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# Variations on Internet of Things adoption factors between India and the USA

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**Purpose:** This study examines the variations on Technology Adoption Factors, including the cultural aspects in both developing and developed countries for Internet of Things, as the Technology Adoption Factors are not common across the globe.

Although much research has focused on the technical aspects of Internet of Things (IoT) devices, attention is still required regarding IoT applications, features, use cases, and behavioural aspects in the context of the consumption and perception of IoT services.

**Design/methodology/approach:** In this research, an empirical study is undertaken to identify the factors that influence the adoption of IoT services, using a model based on the unified theory of acceptance and use of technology.

**Findings/results:** A survey of 800 users was administered in the United States of America (USA) and India. Reliability Tests, Validity Tests and exploratory factor analysis were performed to find the presence of common method variance across both countries. The findings reveal the significance of several independent variables on the adoption of IoT services, namely perceived security risks, perceived trust, social influence, facilitating conditions, and performance expectancy.

**Practical implications:** This research provides evidence that cultural aspects, social influence and facilitating conditions play a significant role. Illustrations of Airtel, Reliance Jio promotions in India and data-driven decision making from mayors of the USA included.

**Originality/value:** The research reveals the variation in IoT adoption factors between India and the USA. There are unique variations involved per country that need to be considered for the effective adoption of IoT.

**Keywords:** IoT; TAM; technology adoption; UTAUT; cross culture.

## Introduction

Usage of the Internet of Things (IoT) has accelerated in recent years owing to the increased consumption of IoT-enabled devices and services. There are multiple variables that contribute to this, among which the role of trust in IoT services is significant, similar to mobile banking services (Kumar Sharma & Sharma, 2018). The IoT began as a network incorporating smart devices in the 1980s, gaining traction in 1999 using Radio Frequency IDentification (RFID)-based connectivity. In late 2000s, the IoT started evolving into the Web of Things (WoT), based on the notion of leveraging Web standards to interconnect various types of embedded devices. By enabling various computing systems to interact unambiguously and understandably, editable both by humans and computers, the WoT subsequently evolved into the Semantic WoT (SWoT) (Chatzimichail et al., 2021; Pandey et al., 2021). Based on industry reports provided by DataProt, the number of installed IoT devices will increase to 25.4 billion by 2030 (*Internet of Things Statistics for 2022 – Taking Things Apart*, 2023). Coronavirus disease 2019 (COVID-19) has been a catalyst for IoT diffusion by attracting sponsorship from various countries' governments in an effort to promote Information Technology (IT) as much as possible in order to increase levels of automation, robotisation, and remotisation. The demand began with critical industries such as healthcare and has since spread to other industries. In 2020, 31% of decision-makers had decided towards IoT adoption in the enterprise sector worldwide. The combat measures including lockdown, quarantine, social distancing, among others, have caused delays in the IoT projects. The global framework 3GPP that leads the 5G specifications got to announce delay in their milestone. Post coronavirus disease 2019 (COVID-19), the growth of 5G IoT Market for the forecasted period of 2023–2030 is expected to reach 17.68 bn USD (US Dollars). This growth is significantly high because of increasing smart city projects, higher demand on digital wearable devices, high potential 5G deployments on connected healthcare, security and surveillance segments (*Insights 360*, 2023).

IoT applications vary in nature, encompassing consumer applications, enterprises, and government agencies. The IoT makes use of synergies that are generated by convergence among customer, business, and industrial Internet consumers. Industrial IoT applications can be classified based on delay tolerance and delay sensitivity (Michailidis et al., 2020). This convergence establishes a network of connected people, things, and data globally. This convergence also leverages the cloud to connect the intelligent products or things that can sense and transmit a broad array of data, which supports the creation of services that would be difficult to provide without such a level of artificial intelligence and connectivity. Internet of Things projects are attracting extremely large investments across the globe, leading to research and development in various kinds of smart projects (Asir et al., 2015).

These transformative technologies, including mobile, cloud, and IoT, are driving the use of platforms. The services provided by the IoT are improving manufacturing processes, transforming factories into smart buildings and smart environments by incorporating the multiple networks involved in production and delivery. Global infrastructure is being reshaped by cloud technologies that allow anyone to create services, applications, and content, and making it accessible for users across the globe. The IoT creates and maintains connections with these things globally and maintains their identity online. Mobile access provides connection 24×7 across the globe, anywhere, anytime. The net result is a network of things, with global access for consumers and users, who can create multiple business opportunities, generate new services, purchase globally, contribute content, among others (Vermesan & Friess, 2014).

Research on the technical aspects and evolution of the IoT is occurring in several dimensions. However, there is less research focusing on the behavioural consumption and usage aspects of IoT services, especially in the context of cross-cultural analyses. Differences in the cultural dimensions exist if various national cultures will have differences in perception and towards the adoption of technology evolutions (Rufin et al., 2014). People's decision making is influenced by the country's cultural aspects, as found by the study done with 830 university teachers across Spain and China (Huang et al., 2019). The cross-cultural studies performed with British and Lebanese students confirm that there is a variation in perceived ease of use, facilitating conditions, whereas perceived usefulness and behavioural intention show no significant difference (Tarhini et al., 2015).

Based on geography, the largest share of 5G IoT market for the year 2023, is expected to count Asia Pacific region, that has many developing nations (*Insights 360*, 2023). Considering the proximity of author, the authors picked India as one of the developing nations from Asia Pacific, for this study. United States is leading the technology curve on Industrial Revolution 4.0 with the combination of IoT, artificial intelligence and cloud computing. Forecast by Statista reveals that United States will be the global leader on IoT spending up to 194 bn USD by the year 2029 (*Global IoT Spending by Country 2029/Statista*, 2022). It can be observed from the pace of 5G deployments, where North America will exceed 50% of global deployments by the year 2023 (*5G Network Deployment/VIAVI Solutions Inc.*, 2023). These factors motivated the authors to choose the country level cross-cultural study between a developing nation (India) and a developed nation (United States).

The remainder of this article is organised as follows. The section 'Theoretical framework' describes the theoretical framework, which is based on the relevant literature. The research hypotheses are postulated in the section 'Hypothesis development'. The methodology, including data collection, measures, and data analysis, is examined in the section 'Research methodology'. The results are presented and discussed in the section 'Results and discussions'. Theoretical and managerial implications are presented in the sections 'Theoretical contributions' and 'Managerial implications', respectively. Conclusions are provided in the section 'Conclusion', and the article concludes by discussing limitations and future research opportunities in the section 'Limitations and future scope'.

## Theoretical framework

In their study on IoT adoption, Hsu and Lin highlighted the dimension of network externalities and information privacy as this plays a significant role in consumers' motivations (Hsu & Lin, 2016). Network externalities refer to the added value that users gain with the increase of users, services, and complimentary products. In the information technology field, this is extremely relevant as the value to the users increases as the number of adopters increases, as has been witnessed in the context of social networking sites such as Facebook, Twitter, among others.

Caputo et. al (2018). used motivational theories in their study of IoT-based products, in which the motivators were classified as intrinsic motivators and extrinsic motivators. Intrinsic motivators include information acquisition, technology readiness level, and privacy risks, while extrinsic motivators include entertainment and social interaction. Using assemblage theory, Hoffman and Novak studied the customer experience in consumer IoT products (Hoffman & Novak, 2018), focusing on how experience assemblages are embedded in socio-material networks, assemblage formation processes, and the implications of object experience and customer experience.

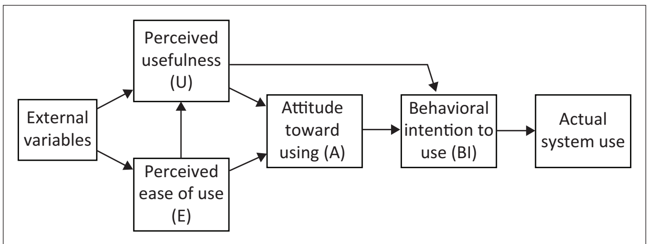
In a study of USA farmers regarding IoT adoption towards smart agriculture, Jayashankar et al. used consumption value theory, focusing on the risks and values that affect IoT adoption (Jayashankar et al., 2018). The study revealed that perceived value is enhanced by trust, while perceived risk has a negative impact, with personal data misuse considered a factor inhibiting IoT adoption. Another exploratory study in the United Kingdom (UK) with 35 students focusing on the adoption of smart refrigerators revealed that social factors such as cost, social influence, and technology anxiety, as well as technical factors such as perceived usefulness and perceived ease of use are the key factors (Alolayan, 2014). The IoT contributes to productivity increase in large companies, small and medium-sized enterprises including start-ups. In a survey involving 4800 Small Medium Enterprises (SMEs) across 12 countries, it was found that the enterprises using Internet technology have increased their revenue twice as quick as the businesses with minimal use of IoT. In addition, the export revenues of Internet-savvy SMEs that actively use IoT were twice as high as the revenue of the enterprises that were not active in using IoT (Kim & Shin, 2015).

The technology models that are frequently used when it comes to technology adoption are the technology acceptance model (TAM) and the unified theory of acceptance and use of technology (UTAUT) model. These models have been widely used in a variety of adoption studies and research (Venkatesh & Davis, 2000; Venkatesh & Zhang, 2010).

## Technology acceptance model

As technology is undergoing continuous evolution, the associated models also require refinement to match the evolving needs. This viewpoint has been endorsed by the study of Gao who revealed that TAMs can be enriched by adding characteristics, such as fun and pleasure, in their study utilising the customer acceptance model in the context of IoT technology adoption (Gao & Bai, 2014). In their study of IoT smart home service, Kim proposed enriching the TAM by combining it with the value-based adoption model (Kim et al., 2017). This study balanced the benefits and sacrifices of the user in adopting IoT-based smart home services. The benefits included usefulness, enjoyment, and variety seeking, while the sacrifices included the technicality and perceived fees. The conceptual model of TAM is shown in Figure 1.

In the context of information technology adoption across organisations, enterprises, and individuals, the primary determinants are perceived usefulness and perceived ease of use. These aspects underpin the attitude towards IT systems, which is linked to user intention and usage behaviour. Here, perceived ease of use refers 'to what extent the respondent feels that using a system is not complex and will not consume mental efforts', while perceived usefulness refers to 'the extent to which a person feels that using a system would enhance his or her job performance' (Davis, 1989).




*Source*: Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly: Management Information Systems*, 13(3), 319–339. https://doi.org/10.2307/249008

**FIGURE 1:** Technology acceptance model, version 1.

Technology acceptance model (TAM) focuses mainly on the instrumental considerations of technology acceptance. One of the main constructs of TAM is perceived usefulness. Perceived usefulness focusses on results, performance, and job orientation that are the masculine cultural value expressions. The feminine values such as employee focus, people orientation and their relationships are absent. Extending TAM to include the concepts such as quality of life and work are important technology adoption concerns (Srite & Karahanna, 2006).

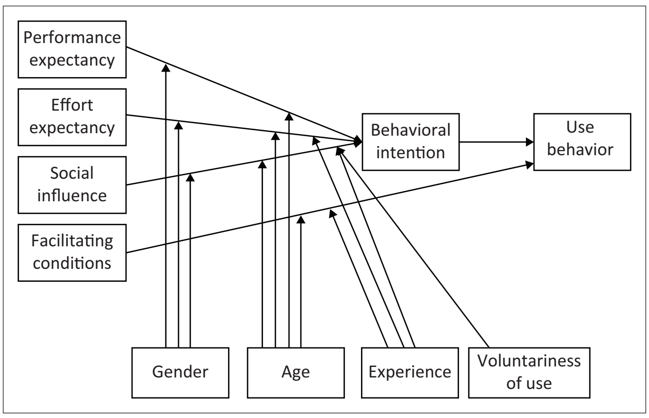
## Unified theory of acceptance and use of technology

Prior literature has shown that technology adoption models, such as TAM, diffusion of innovation (DOI), the theory of planned behaviour (TPB), and the theory of reasoned action (TRA), all focus on user acceptance. Regarding the search for a comprehensive model, the UTAUT model devised by Venkatesh integrates the findings of these earlier studies (Venkatesh et al., 2003). This model comprises four critical antecedents: facilitating conditions, social influence, effort expectancy, and performance expectancy. These variables affect the behavioural intention and the actual behaviour, as shown in Figure 2.

The unique attributes of various other theories and models pertaining to technology acceptance are considered key variables in the UTAUT model, as shown in Table 1.

The moderators are voluntariness, age, experience, and gender. Their relationships have been validated by multiple researchers, including Weerakkody's research on technology adoption in the electronic government context (Weerakkody et al., 2013), Wang's study of consumer adoption for interactive decision aids (Wang & Benbasat, 2009), and Lian's study of the adoption of e-services provided by cloud technologies (Lian, 2015).

Futhermore, the UTAUT model has been used across several fields of empirical studies around the globe, including: a user acceptance study in Bangladesh focusing on open government data (Talukder et al., 2019); a study of students'




*Source*: Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems, 27*(3), 425–478. https://doi.org/10.2307/30036540

**FIGURE 2:** Unified theory of acceptance and use of technology.

**TABLE 1:** The core variables of unified theory of acceptance and use of technology.

| Variable | Sources |
|---|---|
| Performance expectancy | Extrinsic motivation (MM)<br>Perceived usefulness (TAM/TAM2)<br>Relative advantage (DOI)<br>Job-fit (MPCU) |
| Effort expectancy | Complexity (MPCU/DOI)<br>Perceived ease of use (TAM/TAM2) |
| Social influence | Social factors (MPCU)<br>Subjective norm (TRA, TAM2, DTPB)<br>Image (DOI) |
| Facilitating conditions | Facilitating conditions (MPCU)<br>Perceived behavioural control (TPB/DTPE, C-TAM-TPB)<br>Compatibility (DOI) |

TAM, technology acceptance model; DOI, diffusion of innovation; TRA, theory of reasoned action; MM, Motivation Model; MPCU, Model of PC Utilization; DTPB, Decomposed Theory of Planned Behaviour; TPB/DTPE, Theory of Planned Behaviour/Decomposed Theory of Planned Behaviour; C-TAM-TPB, Combined-Technology Acceptance Model-Theory of Planned Behaviour.

awareness and perceptions of m-learning in Palestine (Sabah, 2016); a study of the adoption of mobile health across countries (USA, Canada, and Bangladesh) (Dwivedi et al., 2016); a study of the adoption of mobile banking in Portugal (Oliveira et al., 2014); and a study of m-payment adoption factors using the extended UTAUT model in Oman (Al-Saedi et al., 2020). Thus, we learn that the UTAUT model is widely accepted in investigations into the acceptance of users with respect to the adoption of new technology. Unified theory of acceptance and use of technology has higher explanatory power than earlier models such as TAM and is well suited to understanding the acceptance of IoT services (Mohammad Al-Momani et al., 2016).

## Cultural comparison

Culture is commonly defined as, 'the collective mental programming, of human mind that distinguishes one group of people from other'. This collective mental programming influences the meaning attached by various people in various aspects of life. Hofstede's studies bring six dimensions of cultural dimensions:

- Power Distance Index, refers to 'the degree of inequality that exists and is accepted between people with and without power'.
- Individualism versus Collectivism – refers to 'the strength of the ties that people have to others within their community'.
- Masculinity versus Femininity – refers to 'the distribution of roles between men and women'.
- Uncertainty Avoidance Index – refers to 'how well people can cope with anxiety'.
- Long versus Short-Term Orientation refers to 'the time horizon people in a society display'.
- Indulgence versus Restraint refers to 'the encouragement or restrictions towards relatively free gratification of people's own drives and emotions' (Hofstede et al., 1991).

With the differences in cultural aspects shown in Figure 3, there is also a difference noticed on the e-commerce categories between India and United States, which are evident from data as shown in Table 2.

**TABLE 2:** Online market data comparison.

| Description | India | United States |
|---|---|---|
| Global market rank | 8 | 2 |
| 2021 Revenue (USD billions) | 63 | 599.2 |
| Growth (%) | 26 | 11 |
| CAGR 21–25 (%) | 10 | 5 |
| Online penetration (%) | 36 | 75 |

Table 2 shows the data based on the online market study of United States and India in the year 2021 (*ECommerce Insights/EcommerceDB.Com*, 2022).

Two countries that this study has chosen for comparison, the United States and India, are not intuitively similar. A cross-cultural study may provide greater insights on the users with respect to the similarities and differences on technology adoption. Based on the studies performed in two countries, National culture is found to have influence on user's adoption attitude (Muk & Chung, 2015). The primary conclusion in the cross-country studies performed in Egypt and United States focusing mobile banking adoption reveal that country culture could influence user's perception towards the consumption of new technological services (Hassan & Wood, 2020).

## Perceived trust

Trust is the expectation that others will not take advantage of a situation to behave opportunistically (Wu & Chen, 2005). Trust is defined as the combination of benevolence and perceived credibility. Perceived credibility is referred to as the expectancy that verbal or written statements made by the other partner can be relied on. On the other hand, benevolence is the level to which one partner is sincerely interested in the welfare of the other (Chiou & Pan, 2008).

Trust on IoT provider is an essential factor, as IoT devices are plenty in numbers and involve multiple nodes. When a single IoT device or node gets attacked, it leaves a way towards greater collapse of the system. Internet of Things providers need to have adequate security protection mechanisms in place with timely updates to take over the continuous evolving threats and challenges.

Perceived trust denotes the awareness of a partner to being exposed to the actions of another partner, with the expectation that the other partner will perform actions vital to the trustor, irrespective of the ability to control or monitor that partner. Multiple researchers who have conducted studies on technology adoption have highlighted the role of perceived trust, which increases credibility, the customer engagement relationship, and perceived security. These studies (Hayashi & Bradford, 2014; Liébana-Cabanillas et al., 2021) confirms that, according to most merchants, trust is an important attribute in mobile transactions. Perceived trust has been found to have a direct and a mediating effect on merchants' behavioural intention (Singh & Sinha, 2020). Subsequently, perceived trust has been further refined and classified into honesty, benevolence, and competence. Honesty is the

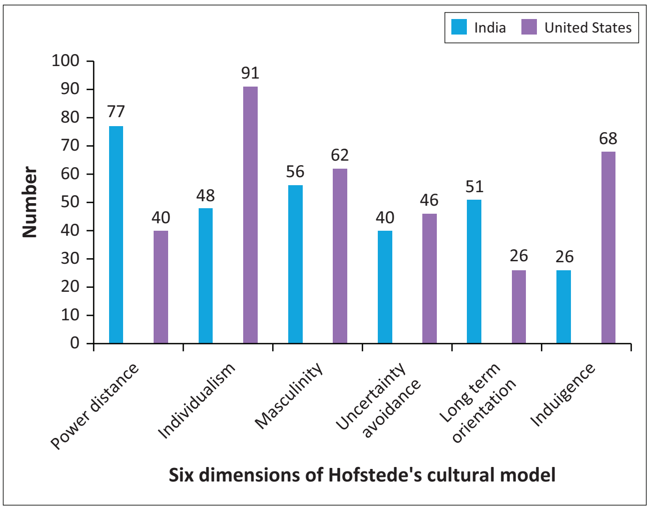



**FIGURE 3:** Hofstede's cultural comparison on India versus United States.

tendency to always share truthful information and the quality of being reliable (Bellucci et al., 2019).

# Hypothesis development

The conceptual framework for this article was constructed based on the literature review presented here. Based on prior research undertaken on cloud computing (Mayer et al., 1995), in which trust was shown to be a major construct, the present research includes trust as a construct. The framework of this research model is shown in Figure 4.

## Performance expectancy

Performance expectancy refers to 'the degree to which an individual perceives that using the system will help them to attain gains in job performance' (Venkatesh et al., 2003). This research adapted performance expectancy to fit the study scope as follows:

> [*T*]he degree to which IoT users find it useful in their lifestyle, the extent to which it enables them to accomplish their tasks quickly, and how much it increases their chances of a better life and their productivity. (p. 447)

Accordingly, the following hypothesis is formulated:

> **H1**: Performance expectancy has a significant positive impact on behavioural intention to use IoT services and products.

## Effort expectancy

Effort expectancy refers to 'the degree of ease associated with the use of the system' (Venkatesh et al., 2003). The present research adapted effort expectancy as follows:

> [*T*]he ease of using the IoT, how easy it is to learn to operate it, how clear and understandable interaction with the IoT is, and how easy it is for the user to be skillful in using IoT-enabled products and services. (p. 450)

Accordingly, the following hypothesis is postulated:

> **H2**: Effort expectancy has a significant positive impact on behavioural intention to use IoT services and products.

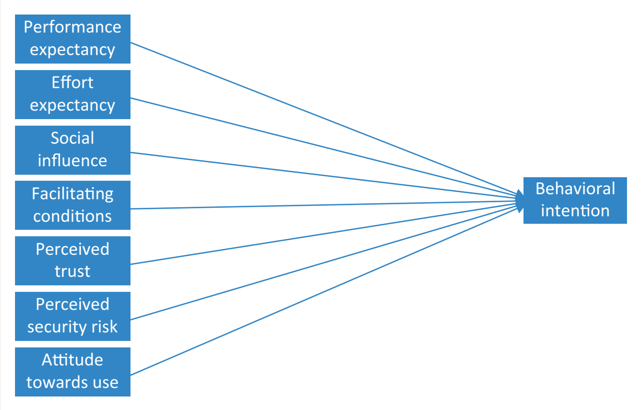



**FIGURE 4:** Research model.

## Attitude towards use

Attitude refers to 'the feeling of a person's assessment, either favorable or unfavorable with respect to the behavior in question' (Venkatesh et al., 2003). A favourable or unfavourable attitude has a direct influence on the strength of behavioural beliefs concerning the likely salient consequences (Wu & Chen, 2005). Johnson et al. (2008) proposed the concept of satisfiers and dissatisfiers in their study of various paradoxical attitudes in which satisfiers are positive drivers and dissatisfiers are negative drivers. Lee (2016) asserted that satisfaction with the IoT service scenario has a positive effect on IoT adoption intention. Based on this, the following hypothesis is formulated:

> **H3**: Attitude has a significant positive impact on behavioural intention to use IoT services and products.

## Social influence

Social influence refers to 'the degree to which an individual perceives how others believe that we should use the system' (Venkatesh et al., 2003). The present study includes social influence, refining it as follows:

> [*T*]he people who influence my behavior, that is, those people I think are important and feel that I should use IoT-enabled products and services, as well as my colleagues, the place of work, and the work administration supporting the use of IoT-enabled products and services. (p. 451)

This leads to the following hypothesis:

> **H4**: Social influence has a significant positive impact on behavioural intention to use IoT services and products.

## Facilitating conditions

Facilitating conditions refer to 'the degree to which an individual believes that organisational and technical infrastructure exists to support use of the system' (Venkatesh et al., 2003). This study includes facilitating conditions as follows: 'the availability of necessary resources, knowledge, and alternate technologies for non-compatible cases and those people assisting in the journey toward IoT products and services'. Accordingly, the following hypothesis is posited:

**H5**: Facilitating conditions have a significant positive impact on behavioural intention to use IoT services and products.

### Perceived trust

Perceived trust refers to:

> [*T*]he willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party.

Perceived credibility focuses on 'the expectancy that the other party's word or written statement can be relied on'. Benevolence is 'the extent to which one partner is genuinely interested in the other partner's welfare' (Chiou & Pan, 2008). This leads to the following hypothesis:

**H6**: Perceived trust has a significant positive impact on behavioural intention to use IoT services and products.

### Perceived security risk

Perceived security is defined as:

> [*A*] threat that creates a circumstance, condition, or event with the potential to cause economic hardship to data or network resources in the form of destruction, disclosures, modification of data, denial of service, and/or fraud, waste and abuse.

It represents customers' perceptions that their personal information will not be inappropriately used, stored, or manipulated during transit, storage, or any processing, and that their expectations in this regard will be fully met (Flavián & Guinalíu, 2006).

There are multiple security risks for IoT domain. The data that are present inside IoT devices are unprotected (*The Ultimate Guide to Zero Trust Security*, 2020) and distributed across the network. The data from edge devices travels to corporate network through multiple heterogenous protocols and diverse devices. This increases the vulnerability of attacks on data privacy, integrity, and confidentiality (Hossain et al., 2015). The IoT devices are light-weight in terms of processor, memory, and computing capacity. This poses the constraints on data encryption, implementation of security policy, and privacy settings capabilities on IoT devices. The application layer that processes the data and caters IoT services needs to overcome the attacks, including, but not limited to, denial of service, malwares, crypto attacks, phishing, and sniffing.

Thus, the following hypothesis is formulated:

**H7**: Perceived security risks have a significant positive impact on behavioural intention to use IoT services and products.

# Research methodology

## Data collection

Data collection was performed in two steps, with a pre-test being the first step. The pre-test was done to validate the survey instrument using hard copy questionnaires and, in-person surveys. The findings were shared in an IFIP_WG86 conference (Sharma et al., 2020b). Based on the lessons learned, the instrument was refined and data collection is performed using the crowd sourcing forum Amazon's Mechanical Turk (MTurk), where participants join based on their external login. Mechanical Turk uses an anonymous way where the data gets anonymised before being accessed and assessed by the authors. The survey is driven on participants' willingness to participate. Participants pick the research survey, based on their interest, field of exposure, and all participants are above 18 years only. The authors have collected the data (India = 388, USA = 413) for this study using MTurk crowd sourcing method. This crowd sourcing forum has a probability of containing high numbers of technologically literate and informed crowd. Internet of Things technology is still in its early stages before it gets into the hands of ordinary people. Indeed, this study benefits from the MTurk crowd by getting an early insight from each country responses, although it cannot be generalised at this stage.

Studies such as that of Paolacci and Chandler (2014) have shown that data collected from MTurk possess high reliability. Mechanical Turk respondents' details for the present study are presented in Table 3.

## Measures

All measures used in the present study were adopted from prior studies; they were measured using a five-point Likert scale (from strongly disagree to strongly agree). Demographic details (age, gender, marital status, educational qualification, income, and online time) were provided at the end of the study questionnaire, given in Appendix 1. Details of the study variables are presented in Table 4.

## Data analysis

To evaluate the conceptual model, the multiple linear regression method was used with the help of SPSS 22. However, before proceeding to structural model evaluation, the validity and reliability parameters were measured for both the samples (India and the USA), using composite reliability (CR) to assess the internal validity of the constructs and the variance inflation factor (VIF) values to check for the presence of collinearity issues (see Table 4). Harman's one-factor test was also conducted while performing the exploratory factor analysis (EFA), which is often used to find the presence of common method variance (CMV). Here, the first factor explained 35.8% and 37.6% of the variance for India and the USA, respectively; because the explained variance for both the countries was less than 50, this suggests the non-presence of CMV (Podsakoff et al., 2003). To validate Harman's one factor test results, the VIF values were calculated for the study variables for each country, and the obtained values were all less than 5, which again confirms that this study's model is free from common method bias issues (Kock, 2017).

**TABLE 3:** Demographic details and descriptive statistics.

| Sample characteristics | India ($n$ = 388) | USA ($n$ = 413) |
|---|---|---|
| Gender (Male–Female–Prefer not to say) | 274–113 | 261–149 |
| Average age (In years) | 32.3 | 36.5 |
| Average time spent on online/day (hours) | 2.23 | 4.41 |
| Educational qualification (from school standard/grade '1' – in years) | 12.29 | 13.8 |
| **Income level (in $)** | | |
| < $10 K = | 144 | 57 |
| $10 K – 20 K | 104 | 84 |
| $ 21 K – 40 K | 95 | 133 |
| $ 41 K – 80 K | 42 | 112 |
| > $80 K = 3 | 3 | 27 |
| **Marital status** | | |
| Single | 131 | 164 |
| Married | 255 | 242 |
| Prefer not to say | 2 | 7 |
| **Occupation** | | |
| Employee | 95 | 89 |
| Self-employed | 82 | 90 |
| Business | 60 | 97 |
| Students | 120 | 132 |
| Any other | 31 | 5 |

**TABLE 4:** Validity results.

| Constructs | CR (India/USA) | VIF (India/USA) |
|---|---|---|
| 1. Performance expectancy | 0.819/0.758 | 2.43/2.26 |
| 2. Effort expectancy | 0.789/0.745 | 2.72/1.98 |
| 3. Attitude | 0.742/0.747 | 1.44/1.48 |
| 4. Social influence | 0.778/0.786 | 2.39/2.39 |
| 5. Facilitating conditions | 0.713/0.711 | 2.65/2.20 |
| 6. Perceived security risks | 0.785/0.735 | 2.27/2.42 |
| 7. Perceived trust | 0.755/0.731 | 2.39/3.15 |
| 8. Behavioural intention | 0.778/0.715 | 2.51/2.55 |

CR, composite reliability; VIF, variation inflation factor.

As shown in Table 5, all the hypotheses were significant and positive (for both samples), except for the relationships from effort expectancy to behavioural intention and from attitude to behavioural intention. The relationships, performance expectancy → behavioural intention, facilitating conditions → behavioural intention, perceived security risks → behavioural intention, and perceived trust → behavioural intention were in line with the hypothesised assumptions. However, the causal path social influence → behavioural intention was significant only for the Indian sample because the $t$-value was less than 1.96 for the USA sample.

## Results and discussions

Although the IoT is a recent phenomenon, evolving greatly in this decade, much recent research has been undertaken to identify the factors that influence the acceptance and adoption of IoT services by consumers (Dachyar et al., 2019). The technology adoption and its factors are found to vary according to their culture, be it individualistic culture such as the United States or collectivistic culture such as India (Nam & Kannan, 2020). This is in line with past studies that show how cultural differences exist in the technology adoption. For example, the usage of email and fax (Straub,

**TABLE 5:** Regression results.

| Path name | India | | United States | | Inference |
|---|---|---|---|---|---|
| | Beta | $t$-value | Beta | $t$-value | |
| H1: Performance expectancy → Behavioural intention | 0.171† | 3.437 | 0.217† | 4.776 | India < USA |
| H2: Effort expectancy → Behavioural intention | 0.050‡ | 0.932 | 0.058‡ | 1.317 | No difference |
| H3: Attitude → Behavioural intention | 0.010‡ | 0.016 | 0.075‡ | 1.452 | No difference |
| H4: Social influence → Behavioural intention | 0.104† | 2.088 | 0.012‡ | 0.016 | India > USA |
| H5: Facilitating conditions → Behavioural intention | 0.235† | 4.546 | 0.159† | 3.496 | India > USA |
| H6: Perceived trust → Behavioural intention | 0.205† | 4.232 | 0.263† | 4.904 | India < USA |
| H7: Perceived security risks → Behavioural intention | 0.239† | 5.074 | 0.274† | 5.899 | India < USA |

†, Regression coefficient significant at 99%; ‡, not significant.

1994), adoption of online shopping (Ashraf et al., 2014), usage of SMS advertising (Muk & Chung, 2015), and acceptance of mobile commerce (Ashraf et al., 2017). According to Gao, whose study was based on 368 respondents in China, perceived ease of use, perceived usefulness, perceived behavioural control, perceived enjoyment, and social influence all have a significant effect on the use of the IoT (Gao & Bai, 2014). In the present research, it was found that social influence has a greater significance and that this relationship is stronger for India compared with the USA.

According to a research performed on 2000 customers in the USA, focusing the concerns of customers regarding IoT adoption, awareness of the technology, security, privacy, and price (cost) are the key factors (Al-Momani et al., 2018). In the present research, it can be seen that perceived security risks have a greater significance and that the relationship is stronger for the USA compared with India. Similar studies in India on technology adoption research with respect to internet banking services also reveal that the intention to use internet banking is positively influenced by perceived security (Patel & Patel, 2018). India has relatively higher values for uncertainty avoidance per Hofstede's metrics, that endorses the higher significance on perceived security risks. The effort expectancy results were found to be insignificant for both USA and India as it has lower $t$-values. It has a coincidence with the study performed with Omani entrepreneurs. The effort expectancy for IoT applications are insignificant (Nikbin & Abushakra, 2019).

Similarly, an exploratory research revealed that ease of use, privacy, usefulness, and knowledge and awareness of IoT technology are the key factors (Coughlan et al., 2012). The optimum solution on the combined challenges of IoT security and privacy requires decomposition of the complexity and address it by effective conjunction of policy boundaries, economic and business drivers, technology constraints and opportunities (Sollins, 2019). In the present research, facilitating conditions was shown to be significant, although more so in the Indian sample than the USA sample.

Social networks have a crucial role towards influencing the user adoption in IoT adoption. Users generally seek out for information from family, peers, famous social networks influencers reviews to handle the uncertainty that arises prior to purchase (AlHogail & AlShahrani, 2019). Several users have considered IoT devices as trustworthy as it is one of the trending topics by social networks (Gao & Bai, 2014). Social shopping is one of the six dimensions of customer shopping (Atulkar & Kesari, 2017). The greater significance of social influence indicates that the positive views and experiences carried by friends and families will have a greater influence on the IoT adoption.

The impact of facilitating conditions and performance expectancy on behavioural intention towards IoT adoption is quite significant for both countries. This is in line with the past studies performed across countries on IoT adoption (Ben Arfi et al., 2021; Ronaghi & Forouharfar, 2020).

## Theoretical contributions

This study contributes the following theoretical contributions. The hypotheses proposed in this research are consistent with UTAUT model and confirm the generalisability of this model. The contextual insights of this research findings add to the state of the art with respect to the technology adoption, more specifically to IoT technology. Theoretical contribution back to the society includes following findings, as in below paragraphs.

Firstly, one to note is, the independent variables of TAM3 model that are often used to measure technology adoption are perceived usefulness and perceived ease of use (Venkatesh & Bala, 2008). In the present study, the authors added the factors of perceived trust, perceived security risks that are increasingly being considered significant factors for predicting e-commerce adoption (Bonsón Ponte et al., 2015).

Secondly, this study shows the variation of results across cultures. Prior cross-cultural studies have found that trust-related factors vary with respect to individual cultures and that there is no universally valid model across cultures (Keil et al., 2000). There is a significant role played by the culture in each country. Culture has an influence on IoT applications when the transactions are compatible with beliefs, values, practices, among others (Van Slyke et al., 1 C.E.). Therefore, the present study used data for two countries, namely the USA and India (i.e. country effect as a moderator), revealing some variations in the formulated hypotheses.

Thirdly, among other factors influencing the IoT adoption by the Indian citizens, the Word of Mouth (WOM) through social networks plays a significant role. From the trends of social media, people get an opportunity to learn several things regarding IoT. The learnings gained through social networks would effectively spread out through WOM. In the study with Indian users it is noticed that, WOM through social networks has influence on user behaviour towards IoT (Chatterjee, 2019). The study on barriers of IoT adoption in India reveals the lack of standardisation, the lack of regulatory norms, policies, directions and the lack of connectivity issues (Sharma et al., 2020a). These are the essential technical resources that contribute to the facilitating conditions.

Fourthly, based on the findings using the multi-group moderation technique, it is evident that perceived security risks and perceived trust have a greater influence for the USA sample compared with the Indian sample, while social influence and facilitating conditions have greater significance for the Indian sample compared with the USA sample. Multiple customers are willing to accept and use new products and services when the complexity is reduced. According to the studies carried out by Arts et al., technology adoption is improved by innovations that have a low level of uncertainty (Arts et al., 2011). The question of privacy and security policies are very complex in the United States (Sollins, 2019).

In this context, this study has attempted to simplify perceived trust by classifying its characteristics through a deeper study, at a per-country level, that can be used to help consumers adopt the IoT.

## Managerial implications

The initial observation is that the younger generation is relatively accepting the IoT technology (Qian & Li, 2020). The present research provides evidence that social influence and facilitating conditions play a significant role in the Indian market.

Airtel produced a variety of advertisements focusing on ‘zero complaints’ and actions to reduce the number of queries that consumers may have (*Airtel Targets Zero Questions with New Campaign – The Financial Express*, 2020). This coincides with the competence factor by ensuring that promises made to the end customer can be fulfilled. This increases the adoption rate and the use of products in IT and IoT services. This also addresses the strategic approach that recommendations and feedback from peers play a significant role in reducing the uncertainty driven by technology, thus favouring technology adoption (Park et al., 2019). Adoption readiness is increased when users are provided with a user friendly, seamless service. Advertisement campaigns can target the innovative users’ segment with uninterrupted access as a pre-requisite, according to a study of the adoption readiness among mobile users in India (Thakur & Srivastava, 2014).

The United States and India have announced their strategies and initiatives to motivate production in their own soil. Make in India is an initiative from the Government of India to encourage companies to do production in India (*Make In India*, 2015). The *Build America, Buy America Act* is created in the United States, to motivate the manufacturing products and construction materials used are produced in United States (*Build America Buy America/U.S. Department of Commerce*, 2019). These strategies provide waivers and concessions to the productions performed on their country.

The study on IoT adoption factors from the early adopters of smart and connected sensors in the United States reveals data-driven decision making as the key variable for IoT adoption. For IoT provider to deploy IoT projects, for example, smart city, the deployment of sensor networks relies on both local government's persistent efforts and established procedures of data-informed decision-making. This increases the performance efficiency by linking functional departments to work together from IoT planning iteratively and systematically by using the data generated from IoT devices (Tang & Ho, 2019). Mayors, being the public image champions for their cities use the data-driven results to demonstrate their progressiveness and innovations in their cities (Ho, 2017). Internet of Things providers to focus on the organisational incentives with emphasis on data-driven decision-making. Examples include performance budgeting using big-data, and leadership support on embracing the data-driven culture that enables necessary analytical capacity to utilise IoT data in the decision-making process.

Reliance Jio has the largest mobile subscriber base in India and is driving Industry 4.0, focusing on the 'Made in India' strategy (Khanna, 2020). This strategy implements the social influence factor by aligning with the sentiments of Indian users, increasing their comfort and confidence by aligning with the 'Made in India' strategy of the Indian Government, as the 'country of origin or make' has significance in e-commerce, especially in cross-border transactions (*E-Commerce Rules, 2020 – Consumer Protection – India*, 2020). The findings from this research study will benefit IoT providers to make key decisions that increase IoT adoption across countries. The IoT devices provide various opportunities to expand customer satisfaction and customer experience (Novak & Hoffman, 2019). By integrating and connecting with other devices and networks, IoT can anticipate ahead of customer needs and also provide detailed and comprehensive information tailored to their needs. Internet of Things has profound effect on the business model focusing the two tenets, value capture and value proposition, that enable firms and customers to reinforce and reinvent their role in the new service economy (Pantano & Timmermans, 2014).

The significant positive effect of social influence towards IoT adoption tells that the thoughts and opinions of network around a person such as friends and family members have an influence on user attitude (Aldossari & Sidorova, 2018). The end users who see that individuals in their social network have a positive attitude towards using IoT adoption are more likely to get the similar attitude. Higher social influence in India gives an indication to IoT providers that appropriate campaigns and advertisements based on country-specific culture including social networks, would favour IoT adoption. Improvement in the IoT adoption rate by the fellow citizens can be influenced by effective and relevant activities of the IoT providers. The IoT providers will have immense and effective opportunities to increase their business by leveraging social platform. This has less cost compared with other marketing modes and campaigns (Mikalef et al., 2016).

Enhancements of facilitating conditions has a positive effect on IoT adoption (Ronaghi & Forouharfar, 2020). This includes the knowledge enhancement on IoT technology, the compatibility of current applications with IoT applications and adequate technical resources needed for IoT technology.

The number of IoT connections are set to surpass 100 million users by the year 2026 (*5G IoT Connections to Surpass 100 Million for First Time Globally by 2026*, 2023). Right decisions by IoT providers focusing the country-specific cultural findings are essential to be a successful player as the IoT projects are expected to bridge multiple cultures (Shin, 2019).

## Conclusion

This research has revealed interesting findings regarding the factors that influence IoT adoption. The research model comprises the following independent variables: performance expectancy, effort expectancy, social influence, facilitating conditions, perceived security risks, and perceived trust. Social influence and facilitating conditions have a relatively greater significance in India, whereas performance expectancy, perceived security risks, and perceived trust have relatively greater significance in the USA. Effort expectancy and attitude are significant both in India and the USA, with no major difference between these countries. This study model can be used to capture the findings from multiple respondents across the globe.

## Limitations and future scope

Every research has its boundaries and limitations. Firstly, this research was validated through regression techniques to find the relationships and significance of the factors influencing IoT adoption. This requires extension by applying other methodologies for data analysis. Secondly, the conclusions of this study are limited to two country samples (the USA and India), thus covering samples from cultures from developed and developing nations. The present study used online means to distribute the survey questionnaire to end users. These users were therefore relatively technically enabled in terms of using IoT devices and services compared with people who are not used to online survey methods. To obtain the views of users who have limited or no access to the Internet world, the authors recommend that future studies use legacy in-person interviews with rural communities. The authors therefore recommend that future studies utilise data from additional countries to obtain a deeper understanding of global IoT adoption.

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## Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

## Authors' contributions

R.G.A.T. and H.L.M. equally contributed to the research and writing of this article.

## Ethical considerations

This article followed all ethical standards for research without direct contact with human or animal subjects.

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## Data availability

The data were obtained from public and commercial sources and are available from the corresponding author, R.G.A. on reasonable request.

## Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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Appendix 1 start on the next page →

# Appendix 1

The questionnaire used in data collection is given.

**TABLE 1-A1:** Data collection questionnaire.

| Item ID | Constructs |
|---|---|
| **Performance expectancy** | |
| PE1 | Using IoT applications helps me accomplish my tasks more efficiently. |
| PE2 | Using IoT applications allows me a faster data management. |
| PE3 | IoT technology usage will increase my chances of better life. |
| PE4 | Using IoT technology increases productivity. |
| **Effort expectancy** | |
| EE1 | I find IoT applications easy to use. |
| EE2 | Learning how to use IoT applications is easy for me. |
| EE3 | It is easy for me to become skilful at using IoT technology. |
| EE4 | My interaction with IoT technology is clear and understandable. |
| **Attitude** | |
| A1 | Using IoT applications is a good idea. |
| A2 | Using IoT applications is a bad idea. |
| A3 | Using IoT applications is advantageous. |
| A4 | Using IoT applications is disadvantageous. |
| A5 | Using IoT applications makes lifestyle more interesting. |
| **Social influence** | |
| SI1 | People who are important to me think that I should use IoT applications. |
| SI2 | People who influence my behaviour think I should use IoT applications. |
| SI3 | My friends have been supportive in the use of IoT applications. |
| SI4 | Overall, my social circle supports the usage of IoT applications. |
| **Facilitating conditions** | |
| FC1 | I have the technical resources necessary to use IoT applications. |
| FC2 | IoT applications are compatible with other applications I use. |
| FC3 | I have the knowledge necessary to use IoT applications. |
| FC4 | Where IoT is not compatible, I use other available technologies. |
| **Perceived security risks** | |
| PSR1 | I would adopt IoT if I have enough authority over my data. |
| PSR2 | I would adopt IoT if good encryption approaches are used. |
| PSR3 | I would adopt IoT if privacy towards my company information is guaranteed. |
| PSR4 | I would adopt IoT if an audit system or environment is offered. |
| **Perceived trust** | |
| PT1 | I have trust in the protection of data privacy of IoT applications. |
| PT2 | I think the suppliers of IoT applications are trustworthy. |
| PT3 | I would adopt IoT if an SLA was provided. |
| PT4 | I would adopt IoT if regular and clear backup was offered. |
| **Behavioural intention** | |
| BI1 | I intend to continue IoT services in the near future. |
| BI2 | I predict I will use IoT services in the next 6 months. |
| BI3 | I plan to further use IoT services in the next 6 months. |