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E-Learning during COVID-19 Outbreak: Cloud Computing Adoption in Indian Public Universities

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Abstract: In the COVID-19 pandemic situation, the need to adopt cloud computing (CC) applications by education institutions, in general, and higher education (HE) institutions, in particular, has especially increased to engage students in an online mode and remotely carrying out research. The adoption of CC across various sectors, including HE, has been picking momentum in the developing countries in the last few years. In the Indian context, the CC adaptation in the HE sector (HES) remains a less thoroughly explored sector, and no comprehensive study is reported in the literature. Therefore, the aim of the present study is to overcome this research vacuum and examine the factors that impact the CC adoption (CCA) by HE institutions (HEIs) in India. The scope of the study is limited to public universities (PUs) in India. There are, in total, 465 Indian PUs and among these 304 PUs, (i.e., 65% PUs) are surveyed using questionnaire-based research. The study has put forth a novel integrated technology adoption framework consisting of the Technology Acceptance Model (TAM), Technology-Organization-Environment (TOE), and Diffusion of Innovation (DOI) in the context of the HES. This integrated TAM-TOE-DOI framework is utilized in the study to analyze eleven hypotheses concerning factors of CCA that have been tested using structural equation modelling (SEM) and confirmatory factor analysis (CFA). The findings reveal that competitive advantage (CA), technology compatibility (TC), technology readiness (TR), senior leadership support, security concerns, government support, and vendor support are the significant contributing factors of CCA by Indian PUs. The study contends that whereas the rest of the factors positively affect the PUs' intention towards CCA, security concerns are a significant reason for the reluctance of these universities against adopting CC. The findings demonstrated the application of an integrated TAM-TOE-DOI framework to assess determining factors of CCA in Indian PUs. Further, the study has given useful insights into the successful CCA by Indian PUs, which will facilitate eLearning and remote working during COVID-19 or similar outbreak.

Keywords: Cloud computing; higher education institutions; public universities; adoption techniques; TAM; TOE; DOI; structural equation modeling (SEM)

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1 Introduction

The world is facing the biggest challenge of the 21st century called the COVID-19 pandemic, influencing almost every walk of human life, including the education of more than 1700 million students worldwide [1]. Many countries have imposed restrictions or even lockdown. This COVID-19 pandemic situation is making online education a popular and perhaps the only choice for higher education (HE) institutions [2–4]. It is necessary to adopt cloud computing (CC) applications by educational institutions, in general, and HE institutions (HEIs), in particular, for delivering education online [5]. CC adoption (CCA) has transformed the global business information technology into a new paradigm of online data storage, management, and processing instead of using traditional brick and mortar-based servers. This new paradigm offers easy online access to massive computing power [6]. Further, CC can deliver the 24 × 7 IT services in an economical, scalable, easily accessible, reliable, secure, and transparent manner, with improved efficiency and collaboration for mobile and digital environments [7]. Owing to the unique benefits offered by CC, it is being adopted by organizations across various sectors [8]. According to Costello et al. [9], the total worldwide public cloud service revenue is expected to be USD 354.6 billion by 2020. The 2025 forecast for the global market size of CC is USD 832.1 billion [10]. CC has the potential to offer a broad gamut of services across education delivery and research for the educational institutes [11]. The cloud-based resources can improve the quality of learning cost-effectively and support to the sustainability of education by facilitating the needed storage capabilities, software and infrastructure [12]. The market size of CC in education is expected to reach USD 25.36 billion by 2021 [13]. Although CC offers enormous benefits to educational institutes, there are concerns relating to reliability, security, privacy, performance, latency, control, proprietary lock-in, and the maturity of technology [11]. Further, challenges like the availability of computing resources, physical facilities, and adequacy of skilled personnel negatively affect technology adoption by the education sector, especially in developing countries [14].

Due to the benefits of CC and the adoption of technology by competitors, the HEIs across the world, including developing countries, are increasingly adopting cloud-based services (CBSs) [15]. The CCA by HEIs has also started receiving due importance from the researchers. However, the present research on the CC applications in the education sector has mostly focused on CC frameworks, implementation, security, and pricing mechanisms. The utilization and adoption of CC in education have not been adequately addressed [16]. There has been the least emphasis on the organizational and individual perspectives, including the CCA [17]. Hence, it is crucial to explore CCA in the HE sector (HES). Technology adoption is defined as *the acceptance or use of a new product or technology voluntarily* [7]. To ascertain the priorities of the users, it is needed to study the factors that impact their CBSs' adoption intent and decision [18]. Studies in this regard are scarce [14,17], More literature is needed on contributing factors of CCA in the HEIs in the developing countries [14], including India [16].

1.1 The Study Approach

This research focuses on identifying and addressing the aspects that impact the CCA by Indian HEIs. The scope of the study is limited to public universities (PUs), including Indian central and state universities. An extensive literature survey was undertaken to build a theoretical base for the study. For the stated research purpose, the present study ushers in a comprehensive, integrated framework based on three renowned theoretical adoption models viz., Technology Adoption Model (TAM), Technology-Organization-Environment (TOE) Model and Diffusion of Innovation (DoI) Model. The data was collected from the key IT professionals and administrators of 304 Indian PUs. The participants were invited to participate in the study by emailing them information about the purpose of the research. In some instances, the respondents were approached through personal contacts or visited in-person for the data collection. The survey responses were collected over one month, from 15th February -to 15th March 2020. The Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) were used to assess the factors concerning CCA by Indian PUs. The study also identifies currently in-use CBSs and solutions being used by Indian PUs. The recommendations were formulated based on the results of the investigation. The findings are intended to assist the educational institutions in understanding the factors to be considered while adopting CC. Further, based on better knowledge of the HEIs' needs, the developers and suppliers of CBSs may pitch their services more effectively by offering customized technology features. The proposed integrated TAM-TOE-DOI framework applied and assessed in this research is anticipated to improve the predictive power of the resulting model. The empirically validated model for data collection used by the present study may be adopted by similar studies in India and abroad. The research will also contribute to literature on the new technology adoption in organizations.

1.2 The Indian Context

India has a population of 1.35 billion [19], with approximately 500 million individuals in the young age group of 5–24 years [20]. In the HES, there are a total of 945 universities in India as of 1st June 2020 [21] including 465 PUs (412 state universities and 53 central universities), 361 private universities and 124 deemed to be Universities [21]. Further, there are 39,931 colleges affiliated to these universities and 10,725 stand-alone institutions. The total number of teachers in HE in India is 14,16,299. The total enrolment in the HES of India has been estimated to be approximately 37.4 million, with 51.34% males and remaining 48.66% females. India has a 26.30% Gross Enrolment Ratio (GER) in HE for the age group 18–23 years [22]. The size of the education market in India is estimated to reach USD 101.1 billion in 2019. The E-learning market in India is projected to reach USD 1960 million by 2021, with an estimated 9500 thousand users [20]. The CCA prediction in the Indian context by Gartner (June 2019) reveals that SaaS, PaaS, and IaaS models will respectively contribute USD 1,396 million, USD 313 million, and USD 809 million and total market revenue would be USD 3048 million by 2020 end [23]. The benefits of CC are pushing the Indian HEIs to adopt many applications of CC, especially SaaS viz., Google's Gmail, Google calendar, Zoom platform, and Google Meet. Further, the institutions are employing learning management systems (LMS) to facilitate course delivery and assessment. In the pandemic COVID-19 situation, the need of adopting CC applications by education institutions, in general, and HEIs, in particular, has especially increased to engage students in an online mode. Hence, the present study assumes relevance in the Indian context. The next section describes the literature review to provide background about the relevant research on CCA in various sectors, including HE in India and other countries. After that, the research framework is described, followed by hypotheses development. The fifth section on research methodology delves into sampling, data collection, research instrument design, and data analysis methods. Next, the results and discussion section contain sampling description, data analysis, including hypotheses testing and discussion about the findings. Finally, the conclusion section describes implications, limitations, and avenues for future research.

2 Review of the Literature

A review of the relevant literature on CC including the concept of CC, theoretical adoption models, theories used by the existing studies, and the CCA in the education sector in general and HES in particular in various contexts including India is presented in the following paragraphs.

2.1 Cloud Computing (CC)

There are several different definitions of CC by various experts [24]. CC has been commonly defined as "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources like networks, servers, storage, applications, and services that can be released with management effort or service interaction with the provider*" [25]. There are three types of CC service models viz., SaaS, PaaS, and IaaS. SaaS offers application service in the user premises flexibly and securely via cloud infrastructure and is billed on a subscription basis [25]. PaaS provides computing platforms and allows end-users to develop, run, and manage the application software [26]. Further, IaaS offers computing, storage, networking resources, and system software, including operating system with security and recovery features. It reduces the burden to manage and maintain the servers as infrastructure is provided by the service provider [27]. There are four CC deployment models viz., private, public, hybrid, and community cloud [25]. Public cloud services like Gmail, Hotmail, etc. are available publicly through the Internet with cloud being hosted on the service provider's premises [28]. Private cloud services are for exclusive internal use and can be accessed under the control of the company's IT department. Only authorized users can access them through a secure VPN connection such as Microsoft Exchange. Hybrid cloud is the blend of the public and private cloud, with users being able to store confidential data on private cloud and general data on a public cloud. In a community cloud, two or more organizations with common interests set up their own private cloud data centre for use and sharing purposes [29]. A standard CBS being shared by government departments for functions such as centralized payroll processing is an example of a community cloud [14]. Low et al. [30] has reported that the determinants of CC deployment models are the type of organization, its strategy, and its environment.

2.2 Technology Adoption Theories and Model

There are various information system theories and models to study the determinants impacting the technology and innovation adoption at the societal organizational and individual level [14]. Researchers have considered various theories and models including Adaptive Structuration Theory (AST) [31], Social Cognitive Theory (SCT) [32], Human, Organization, Technology (HOT) Fit [33], Task–Technology Fit (TTF) [34], Theory of Reasoned Action (TRA) [35], Knowledge-based view of the firm [36], Technology, Organization, and Environment (TOE) Framework [37], DOI Theory [38], Technology Acceptance Model (TAM) [39], TAM 2 [40], TAM 3 [41] and the Unified Theory of Acceptance and Use of Technology (UTAUT) [42]. The extant literature on CCA shows that researchers have generally used TOE model [30,43], and DOI model [29], Abubakar et al. [44] for ascertaining the acceptance and usage of CCA by organizations. Some other studies have also used TAM-TOE model [45,46] and TAM-DOI model [47,48],TOE—DOI model [7,30,49,50], and TAM-DOI-TOE model [8].

2.3 Cloud Computing Adoption (CCA) in Education

In the education sector, the CCA may contribute to improving organizational efficiency, stimulating innovation, saving money on technology investment, and increasing agility [51]. The use of CC is also expected to cut down the operational cost [52] of educational institutes. CC offerings may find out the solution for advanced IT resource scarcity and unavailability of the latest technology in developing countries [53]. Further, CC offers the availability and ease of access in 24 × 7 fashion for using own equipment, mobile devices, and university computers for students and educators who can collaborate, edit, store, share, and process vast amounts of data [12]. Hence, the significance of CC in the education sector has amplified rapidly over time, and it will continuously grow in the future [11]. However, the technology adoption by educational institutions, especially in the developing countries, face many challenges like inability to match the development of e-learning curriculum and training requirements of staff with the rate of technological change [54], security issues, inadequate infrastructure, non-supportive government policies and lack of technical knowledge [55]. In the Chinese context, the application of UTAUT model revealed that factors like recognized cost, recognized risk, individual's innovativeness, performance expectancy, social influence, effort expectancy, and enabling terms influence students' CC adaptation [56]. Further, using TAM framework, risk, trust, and recognized usefulness were reported to impact the intention of German universities' students to use CC [57]. In Turkey, privacy and security were found as the primary factors impacting the students' CCA [58]. Based on the TOE model, Tashkandi et al. [59] found three factors viz., complexity, privacy and competitive advantage (CA) affect CCA by Saudi Arabia's HEIs. Sabi et al. [60] used an integrated TAM-DOI model and listed a total of 18 factors that affect CCA by sub-Saharan African universities. Using TAM framework, the CC usage by universities in Thailand was investigated [61]. This study revealed that recognized usability, usefulness, convenience, trust, intent to use, and software functions were considerably impacting the CCA of the universities in Thailand.

Further [62] examined the determinants of CCA by Malaysian universities. Ashtari et al. [12] explored the CCA among the students at a University in Southeast Michigan, and reported CC determinants like recognized usability, computer anxiety and self-efficacy, internet self-efficacy, and recognized usefulness of CC services. Using TAM model [63] revealed that recognized usability affected the intention of teachers to use technology in HE in the United Arab Emirates (U.A.E.) [64] applied DOI theory, and identified CCA determinants in the context of HEIs in Jordan. These determinants include the resistance of latest technology, privacy, data safety, cost-effectiveness, centralization, compatibility, usability, senior leadership support (SLS), and knowledge sharing. To investigate the factors impacting CCA in the HES of Kenya [14] used the TOE model. This study identified seven significant CCA factors viz., technology readiness (TR), recognized barriers, CAs, complexity, compatibility, regulatory policies, and vendor's support. Further, a study [18] conducted in the Ethiopian HES used an integrated TOI-DOI model and reported the relevance of technology, environmental, organizational, and socio-cultural factors for CCA.

In the Indian context, some studies [16,24,65] have investigated the determinants that impact the CCA in the education sector. Out of these studies conducted in the Indian context [16,24] applied the TOE model. Further, [24], studied the CCA in school in India. The determinants of CCA among librarians of the Indian universities were explored by Yuvaraj [65]. This study reported that recognized usability, usefulness, and ubiquitous availability of the enabling technology strongly drive technology adoption. Further, a study [16] examined the factors influencing CCA in the Maharashtra state of India, targeting HEIs and reported CA, complexity, and data concern as the primary determinants. [17] indicates that very few studies across the world have assessed the determinants of CCA by the HEIs. Researchers criticized the scarcity of research on CC in the HES in comparison with the business sector. A systematic literature review study [66] reported that several universities were inclined to adopt CC; however, available literature in this regard is very scanty [14]. Hence, there is a need to explore this area further. The review of existing studies also suggests that not much work has been done to investigate the determinants affecting the CCA in the education sector, in general, and the HES, in particular, in India. Further, hardly any study on CCA in the Indian context has been founded on a strong theoretical framework based on the established information system theories and models like TOE, TAM, DOI, TRA, TTF, etc. The extant literature also reveals the lack of empirically verified studies in the Indian context that used robust statistical approaches, for instance, CFA and SEM. Thus, CCA in the Indian HES remains a less thoroughly explored area. Therefore, the present study is an effort to overcome the literature gaps.

3 Research Framework

Our study integrates TAM, TOE framework, and DOI theory to arrive at an integrated TAM-TOE-DOI framework for investigating the factors impacting CCA in Indian HEIs. DOI theory [38] offers a commonly accepted adoption model that has been used by many researchers. DOI explains how the users from a population respond to and accept a new product or concept and divide the population into five kinds of technology adopters viz. innovator, early adopters, early majority, late majority, and laggards. DOI proposes five attributes that explain the rate of adoption of new technology viz., 1) CA: How valuable is an innovation than a traditional one; 2) compatibility, how much innovation can be adapted into the current business practices, processes, and value systems; 3) complexity, the difficulty to use the innovation; 4) observability, how noticeable the innovation is to others; and 5) trialability, how easy it is to test the innovation. Further, innovation is considered as *a communication process, and three factors affect the innovation adoption in organizations viz. individual (leadership attitude toward change), organization's internal structure (complexity, centralization, interconnectedness, number of personnel, and the organizational slack), and the organization's external traits (system openness)* [67]. TOE framework [37] explains an enterprise-level acceptance of innovation considering three primary contexts that affect an innovation adoption: 1. The organization context: the various explanatory attributes of the organization viz., organizational structure, departmentalization, role and responsibilities of human resources, degree of control, the process of communication among employees, etc. 2. The technology context: the latest technology appropriate to the organization and its benefits. 3. The environmental context: the market components, competitors, and the regulatory environment. Many studies have used TOE framework [30,43,45,49] on CCA.

TAM [39], an adaptation of TRA [39,68] is used to know the behaviour of an individual in acceptance of technology innovation. TAM consists of four factors viz., recognized usability, recognized usefulness, mindset towards using, and behavioural intent to use. The recognized usability (or perceived ease of use) and recognized usefulness factors are the predictors of attitude towards using and behavioural intention factors. Hence, TAM hypothesizes that user's perceptions of the technology's usefulness and usability are the significant determinants of technology acceptance. Recognized usefulness is defined as the potential user's perception that utilizing a specific system will improve his or her job performance within the organization. Recognized usability implies the usability of the target system the potential user expects [39]. To examine the enterprise-wide technology adoption and acceptance, the scaled extensions of the basic framework, that is, TAM2 [40] and TAM3 [41] have considered various types of antecedents to the recognized usefulness and recognized usability. Previous studies [45–47] have applied this model to CCA. As explained in the previous paragraphs, many empirical studies on the CCA has used TAM, TOE framework, and DOI theory. The rationale for selecting DOI to explore the diffusion and CCA is that CCA is yet at the early maturity stages of diffusion in the developing countries like India. The technology context of TOE has similarities with the attributes of technology adoption offered by DOI theory. The TOE framework also considers the organization and environmental contexts and thus, extends the DOI concept. Many studies have employed an integrated TOE-DOI model [30,49]. Further, the user perception of technology has a vital role in the user's technology adoption decision. In the HES in India, especially the PUs, the decision making is done by the senior leadership, and the expert users' and decision-makers' propensity to propose the CCA is due to its recognized usefulness and usability. TAM offers these two constructs as two significant determinants of technology acceptance by individuals, and they have also been considered by many studies [45,46]. The previous studies on CCA have also combined TAM with the TOE model [45,46] and DOI theory [47,48]. The integrated TAM-TOE-DOI framework used in our study, is expected to be more comprehensive with a better understanding of CCA. It includes three enterprise-wide contexts offered by TOE framework, individual factors explained by TAM, and the attributes of innovation put forth by DOI theory. The existing literature indicates that such an integrated framework has not been used in the HES in India or abroad. Kumar et al. [8] attempted to integrate TAM, TOE, and DOI to study the CCA by Indian SMEs (small and medium enterprises).

A total of 11 technology adoption factors adapted from TAM, TOE framework, and DOI theory are found pertinent in the context of our study. Three attributes of DOI theory considered relevant as innovation characteristics for the CCA by Indian PUs are CA, technology compatibility (TC), and complexity of technology (CoT). Further, the technical context of the TOE framework explores the TR of PUs to adopt CC. The organizational context of TOE examines the contribution of SLS in the technology adoption intention of PUs. The security concerns of the PUs regarding CC and cost advantage, if any, from using the technology are the apparent factors that may have a bearing on the intention of the universities to adopt the technology. Hence, security concerns and cost advantage, in addition to the SLS, are considered under the organizational context. The environmental context of the TOE framework predicts the role of government support and vendor support in influencing CC intention of PUs. Finally, the two factors of TAM model viz., recognized usability, and recognized usefulness of CC technology are found appropriate as individual characteristics to examine senior leadership's intention of adopting the technology. The various factors considered in the study are based on the published literature as per Tab. 1.

Table 1: Factors and respective sources

Factor	Source(s)	Factor	Source(s)
Competitive advantage (CA)	[14,16,59]	Technology Compatibility (TC)	[43,69]
Complexity	[14,45,59,60,65]	Technology Readiness	[8,14,69]
Senior leadership support (SLS)	[7,8,45,49,64]	Security Concerns	[7,29,58,60]
Recognized usefulness	[8,12,45,57,60,65]	Cost Advantage	[7,56,60]
Recognized usability	[8,12,29,45,60]	Government Support	[13,50,70]
Vendor Support	[21,45,47,49]	Adoption intention	[8,45,71]

4 Hypotheses Development

Based on the integrated TAM-TOE-DOI framework for CCA and review of the relevant literature, a total of eleven factors were found to be pertinent to influence CCA of Indian PUs. The following hypotheses concerning these factors were formulated:

4.1 Hypothesis Development-Competitive Advantage (CA)

The competitive (or relative) advantage of technology is the benefits it offers over that offered by the existing technology and practices. It is the extent of recognition of an invention as being superior to one it replaces [67]. The CCA would offer distinct features like usage-based payment options [72], shared resources, accessibility of uploaded documents from anywhere [73], faster service [74], new educational and research opportunities [75] and more straightforward installation and upgrade process [76]. Thus, it may be assumed that the benefits of CC will exceed existing practices and procedures [49] and hence, will positively influence its adoption [7]. The existing literature [7,30,50,59] further shows that CA has been found as an essential determinant of CCA. Therefore, the proposed hypothesis is as follows:

H1: Competitive advantage (CA) of CC will positively affect the intent of Indian PUs to adopt CC.

4.2 Hypothesis Development-Technology Compatibility (TC)

TC indicates how interoperable the new technology is with the present technology, systems, processes, activities, etc. in the organization. It is the extent of an innovation's recognition as consistent with prospective adopter's current values, previous experiences, and present needs [67]. Further, while examining the compatibility of new technology, one should consider organizational culture [59], current technology architecture [45], and existing formats, interfaces, and other structured data [77]. If a university finds CC technologies being technologically compatible, it may have more inclination to offload its capability to the cloud infrastructure. The available studies [7,14,69], have also indicated TC as an essential determining factor to influence CCA. Hence, the hypothesis is as follows:

H2: Technology compatibility (TC) will positively impact the intent of Indian PUs to adopt CC.

4.3 Hypothesis Development-Complexity of Technology

The complexity of technology is associated with the challenge of using it. It is the extent of an innovation's recognition as being comparatively hard to understand and use [67]. The use of technology may be complicated due to lack of technological knowledge and expertise in using it [30,74], and difficulty in integrating it in the business operations [7]. The complexity of CCA is measured in terms of time needed to carry out tasks, applications' integration with the particular CC infrastructure, data transfer efficiency, system features and functionality and design of the interface [45]. Thus, it is expected that if a PU perceives CC as complex to use, it may not be inclined to adopt the same. The existing literature [7,14,59] has also reported complexity as an inhibitor for the CCA. Hence, the hypothesis is as follows:

H3: Complexity will negatively impact the intent of Indian PUs to adopt CC.

4.4 Hypothesis Development-Technology Readiness (TR)

Technology readiness refers to the preparedness of the organization for new technology adoption. It includes structural aspects, that is, availability of the requisite platform or the technological infrastructure and the specialized human resources, that is, availability of employees with essential knowledge and skills to facilitate the implementation of the new technology within the organization [30]. Thus, PUs with TR are better equipped for CCA. The available studies [7,78] have reported that TR has a crucial role in the organizations' CCA decision. Hence, the proposed hypothesis is as follows:

H4: Technology readiness will positively impact the intent of Indian PUs to adopt CC.

4.5 Hypothesis Development-Senior Leadership Support (SLS)

SLS ensures the commitment of resources for the adoption of any new technology [79]. The available literature further describes SLS in terms of its commitment, involvement [49], long term vision [80], and creation of friendly organizational environment [69], and thus, overcoming resistance to change for adopting new technology. If senior leadership of the university is convinced of the benefits of CC, they will be more inclined to dedicate institutional resources to adopt such technologies. The available studies have also indicted the decisive role of SLS in the CCA. Hence, the following hypothesis follows:

H5: Senior leadership support (SLS) will positively impact the intent of Indian PUs to adopt CC.

4.6 Hypothesis Development-Security Concerns

Security concerns of users in a CBS environment relate to data privacy, confidentiality, theft, loss, and ownership [81]. Further, there are also concerns over the geographical location of data centres as data protection laws vary for each country [81]. Hence, if the CC technologies do not have robust security features and processes, and organizations apprehend any chances of security violation, there will be a reluctance to adopt CBSs. The existing studies [7,82,83] have also reported security concerns as an essential impediment to the CCA by organizations. Hence, the proposed hypothesis is as follows:

H6: Security concerns will negatively impact the intent of Indian PUs to adopt CC.

4.7 Hypothesis Development-Cost Advantage

CC technologies offer cost-saving benefits by reducing operations and maintenance costs [84], infrastructure cost, and energy consumption [85]. By adopting CBSs, the organizations can concentrate on their core business without being bothered by technological changes, system maintenance, or routine upgrades [7]. Hence, significant time and cost savings can result. If an organization is well-versed with the cost advantage that may occur due to CBSs, it is expected to be more inclined to adopt CC. Thus, cost advantage is an essential determinant of CCA as indicated by the extant literature [7,29,50]. Therefore, the proposed hypothesis is as follows:

H7: Cost advantage of CC will positively impact the intent of Indian PUs to adopt CC.

4.8 Hypothesis Development-The Recognized Usefulness

The recognized usefulness is a subjective probability of the prospective user that the use of a particular application will result into his or her job performance improvement within the organization and report the direct effect of recognized usefulness on the adoption intention of a technology [86]. In the context of CC technologies [87] found that CC would result in improved business efficiency, performance, and productivity. Thus, if users understand that CBSs are useful to their operations, they are inclined to adopt CC [45,71]. Given the above, the proposed hypothesis is as follows:

H8: Recognized usefulness will positively impact the intent of Indian PUs to adopt CC.

4.9 Hypothesis Development-Recognized Usability

Recognized usability of technology refers to perceptions of users regarding usability and learning, simplicity, clarity, understandability, and flexibility of technology [40,86]. It is the extent of the potential user's expectations about the usability of the target system [86]. Hence, if CC technology is recognized as easy to use, the users can be expected have more inclination to adopt the same as indicated by the findings of many existing studies [29,45,71]. Therefore, the following hypothesis is proposed.

H9: Recognized usability will positively impact the intention of Indian PUs to adopt CC.

4.10 Hypothesis Development-Government Support

The government support means the policies, rules and regulations set by the authorities to assist in the implementation of the technology [70]. The government significantly impacts the organizations [14,70] to adopt CC by offering fiscal incentives [14,29], instituting adequate regulatory framework [14], and creating a trustworthy environment [50]. In the Indian context, any kind of strategic decision like CCA with financial implications in an India PU is governed by the government policy framework. Thus, government support may influence the CCA by Indian PUs. This leads to the following hypothesis:

H10: Government support will positively impact the intention of Indian PUs to adopt CC.

4.11 Hypothesis Development-Vendor Support

Vendor support is critical for ensuring success with the CCA by an organization. This is because the organizations will have to depend on vendors for all services migrated into the cloud-based environment [8]. The specific issues concerning vendor support to the organization include infrastructure customization [29], technical support, user training [14], security controls, and data availability [45] by the vendor in a cloud-based environment. Hence, vendor support is expected to affect the users' intention positively to adopt CC as per the literature [14,30,45,70]. Hence the hypothesis is as follows:

H11: Vendor support will positively impact the intention of Indian PUs to adopt CC.

5 Research Methodology

The exploratory study design was applied to meet the stated research objective. The study used primary as well as secondary data sources. A quantitative research approach using a pre-tested structured questionnaire as a survey instrument was employed for the data collection.

5.1 Sampling and Data Collection

The collection of secondary data was carried out by visiting relevant websites and reviewing relevant articles and research papers published in various magazines and journals. For the collection of primary data, the survey method using a personal interview and a pre-tested structured questionnaire was adopted. The HEIs selected for the survey were Indian PUs. There are 945 universities, including 465 Indian PUs [21]. Out of these 465 PUs, 53 are categorized as Central and 412 as State Universities. The respondents were generally key IT professionals, and administrators like IT managers/officers/System Administrators/ Computer Centre In charge of the PUs. The websites of the various public-sector universities were visited to collect contact details of the respondents. Wherever contact details of the relevant respondents were not available, the Registrar/Deputy Registrar of the university was approached to authorize the appropriate authority for sharing the required data. Every respondent was provided with details of the research objectives and a request to participate in the study. A questionnaire link using Google form was created (hosted online from 15th February and 15th March 2020) and sent by email to the respondents. In some instances, the respondents were approached through personal contacts or visited in-person for the data collection. The consent of the respondents to participate in the survey was obtained before seeking their responses to the survey questions. All the 465 Indian PUs were approached for examining their intention to adopt CC. However, only 318 PUs responded. Fourteen filled questionnaires were rejected due to missing data or illegible responses. Therefore, the valid sample size was 304. The responses of the participants to the survey questions were gathered and stored in an online file.

5.2 Research Instrument

A questionnaire was developed as a survey instrument to examine the determinants impacting the intent of CCA of Indian PUs. The questionnaire contained items determined on a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). The scale items were decided based on the available studies in the context of CC and then reviewed with three researchers and two CC professionals. A pilot survey of eleven Indian PUs was undertaken to further revise and finalize the scale items before data collection. Thus, a total of 44 scale items were initially finalized as part of the questionnaire administered to the respondents. Five scale items were subsequently dropped during data analysis, finally leaving a total of 39 scale items. In the final questionnaire, different sections related to factors affecting the intention for CCA, and details of the PUs and their respective representatives authorized to respond.

5.3 Data Analysis

The identity of the respondents was excluded from the analysis to safeguard confidentiality. The survey data collected from 304 Indian PUs was analyzed using Exploratory Factor Analysis and SEM utilizing the use of IBM SPSS Statistics 26 and IBM SPSS Amos 21.0, respectively. While applying SEM, CFA and Path Analysis were conducted. EFA has been done before undertaking CFA to ascertain the basic structure of factors and identify the dimensions of each of the larger constructs of the measurement model for CFA. Cronbach's alpha was employed to test the reliability of the scale and each of the sub-scales consisting of individual factors. Then, SEM was performed using a two-step approach to assess the measurement model and structural model, as proposed in Anderson et al. [88]. First, the measurement model was formulated, and construct validity and goodness of model fit were examined through CFA. Then, the structural model fit was examined, and path analysis was performed for hypotheses testing.

6 Results and Discussion

The next paragraph describes the sample and findings of the hypotheses testing.

6.1 Sample Description

The sample description indicating designations of key IT professionals of the participating universities, profile of the universities selected for the study, and their usage of CC service and deployment models is presented in Tab. 2. Tab. 2 reveals that 109 PUs (35.86%) have a total faculty and staff strength in the range of 1,000–1,500, followed by up to 500 (26.97%), 501–1,000 (16.12%) and 1,500–2,000 (13.49%), in that order. Only 7.57% of the PUs have a faculty and staff strength of more than 2,000. As far as student strength is concerned, most of the PUs (30.92%) have 10,001–15,000 students, followed by student strength of up to 5,000 (28.62%), 5,001–10,000 (16.78%) and 15,001–20,000 (14.80%), in that order. Tab. 2 further reveals that only 8.88% of the PUs have a student strength of more than 20,000. Concerning the CC service model usage in the respondent universities, Tab. 2 indicates that most (90.79%) of the PUs are using SaaS, while, the usage of IaaS (9.54%) and PaaS (7.57%) is minimal. Moreover, it is found that the hybrid cloud is the most popular, with 89.47% of the PUs using this deployment model. Tab. 2 also shows that out of the key IT professionals and administrators who responded on behalf of the respondent universities, 57.24% were computer centre in-charges, 28.62% were IT managers/officers, and 14.14% were faculty members from the IT departments of the universities.

Table 2: Sample description (N = 304)

Total Number of Faculty and Staff Members	Number	Percentage
Up to 500	82	26.97
501–1,000	49	16.12
1,000–1,500	109	35.86
1,500–2,000	41	13.49
More than 2000	23	7.57
Total Number of Students		
Up to 5,000	87	28.62
5,001–10,000	51	16.78
10,001–15,000	94	30.92
15,001–20,000	45	14.80
More than 20,000	27	8.88
Type of Cloud-based Service (CBS) in Use		
SaaS	276	90.79
IaaS	29	9.54
PaaS	23	7.57
Type of Deployment Cloud Computing (CC) Model		
Public cloud	267	87.83
Private cloud	27	8.88
Hybrid cloud	272	89.47
Designation of the Key IT Professional/ Administrator		
IT department faculty member	43	14.14
IT manager/officer	87	28.62
Computer center in charge	174	57.24

6.2 Exploratory Factor Analysis (EFA) and Reliability Analysis

EFA using principal component analysis (PCA) and varimax rotation was employed to determine and evaluate the initially finalized 44 scale items. From these scale items, three were dropped due to cross-loadings, and thus, a total of 41 scale items were left. The sampling adequacy measure Kaiser-Meyer-Olkin (KMO) had the value 0.712 (>0.5), implying the appropriateness of the sample for the factorability of the data. Bartlett's Test of Sphericity resulted in 0.00 significance, indicating the reasonable correlation among variables for factor analysis, without any outlier. The factors with an eigenvalue one or greater were considered significant. Based on the eigenvalues, the scale items were grouped into twelve factors explaining 76.01% of the variance. Further, reliability analysis revealed Cronbach's alpha coefficient of 0.712 for the scale consisting of 41 scale items. The Cronbach's alpha coefficients of subscales comprising of respective factor constructs varied from 0.735 to 0.925. Thus, the reliability coefficients for the scale and subscales are more than the recommended value of 0.50 [89]. Hence, it can be assumed that all the extracted 12 factors are valid and reliable for the factor structure.

6.3 Confirmatory Factor Analysis (CFA) and Measurement Model

Using IBM SPSS AMOS 21.0, a measurement model was developed. The stability of the scale was checked by applying CFA, and the maximum likelihood method. Two-scale items from the 41 scale items were dropped to improve the model fit of the measurement model as suggested by the standard residual values. Hence, the revised measurement model consisted of 39 scale items. Further, post-hoc modifications were not conducted because of the good fit of the data to the measurement model as represented by model fit indices in Tab. 3. EFA using PCA and varimax rotation was again applied to see any revision in the factor structure of the 39 scale items. The KMO measure (0.725) revealed sampling adequacy. Bartlett's Test of Sphericity resulted in 0.00 significance, showing acceptable correlation among the variables for factorability. It was further found that scale items again grouped into twelve factors, reflecting 75.60% of the explained variance. The Cronbach's alpha coefficients for the revised scale (0.707) and subscales (ranging from 0.735 to 0.925) were found to be more than the recommended value of 0.5. Thus, all the extracted twelve factors from the revised scale after conducting CFA are reliable and valid for the factor structure. Vvarious model fit indices were estimated next to estimate the model fit of the revised measurement model. Tab. 3 shows these model-fit indices of the revised measurement model. Tab. 3 indicates that the chi-square value divided by the degrees of freedom (χ^2/DF = 1.361) is less than the recommended value of 3 [90] and thus, reveals that the group of factors in the model has high stability. The RMSEA value (0.035) is less than the acceptable value of 0.06 [91], which indicates that data has a very less error value and thus, scale items can explain the respective factors to a large extent. Further, the comparative fit index (CFI) value (0.967) is found to be more than the acceptable value of 0.95 [91]. The reasonable level of fit for these three indices reflects a good model fit according to Hair et al. [89]. Further, Tab. 3 also shows that goodness of fit index (GFI) value (0.877) and adjusted goodness of fit index (AGFI) value (0.849) are marginally less than the recommended values of 0.9 [92] in the case of both the indices. However, it has been recommended that GFI value above 0.865 and AGFI value above 0.810 are marginally acceptable [93]. Tucker-Lewis index (TLI) value (0.962) is more than the recommended value of 0.95 [91]. Further, the incremental fit index (IFI) value (0.968) being close to 1 indicates a good fit [94]. Thus, the 12-factor measurement model with a chi-square statistic of 865.589 (d.f = 636, $p < 0.001$) has a good overall fit to the data.

The measurement model's convergent and discriminant validity was tested next. The convergent validity indicates a high proportion of variance in common for measurement items of a specific latent variable in the model. The average variance extracted (AVE) and composite reliabilities (CR) were examined to test the convergent validity, as suggested by Anderson et al. [88]. The AVE is the mean-variance obtained for the item loading on a construct. It indicates the summary of convergence. The CR is the square of the sum of factor loadings for each construct and the sum of error variance terms for a construct. It measures the overall reliability of a set of items loaded on a latent variable. The estimated values of AVE and CR for each construct is presented in Tab. 4. These are more than the minimum recommended values of 0.5 and 0.7 respectively [95]. These findings indicate the measurement model's convergent validity.

Table 3: Goodness-of-fit statistics for the measurement model

Measurement indices	Model Value	Recommended value
Chi-Square (χ^2)/Degree of freedom (DF)	865.589/636 = 1.361	≤3.0 [90]
Comparative Fit Index (CFI)	0.967	≥0.95 [91]
Root Mean Square Error Approximation (RMSEA)	0.035	≤0.06 [91]
Goodness of Fit Index (GFI)	0.877	≥0.90 [92]
Adjusted Goodness of Fit Index (AGFI)	0.849	≥0.90 [92]
Tucker-Lewis Index (TLI)	0.962	≥0.95 [91]
Incremental Fit Index (IFI)	0.968	Close to 1 [94]

Table 4: Convergent validity tests

Measure	Average Variance Extracted (AVE)	Composite Reliability (CR)
Competitive advantage (CA)	0.613	0.856
Technology compatibility (TC)	0.776	0.911
Complexity (CX)	0.567	0.797
Technology readiness (TR)	0.506	0.785
Senior leadership support (SLS)	0.537	0.775
Security concerns (SC)	0.609	0.820
Cost advantage (CA)	0.716	0.882
Recognized usefulness (PU)	0.644	0.843
Recognized usability (PEOU)	0.728	0.888
Government support (GS)	0.775	0.931
Vendor support (VS)	0.712	0.880
Cloud computing adoption (CCA)	0.829	0.936

The discriminant validity indicates the degree a latent variable is truly distinct from other latent variables in the measurement model and requires that the factor correlation among a pair of latent variables should be less than the square root of AVE of each construct [96]. The diagonal elements in Tab. 5 are the AVE values for the respective latent variables, which are found to be higher than the correlation values of each pair of constructs indicating the discriminant validity of the measurement model.

6.4 Hypotheses Testing: Structural Equation Modelling (SEM)

The measurement model was converted into the structural model to test the proposed hypotheses using IBM SPSS AMOS 21.0. The simplified structural model showing hypothesized causal relationships among the latent variables is shown in Tab. 6. The structural model explained 61% of CCA intention by PUs. The estimates of standardized regression weights were used to make interpretations regarding the proposed hypotheses, as represented in Tab. 6. Tab. 6 reveals that out of the proposed eleven hypotheses, seven are supported. The supported hypotheses pertain to factors viz., CA (H1, $p < 0.10$) and TC (H2, $p < 0.01$) in the case of innovation characteristics; TR (H4, $p < 0.1$) in the technological context; SLS (H5, $p < 0.1$) and security concerns (H6, $p < 0.05$) in the organizational context; and government support (H10, $p < 0.01$) and vendor support (H11, p,0.05) in the environmental context. Rest of the four hypotheses that are not supported pertain to factors like complexity (H3) in the case of innovation characteristics; cost advantage (H7) in the organizational context; and recognized usefulness (H8) and recognized usability (H9) in the case of individual characteristics.

Table 5: Discriminant validity test

Latent variables	RA	TC	CX	TR	SLS	SC	CA	PU	PEOU	GS	VS	CCA
RA	**0.783**											
TC	0.140	**0.881**										
CX	−0.110	−0.247	**0.753**									
TR	0.100	0.165	−0.148	**0.710**								
SLS	0.000	0.035	−0.008	0.043	**0.733**							
SC	−0.048	−0.057	0.075	−0.006	−0.067	**0.780**						
CA	0.040	0.083	−0.018	0.095	0.057	−0.058	**0.846**					
PU	0.139	0.126	−0.098	0.119	0.037	−0.037	0.047	**0.802**				
PEOU	0.026	0.190	−0.073	0.123	0.142	−0.013	0.083	0.456	**0.853**			
GS	0.052	−0.193	0.127	−0.069	−0.106	0.045	−0.148	−0.113	−0.100	**0.880**		
VS	−0.018	0.024	−0.012	−0.039	0.020	−0.099	0.050	0.007	−0.016	−0.016	**0.844**	
CCA	0.171	0.457	−0.274	0.220	0.149	−0.141	0.162	0.210	0.209	−0.265	0.123	**0.911**

Table 6: Standard Path Coefficient Estimates and Hypotheses Testing

S. No.	Path	Standardized Path Coefficients	CR	*p*-value	Results
H1	Competitive advantage (CA) → Adoption intention	0.09	1.787	0.074	**Supported ($p < 0.10$)**
H2	Technology compatibility (TC) → Adoption intention	0.331	5.840	***	**Supported ($p < 0.01$)**
H3	Complexity → Adoption intention	−0.077	−1.465	0.143	Not supported
H4	Technology readiness → Adoption intention	0.104	1.904	0.057	**Supported ($p < 0.1$)**
H5	Senior leadership support (SLS) → Adoption intention	0.095	1.675	0.094	**Supported ($p < 0.1$)**
H6	Security concerns → Adoption intention	−0.128	−2.174	0.03	**Supported ($p < 0.05$)**

Table 6 (continued).

S. No.	Path	Standardized Path Coefficients	CR	*p*-value	Results
H7	Cost advantage → Adoption intention	0.075	1.430	0.153	Not Supported
H8	Recognized usefulness → Adoption intention	0.081	1.306	0.192	Not supported
H9	Recognized usability → Adoption intention	0.051	0.832	0.406	Not supported
H10	Government support → Adoption intention	0.142	2.735	0.006	**Supported ($p < 0.01$)**
H11	Vendor support → Adoption intention	0.104	2.030	0.042	**Supported ($p < 0.05$)**

6.4.1 Innovation Characteristics

Tab. 6 shows that in the case of innovation characteristics, only two hypotheses concerning CA (H1) and TC (H2) are supported. The findings reveal that CAs of CC have a positive impact on the intention of PUs to adopt CC. CAs of CC, as indicated by the study include improved efficiency, accessibility benefit, enhanced service quality, and new educational and research opportunities. This finding is consistent with other available studies in the HES [14,59,60]. The second factor, that is, TC, is found to be positively linked to the adoption of CC by PUs. Thus, the universities are encouraged to adopt CC if the institution's IT infrastructure, culture, values, and existing practices are compatible with CC technologies. Other studies [14,64] on CCA in the HES have reported similar results. Further, in line with [18,56,58], the third factor, that is, the complexity of technology is not found to have a significant negative impact on the CCA intention of Indian PUs. Since two out of three factors of innovation characteristics impact the CCA intention of the PUs, innovation characteristics can be presumed to impact the intention partially.

6.4.2 Technological Context

The study has considered one factor of technological context, that is, TR. It is found that universities with TR are more likely to adopt CC. The findings further indicate that PUs' understanding regarding the utility of CC in supporting their operations, hiring workforce with requisite technical and managerial skills, and regular updating of the workforce on CC knowledge enable CCA. UGC [21] also reported similar results. Hence, it is inferred that technological context impacts the PUs' CCA intention.

6.4.3 Organizational Context

Three factors, viz., SLS, security concerns, and cost advantage, have been considered under organizational context. The SLS is found to have a significantly positive impact on the intention of PUs to adopt CC. The findings reveal that the senior leadership should dedicate essential resources for CC and bear the consequences of CCA. Similar findings are reported by Odeh et al. [64]. The results further indicate a significantly negative role of security concerns related to data security, intellectual property, and privacy in influencing PUs' intention to adopt CC. The existing studies [58,64] have also reported a significant role of security concerns in CCA by HEIs. The last factor of organizational context, that is, cost advantage does not significantly impact the PUs' CCA intention. This may be because PUs are not fully aware of the financial benefits of CC. The cost advantage was not reported as a significant factor in

CCA by similar studies [14,58,59]. Since two out of three factors of organizational context impact CCA intention of the PUs, it can be assumed that organizational context partially impacts the intention.

6.4.4 Environmental Context

The present study has considered two factors of organizational context viz., government support, and vendor support. It is found that government support including incentives, facilitation and regulatory provisions by the authorities has a significantly positive impact on PUs' intention to adopt CC. the study by Sayginer et al. [50] also reported the same kind of findings. The second factor, that is, vendor support, is further revealed as a significant factor for positively influencing CC intention of Indian PUs. It is found that vendor support is expected in the form of appropriate technical support, incentives and training of the employees. Njenga et al. [14] informed similar findings. Thus, it may be presumed that the environmental context has a significant impact on the intention of PUs to adopt CC.

6.4.5 Individual Characteristics

None of the factors of individual characteristics viz. recognized usability, and recognized usefulness is found to impact PUs' intention to adopt CC. This may be because CC is not a new technology for the users, and they are well-versed with usability and usefulness of CC technologies. Therefore, they are indifferent to the recognized ease use and recognized the usefulness of CCA. Similar findings are reported by Kumar et al. [8] while examining technology adoption intention in the context of SMEs. Hence, individual characteristics of users do not have a role in the CCA intent.

7 Implications of the Study

The results have implications for various stakeholders like private universities, CC developers and vendors, government agencies, and policymakers associated with HE in India. The findings have given an opportunity to the PUs to reflect on their readiness for adopting CC. The PUs will be positively inclined to adopt CC technology if they are convinced of the CA of this technology for improved efficiency, accessibility benefit, enhanced service quality, and new educational and research opportunities. Hence, CC developers and vendors need to consider these aspects while offering CC technology to PUs. The developers and vendors should also get conversant with the existing set-up and compatibility requirements of the university and customize their offering accordingly. The SLS has been further found as an essential determinant in the decision of the university to adopt CC. This is especially true in the Indian context, where decisions having financial implications are not possible without the consent of the senior leadership. The senior leadership positions in Indian PUs are generally filled with the permission of the government. Hence, the senior leadership, at times, is guided by the government policy while making decisions that have a financial bearing. The senior leadership is also able to impact the government policy framework. Therefore, SLS is critical for developers and vendors. Moreover, security concerns of PUs regarding CC like data security, intellectual property, and privacy is an essential factor that can disincline them from adopting CC. This can impact the potential business of developers and vendors of CC technologies. Hence, they should make every effort to dispel the apprehension of users and management of universities regarding the security features of CC technologies. Since either Central or State Governments fund PUs; hence, it is expected that government support has to have a considerable impact their CCA intent. The present study has unearthed similar results. Therefore, to enhance the use of CC in PUs, both Central and State Governments and policymakers should institute a requisite policy framework. The universities also seek adequate laws to protect and regulate the use of CC technologies. Further, vendor support in the form of technical assistance and training may be instrumental in positively influencing PUs to adopt CC. The universities look forward to vendor support in the face of any problem or technology update during the use of CC. Similar results have been revealed when the effect of TR on the intention to embrace CC was examined. The findings indicate a positive inclination of PUs to adopt CC if they have an adequately skilled and trained workforce.

8 Conclusions

The present study has attempted to assess the determinants of CCA in HEIs in India. The scope of the study is limited to Indian PUs. The study has applied an integrated TAM-TOE-DOI framework consisting of innovation characteristics, technological context, organizational context, environmental context, and individual characteristics. The findings reveal that the technological context and environmental context impact the intention of PUs to adopt CC. Further, innovation characteristics and organizational context partially impact PUs' intention for CCA. However, individual characteristics fall short of influencing the universities' intentions. The findings corroborate that CA, TC, TR, SLS, security concerns, government support, and vendor support are the major determinants of CCA in Indian PUs. The study has further underlined that whereas the rest of the factors positively impact the intention of the PUs to adopt CC, security concerns are a significant reason for the reluctance of these universities against adopting CC. This study is based on a sample of 304 Indian PUs. Hence, care should be taken to generalize the findings of the study. Future studies may extend their research to private-sector universities, colleges, and schools in India and other countries. The present study is cross-sectional. However, since computing technologies keep evolving due to their dynamic environment, it is pertinent to engage in longitudinal studies to ascertain and compare determinants of CC across various types of educational institutes. Due to COVID-19 outbreak, this study and its results have more significance. CC is an essential component to facilitate e-learning and remote working. It is also expected that most of the determinants of CCA are also applicable in the case of e-learning adoption in PUs and HEIs in India.

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