

Table 2 Cronbach's alpha, composite reliability, rotated component matrix, and AVE for the variables

Latent variable	Indicators	Cronbach's alpha (α)	Composite reliability (CR)	Rotated component matrix	AVE
TF	RA	0.849	0.830	0.840	0.510
	COMP			0.869	
	TR			0.882	
	COM			0.720	
OF	TMS	0.886	0.838	0.843	0.541
	ORN			0.886	
	FIC			0.892	
	SL			0.838	
EF	CP	0.847	0.794	0.886	0.514
	ES			0.898	
	GR			0.840	

4 Data Analysis

4.1 Reliability and Validity

4.1.1 Cronbach's Alpha

A reliability test is being performed with the data for each factor. Cronbach's alpha is considered as a measure of the scale reliability. Cronbach's alpha (α) is being calculated for all three factors. The values should be higher than 0.70 [62, 63]. Hence, all the values are within the threshold, as shown in Table 2.

4.1.2 Composite Reliability

For all the components, composite reliability (CR) was measured. It is measured by its ability to provide better results in terms of internal consistency [64]. Three CR constructs have > 0.7, which indicates the reliability of the composite reliability measures [60, 62], as shown in Table 2.

4.2 Exploratory Factor Analysis (EFA)

Evaluation of the sample size was the first step of the EFA. For EFA, SPSS 20.0 has been used. Bartlett's sphericity test had inspected the correlations between the items [65]. For current investigations, the KMO value is 0.741 which is greater than 0.60,

Table 3 Discriminant validity matrix

	CR	AVE	MSV	MaXR (H)	TP	OP	EP
TF	0.830	0.510	0.151	0.881	0.714		
OF	0.838	0.541	0.010	0.894	0.046	0.735	
EF	0.794	0.514	0.151	0.862	0.388	0.100	0.717

i.e., the minimum acceptance level. The principal axis factoring is the extraction method used. Only values with values more significant than one have been extracted because the maximum variance is explained. For these components, components 1 (32.396%), 2 (26.310%), and 3 present the share of the total variance (14.788%). The cumulative proportion of all three components explained is 73.494%.

For interpreting the analysis results, the rotated component matrix is essential. Rotation helps to group items, and the structure is simplified by at least more than two items for each group. This is, therefore, the objective of the rotation objective. We have achieved this goal in this research. Total 11 variables are grouped into three components, as shown in Table 2.

4.3 Construct Validity (CV)

CV is the measure in which a test quantifies the idea or development that should be quantified. CV does not have a cutoff [65].

4.3.1 Convergent Validity

This is measured by the help of the average variance extracted (AVE). As per [66], the convergent validity AVE > 0.5. For the constructions, Table 3 shows AVE values. Every value is more than 0.5, which satisfies all the building structures' convergent validity.

4.3.2 Divergent or Discriminant Validity

Fornell and Larcker [66] suggested that the AVE construct must be more than one square for this validity to be calculated by the relationship between these constructs and the other constructs. Table 3 represents the values for discriminant validity matrix. Hence, in Table 3, we can see that all the constructs, i.e., TF, OF, and EF values for MSV, are lesser than AVE, which satisfies the discriminant validity of all the constructs.

4.4 Structural Equation Modeling (SEM)

For testing the proposed hypothesis taken in the study, SEM is used using the software AMOS 22.0 [67]. This shows the results of the model. The final model and latent variables and their indicators and their dependent variable are represented in Fig. 1. TF: technological factors have four indicators RA, COMP, TR, and COM; OF: organizational factors have four indicators TMS, ORN, FIC, and SL; EF: environmental factors have three indicators CP, ES, and GR. One dependent variable is BDA: big data adoption, which has four indicators: BDA1, BDA2, BDA3, and BDA4. Table 4 shows model parameters.

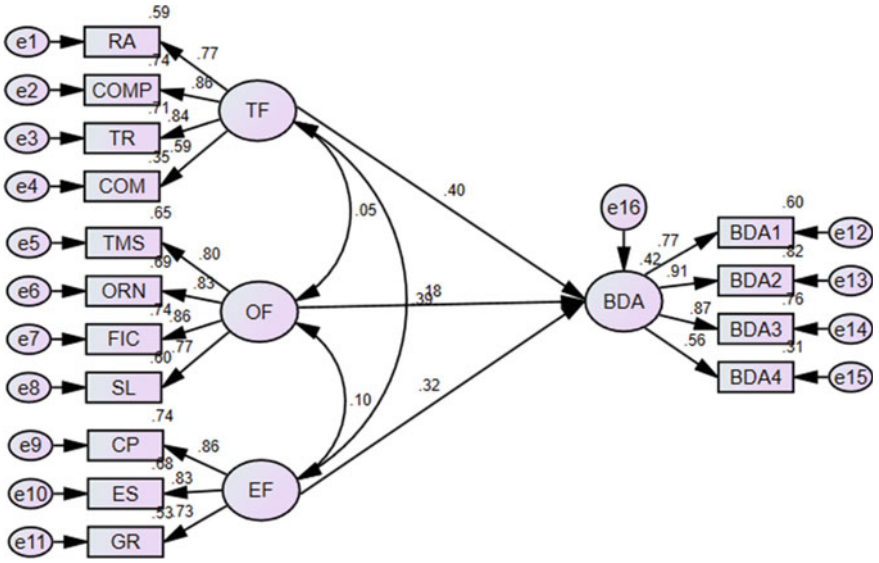

Fig. 1 Final model for the adoption of BDA

Table 4 Model fit measures for the confirmatory factor analysis

Goodness-of-fit Indices	Default Model	Benchmark
Absolute goodness-of-fit measure		
$\chi 2$/df (CMIN/DF)	2.898	Lower limit: 1.0 Upper limit 2.0/3.0 or 5.0
GFI	0.908	>0.90
Incremental fit measure		
CFI	0.934	⩾0.90
IFI	0.925	⩾0.90
TLI	0.917	⩾0.90

Table 5 Path analysis result for structural model

	Estimate	SE	CR	P	Hypothesis
TF ← BDA	0.405	0.138	2.94	***	Supported
OF ← BDA	0.180	0.075	2.40	***	Supported
EF ← BDA	0.318	0.086	3.69	***	Supported

Table 5 shows the path analysis result. Three hypotheses support the *P*-value [68]. Hence, the three factors TF, OF, and EF have a positive impact on BDA. The structural model explains 41.6% of the variance of BDA.

5 Discussion

The current research found that the TOE perspective plays an important role for BDA in Indian SMEs. The indicators which had a significant impact are RA, COMP, TR, COM, TMS, ORN, FIC, SL, CP, ES, and G.R. From the results, it is obvious that the three components suggested by the framework help in BDA in Indian SMEs. The KMO value is 0.741, which is greater than 0.6, which is within the threshold level [60], which allows the data for factor analysis. The values below 0.4 were suppressed in the rotated component matrix table. Only the values more than 0.4 were displayed as output. The component TF relates to the technological aspects for adopting BDA. It comprises four sub-components: RA, COMP, TR, and COM, and each loading is 0.840, 0.869, 0.882, and 0.720. OF relates to organizational aspects for adopting BDA. It comprises four sub-components: TMS, ORN, FIC, and SL, and each loading is 0.843, 0.886, 0.892, and 0.838. EF relates to the environmental aspects of adopting BDA. It comprises three sub-components: CP, ES, and GR, and each loading is 0.886, 0.898, and 0.840. Hence, the loadings of sub-components are $>|0.40|$. In the present circumstances, BDA will play an important role in the smooth running of the Indian SMEs.

Construct validity is also an essential component of the analysis. Hence, AVE was calculated, which is >0.5 for all the three constructs TF, OF, and EF, which satisfies the convergent validity for all the constructs. Further divergent or discriminant validity was also checked for all the three constructs, which shows MSV < AVE. Hence, this criterion was also satisfied. Earlier research conducted by Lai et al. 2018 in logistics and supply chain management for BD supported this research work. Another study using the TOE framework in Korean firms for BD has supported this research [69]. Another study was conducted in the SMEs of Iran using the TOE framework for BD and supported the results and other studies [70]. Hence, the current research is based on a survey method, and a structured questionnaire was developed to collect data from the respondents from various Indian SMEs. Finally, SEM was performed to get the model fit.

6 Conclusion

This study's main aim is to find out the role of BD in the Indian SMEs using the TOE framework. For this, a structured literature review was conducted from the available literature. TOE framework was identified for the research as many earlier IT-related innovation adoptions studies being conducted using TOE. The target population was owners, plant managers, IT managers, and directors. Three independent variables were TF, OF, and EF. The dependent variable was BDA. For the analysis, EFA and SEM were used. The model developed showed a good fit, and the three hypotheses were accepted. This research was supported by other research work conducted in different countries.

Further this study can be extended to other sectors or some other countries.

Annexure: Questionnaire

1. Name of the employee (optional):
2. Designation:
3. Total number of employees:
4. Type of firms
    a. Microenterprises
    b. Small enterprises
    c. Medium enterprises

Please rate the following factors for your firm on the scale of 1–7, 1 for strongly disagree, 2 for disagree, 3 for partially disagree, 4 for neutral, 5 for partially agree, 6 for agree, and 7 for strongly agree.

Questionnaire	Please mark						
Big data adoption	1	2	3	4	5	6	7
Our firm is interested in adopting big data							
Our firm intends to adopt big data							
I would not hesitate to recommend to adopt big data							
I feel comfortable to recommend big data for my firm							
Technological factors							
Relative advantage							
Complexity							
Trialability							
Compatibility							
Organizational factors							
Top management support							
Organizational readiness							
Skilled labor							
Financial investment competence							

(continued)

(continued)

Questionnaire	Please mark						
Big data adoption	1	2	3	4	5	6	7
Environmental factors							
Competitive pressure							
External support							
Government regulations							

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