Evaluating Multi-dimensional Risk for Digital Services in Smart Cities

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Abstract. In current times, emerging economies are providing digital services to its citizen through public or private organization. Literature indicates that digital services are facing major challenges with respect to its adoption among relevant users groups, largely due to the perceived risks surrounding digital services. A purposive sampling methodology was adopted for the empirical validation of the framework among user groups. With the use of Generalized Analytic Network Process (GANP), prioritization of different dimensions of risk has been illustrated. The result indicates that dimensions like privacy risk, performance risk and financial risk are the most important risk across digital services models. However physical risk, social risk, psychological risk and time risk are comparatively less important risk across digital services. This research also finds out that the end users are reluctant to provide their personal information. The sample size is relatively small which limits generalizability of results. However an application of GANP has been showcased for empirical research. The research outcome can help managers in deciding which dimensions of risk are more important for digital service delivery. This study focuses on the different facets of risk perceived by consumers towards the digital services available in smart cities. Perceived risk dimensions like privacy risk, performance risk, financial risk, physical risk, social risk, psychological risk and time risk, have shown that there is a need to prioritize these risk to the digital services which is offered to the residents of the smart cities.

Keywords: Information risk · Digital services · Smart cities · Perceived risk · Analytic Network Process · Emerging economies

1 Introduction

The concept of "smart city" has emerged from the concept of "Intelligent Cities". The basic idea of smart cities is to use the existing resources in a "smarter" way. Smart cities provide ICTs infrastructure and digital services which poses risk while sharing information with the third party [42]. These risk can be classified as privacy, performance,

financial, physical, social, psychological, and time risk [30]. Smart cities are sustainable, creative and livable cities. It is part of government vision for the development of urban habitats through smart cities. In order to develop smart cities, experts from various fields are needed such as consultants, marketing specialists, corporations and officials [40]. These entities should take an active role in provisioning and delivering the digital services which are used by the citizens of the smart cities. The concept of smart cities can be seen as an assemblage of Information and Communication Technologies (ICTs), cyber-physical systems, urban infrastructure, sustainable process and the practices which aims to increase the administrative efficiency, competitiveness and socio-economic inclusion [9, 10]. A smart city needed to solve the issues such as ICTs and Digital services in order to improve the quality of life [42].

The world is moving towards the evolution of urbanization through smart cities. In order to make a smart city, various innovations related to information technology pose a threat to security and privacy. People in smart cities are already connected with various electronic gadgets such as mobile phones and laptops. The use of services are changing with new digital services introduced. In smart cities, many smart appliances, smart devices and smart energy meters have been used which makes the user reluctant to share the information through these digital services. As the number of digital services increases the risk associated with its use also increases [13]. Since 2011, the contribution to the smart cities has been critically scrutinized from different factors such as political economy, science and technology, ideological critiques and socio-economical [40]. In general smart cities create a relation between the usages of technology in a socio-economical ecosystem. In our study, we are focusing on the management of risk in digital services, where literature is still at a nascent stage. Integration of digital services in smart cities lengthy, complex and often requires dispersed resources. There are few publications which indicates the Integration of IT services such as digital services in smart city system [34].

In this study, multi-dimensional nature of risk such as privacy risk, performance risk, financial risk, Physical risk, social risk, psychological risk and time risk has been explored in the context of digital services. Further the study highlights an application of an emerging methodology based on the Generalised Analytic Network Process (GANP) for empirical research for prioritization, which has not been explored till now [44].

This paper Evaluate the raking of the different dimensions of the risk while suing digital services. The organization of the paper are as follows. Section 2 provides a review of the study done on Perceived risk to evaluate the various consumer related services. Sections 3 describe the methodology used to prioritize and rank the multi-dimensions of perceived risk. This section also provides data analysis and interpretation, Cronbach's alpha, exploratory factor analysis, inter-item correlation matrix of variables. Further it provides the ranking of the dimension of the perceived risk. Section 4 discusses the findings of the research, Sects. 5 concludes the paper.

2   Literature Review

A detailed review of literature has been conducted to understand the domain of risk in digital services better. With the increase in population of the urban area, the people are making strategies in order to improve the livings in urban areas. Further the use of digital services which makes the city to improve the existing information and communication technologies (ICTs). In subsequent sections, we first explore the literature surrounding smart cities, then explore the literature surrounding digital services and finally explore perceived risk [1] in such services.

2.1   Smart Cities

Smart city concept was introduced first in 1990s [2, 3, 12, 40]. There is no consistent definition of smart city till now which can fit the all the dimensions of smart city [2, 3, 5, 24, 25, 33, 41]. The concept of smart city has been explained as the utilization of human and technological capital for the development of urban agglomeration [3]. Various theoretical and managerial conceptualization has been introduced and the concepts of smart cities have gained the widest recognition among the urban researchers and the practitioners.

Major dimension of smart city are smart people, smart economy, smart mobility, smart living, smart governance and smart environment [2, 5, 9, 10, 24, 28, 42].

Digital services forms an integral part of smart cities, where residents are empowered to access these services using ICTs. Across all the dimensions of smart cities, digital services play an important role for the end consumers to realize the benefits envisioned from these smart cities.

2.2   Digital Services

There are various definitions of digital services in the literature [4, 7, 20]. The generic definition is "services or resources accessed and/or provided via digital transaction." [18]. With the use of digital services, the city will have a high quality of life which will lead to smart governance [25]. So the risk of sharing the personal information while using digital service make ends user afraid of data getting misused [22].

Digital services are accessed via internet with the use of an interactive software. It is generally referred as an information asset which is made available through internet. The most sought examples of digital services is online purchasing, banking and financial portfolio management. Digital services have been classified in literature based on the value they provide, their model of service delivery and parameters for assessment. For example, categorization of digital service as technology-assisted consumer contact, technology-facilitated consumer contact, technology-mediated consumer contact and technology generated consumer contact, based on the nature of interaction between the consumer, the service provider and technology [17]. The digital services may be categorised on the basis of delivery, maturity, malleability (provider and consumer of service), pricing and funding [43], which again strive to meet business, interaction and technological objectives. Again digital services classification done by the governments

are often done on the nature of benefits. Across these digital services, it has been high-lighted that adoption is significantly affected by the perception of risk in such services [15, 26]; which is why a deeper exploration is required in the domain of risk in digital services.

2.3   Risk in Digital Services

Bauer has introduced the concept of risk and defined it as "a combination of uncertainty plus serious of outcome involved" whereas "the expectation of losses associated with the purchase and act as an inhibitor to purchase behavior" has been defined by [36]. Perceived risk is generally thought of as felt uncertainty with respect to the negative consequences of using a product or service [15].

The consumers are also very much sensitive about the privacy and security of the products or services which they purchase or consume through the internet [6, 9, 39]. The reason behind it was the fear of getting theft of the product or getting personal infor-mation misused by the company [14, 31, 32, 35]. The seven dimensions of perceived risk are as follows.

1. Privacy risk. The risk associated with the loss of personal information without your permission.
2. Performance risk. The possibility that the services or products is not delivering the desired benefits as it was advertised and designed.
3. Financial risk. The price associated with the purchase of products or services and the subsequent maintenance cost associated with it.
4. Physical risk. The risk associated with the safety of consumers while using product or services.
5. Social risk. The risk associated with the use of product or service leads to embar-rassment in social media.
6. Psychological risk. The risk that using of the product or services will decrease the self-image of the consumer.
7. Time risk. The lost time associated with bad purchase decision such as researching and purchasing a product or services.

3   Methodology

Each dimensions of risk such as privacy risk, performance risk, financial risk, physical risk, social risk, psychological risk and time risk has been mapped to digital services. The data has been collected from the end users who are using digital services in two form: online and offline. The survey forms has been circulated to the end users of the smart cities. For proceeding with the analysis, data on preferences needed to be elicited through structured questionnaires from experienced user groups of the digital services residing in smart cities. The data was captured from the smart cities in the national capital region of India, where the access and usage of digital services by the residents was among the top three in the country. The targeted user groups had used at least two different models of digital services out of the four models of service delivery proposed by [17].

A purposive sampling methodology was adopted so that the elicited responses would have more richness and represent the concerns of user groups who are more frequent in using the digital services. Over 441 respondents were approached for administering the questionnaire through a combination of online and offline channels of communication. Out of this, only 100 respondent data could be collected which had the requisite degree of consistency, needed for the subsequent analysis.

During the review of literature, it has been seen that various authors have used different methodologies to evaluate perceived risk in different contexts. Data on preferences needed to be elicited through structured questionnaires from user groups of the digital services residing in smart cities. After the collection of data, analysis has be done using Generalized Analytic Network Process (GANP) proposed by [44] for prioritization of perceived risk dimension. This study also highlights the application of the GANP for prioritization of empirical data. It is an extension of Analytic Network Process (ANP) methodology which is used for Multi Criteria Decision Making (MCDM) to obtain the priorities of the compared element in a network hierarchy [38].

By using the GANP, this study further highlights how empirically prioritization of alternatives, which may not be free of exigencies and internal influences, may be done using this approach. While such empirical prioritization based on surveys on specific user groups has been done in past literature [21, 27] using the Analytic Hierarchy Process (AHP), no study has attempted to do the same using the GANP. The use of AHP becomes restricted when alternatives may also have an impact on one other and are not mutually independent. Hence the proposed approach also highlights the application of a new methodology in the context of risk assessment of digital services.

While following the approach of the GANP, first the Complex Comparison Matrix (CCM) is developed based on the judgment on 1–9 scale [21, 27]. The decision maker's judgment is crisp value which describes the relationship between paired comparisons. Among similar approaches, there are over 20 approaches for prioritization of preferences or judgments [23], however very few of these recent approaches have been used for empirical case studies.

3.1 Data Analysis and Interpretation

It has been noticed that end user are reluctant to provide their personal information [6, 9, 39]. In the survey, 97% respondent are male where as 3% are females. The total respondents' age group varies in such a way that it is 24% from 16–20 years of age group, 53% from 21–25 years of age group, 15% from 26–30 years of age group, 4% from 31–35 years of age group and 2% from 46–50 years of age group. The education qualification of the responds are such that 41% are having bachelor degree, 39% are having Master's degree, 8% are having doctorate degree and 12% have done higher secondary only. The employment status of the respondent are such that 10% belongs to under employment, 4% belongs to self-employed, 86% are still student. The employment types of the respondent are such that 20% are in Government sector, 4% are in private sector, 3% are having their own business and NGOs while 70% are unemployed. The average duration (in months) during which the respondent were using digital services is 51 months.

Reliability analysis was conducted using Cronbach's alpha to evaluate the value of all the variables and it is found to be 0.830. The composite reliability and Cronbach's alpha values of 0.6 or greater are considered to the acceptable [19]. The values are as shown in the Table 1.

Table 1. List of variables

Risk dimension	Variable ID	Risk measurement indicators	Cronbach alpha
Privacy risk	V_C	What are the chances that your personal information and privacy will get compromised?	0.662
	V_D	What are the chances that the personal information will be used while using digital service without your knowledge?	
	V_E	If I use the digital service, hackers will take control of my account	
Performance risk	V_A	Services offered is not able to perform as designed and creates problem for you	0.603
	V_B	Service Provider may not perform well and process transactions correctly	
Financial risk	V_P	What are the chances that you will lose your money by using these services?	0.760
	V_Q	Using banking services will lead to financial loss for me	
	V_R	Using the service subjects your bank account to financial risk	
Physical risk	V_K	Using these digital service poses a threat to my health	0.871
	V_L	If you do NOT use service, you will live for a long time	
	V_M	If I use service, I will get ill	
	V_N	If I use service, I will be exposed to harmful radiation	
	V_O	If I use this service, I will damage my brain	
Social risk	V_H	What are the chances that others thinking will negatively affect by using the services?	0.797
	V_I	With the use of digital services, there will be social loss for me because my relatives and friends will think less highly of me	
Psychological risk	V_F	These digital services will not fit well with my self-image.	0.737
	V_G	With the use of digital services, there will be a psychological loss for me since it will not fit with my self-image	
Time risk	V_J	With the use of digital services there will be a loss of time because of inconvenience to me	0.825

After aggregating all the normalized value from the end user, we get the final priority. Sub-dimension specific priority and dimension level priority, computed using the GANP as illustrated in Table 2. It has been found that the privacy risk has first priority and time risk has the last priority. The priority of the risk are for the digital services from the end user perspective. The priority of the risk dimensions are illustrated in the Table 2.

Table 2. Priority of the different dimensions of Risk

Priority of variable	Priority value	Geometric mean	Type of risk	Rank
V_D	0.100899	0.096011	Privacy risk	1
V_C	0.095285			
V_E	0.092056			
V_B	0.065001	0.063244	Performance risk	2
V_A	0.061535			
V_R	0.062688	0.053748	Financial risk	3
V_P	0.061682			
V_Q	0.040156			
V_K	0.058852	0.043965	Physical risk	4
V_N	0.050532			
V_L	0.044987			
V_M	0.029691			
V_O	0.04135			
V_H	0.043696	0.040426	Social risk	5
V_I	0.037401			
V_F	0.040694	0.038126	Psychological risk	6
V_G	0.035721			
V_J	0.037773	0.037773	Time risk	7

4   Discussion

Previous research has focused on the different dimension of the risk for the adoption of e-services such as given by [11] has focused on the financial risk, social risk, privacy risk, and psychological risk for the adoption of technology has focused on the financial risk, psychological risk, privacy risk, time risk, performance risk, and overall risk in order to evaluate the adoption of e-services [15]. The study by [1] has taken financial risk, privacy risk, psychological risk, and performance risk dimensions of the perceived risk to illustrate how adoption of mobile banking influence the consumer.

In a study done by [8], privacy risk, source risk and performance risk were are first, second and third most important dimensions of risk while time risk, financial risk and social risk were the sixth, seventh and eight position in the raking of all the eight dimensions of risk. In contract to our findings says that privacy risk, performance risk and financial risk are the first, second and third most important dimensions of perceived risk as shown in Table 2. In a study done by [26], it shows that the security, time, financial,

social, and performance risk negatively affects the adoption of online banking services. It also shows that security, financial and performance risk are the top most important risk factor where as social and time risk are fourth and fifth most important risk. The study has taken only four dimensions of the perceived risk and concluded that performance risk are the most important risk dimensions followed by financial risk, psychological risk and time risk during internet shopping [16].

A closer look into the prioritization of risks highlight that dominant cluster of risk would include privacy risk, performance risk and financial risk. This is a contrasting finding from that of previous literature [15] who highlighted that the dominant risks affecting adoption are time risk, psychological risk, privacy risk and financial risk. Probably due to the maturity of technology and processes, the aspect of time risk is lowered in the recent times. Connecting our findings to adoption related literature [26] it is understandable that privacy risk and financial risk affects the perceived usefulness of any digital service, while social risks affect social norms. However privacy risk, time risks and financial risks affect intention for adoption of digital services. It appears that our findings highlight that performance risk becomes a perceived usefulness which again drives adoption. The impact of social risks (and probably social norms) is noticeable in our findings. Hence it is possible that user groups is gradually losing its significance as more and more users of digital services are viewing it as a necessity due to its high utility rather than an alternative, and hence are less affected by social norms [29].

5   Conclusion

The output of the research can be useful for the policy makers, consultants, big enterprises and entrepreners in making the strategic, tactical and operational decisions. The research outcome can help managers in deciding which dimensions of risk are more important for digital service delivery. Also how different dimensions of risk affects consumption of digital services and affect failures will be provided, which will impact policies surrounding service management.

Further this study highlights how empirically prioritization of alternatives, which may not be free of exigencies and internal influences, may be done using the GANP. While such prioritization has been done in past literature using the Analytic Hierarchy Process [21, 27], no study has attempted to do the same using the GANP, since this methodological development is rather recent. Hence the proposed approach also highlights the application of a new methodology in the context of risk assessment of digital services. This approach may be adopted in future research for other prioritization problems when responses are elicited from user groups or experts and findings are validated empirically.

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