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Prioritization of multi-dimensional risk for digital services using the generalized analytic network process

Syed Ziaul Mustafa and Arpan Kumar Kar

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Abstract

Purpose – *In current times, organizations operating in emerging economies are providing digital services to its citizen the internet. Literature indicates that digital services are facing major challenges with respect to its adoption among users groups due to the perceived risks.*

Design/methodology/approach – *With the use of generalized analytic network process (GANP), prioritization of different dimensions of risk has been done on the basis of an empirical survey among user groups in India.*

Findings – *The result indicates that dimensions like privacy risk, performance risk and financial risk are more important risks across digital services models. However, physical risk, social risk, psychological risk and time risk are comparatively less important risks across digital services. This research also finds out that the end users are reluctant to provide their personal information.*

Research limitations/implications – *The sample size is relatively small which limits generalizability of results beyond India. However, an application of GANP has been showcased for empirical research.*

Practical implications – *The research outcome can help managers in deciding which dimensions of risk are more important for digital service delivery and thus facilitate adoption.*

Originality/value – *This paper focused on the different facets of risk perceived by consumers, toward the digital services available in smart cities. Perceived risk dimensions such as 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 risks to the digital services which is offered to the residents of the smart cities.*

Keywords *Emerging economies, Perceived risk, Analytic network process, Information risk, Smart cities, Digital services*

Paper type *Research paper*

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1. Introduction

In the past, most of the transactions were done in physical medium but as we enter the digital era, majority of such transactions are completed though digital medium. The risk associated during the transactions is multi-dimensional in nature (Luo *et al.*, 2010). The risk causes uncertainties during the transaction of digital services. The issues related to risk with the use of digital services has been the central issue to the consumers and service providers. The use digital services are becoming very common but the risk associated with it creates insecurities among the consumers (Lee, 2009). The associated risk some time leads to online fraud (Spears and Barki, 2010), phishing (Chen and Zahedi, 2016), scams (Featherman *et al.*, 2010), spamming (Youn, 2005), theft of identity (Featherman *et al.*, 2010), etc. In this digital era (Barrett *et al.*, 2015), consumers are using digital services despite facing high potential risk. The services provider must be flexible with the consumer to provide digital services to the consumers. The consumer should also be flexible to get the latest digital services by the

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provider. A flexible decision-making system is needed to prioritize and rank the alternative based on the criteria given by experts.

The use of digital services has become more common with the wide use of smart phone penetration (Kerviler *et al.*, 2016; Shin, 2013). Generally, the consumer uses smart phone for shopping, payments and use of digital services through mobile applications (Duane *et al.*, 2014). Digital services are a part of e-commerce and the popularity of digital services increases with the increase in the digitalization of services (Nambisan, 2013). The main use of digital services is to deliver product or service through digital medium to the consumer. An example of digital service is the use of public libraries using network-based models (Higgs *et al.*, 2013). While purchasing the product or service through online the consumer faces risk associated with it (Keaveney and Parthasarathy, 2001). The sharing of personal information also depends on the consumers how much he/she perceive risk due to it. The consumer always perceive risk towards the uses of digital services and it has been shown in the past consumer experience (Alalwan *et al.*, 2016). The trust of using digital services and sharing personal data online depends on the minimization of risk perceived by the consumers and the perceived security of such services (Cases, 2002; Lindsay, 2017). This study attempts to prioritize the multi-dimensional risks for digital services by using the Generalized Analytics Network Process (GANP) framework after taking responses from users.

Because of rapid consumption of digital services in this digital age (Steelman *et al.*, 2014), there is a need to bring the efficient and effective way to adopt the digital services. Several methods have been introduced in the literature which evaluates the factors causing hurdles during the adoption of digital services (Lu *et al.*, 2005). As soon as the digital penetration increases in India, the adoption of digital service also increases proportionately (Lu *et al.*, 2005). This study evaluates and prioritizes the multi-dimensions of risk. These risks are Privacy risk, performance risk, financial risk, physical risk, social risk, psychological risk and time risk. Now all the different dimensions of risk are explored in the context of digital services. The GANP methodology developed by Zhu *et al.* (2015) has been applied to prioritize the multi-dimensions of risk. To the best of our knowledge, there is no study done to prioritize the multi-dimensions of risk using GANP in the past literature. The key research questions of the study are to explore

RQ1. What are the hurdles faced during the adoption of digital services?

RQ2. How are these multi-dimensional risks of digital services prioritized based on users' perspectives?

The remaining of the article is structured as follows. Section 2 discusses the literature review of multi dimensions of risk, digital service and its effects. Later, Section 3 describes the steps of generalized analytics network process (GANP) in computational methodology section. Section 4 of data analysis and result discusses all the steps of GANP in detail. Section 5 discusses the implications for practice, policy maker and academia followed by concluding discussion in Section 6. Limitation and future research direction has also been given in the Section 7 after concluding remark.

2. Literature review

With the increase in population of urban areas, the need of the people also increases to do all the transaction through online (Rust and Kannan, 2003). To facilitate digital services to the citizen, the urban areas need to be improved by providing Information and Communication Technologies (ICTs). In the literature Alalwan *et al.* (2016) has explored the effect of perceived risk in the adoption of Information Technology (Lu *et al.*, 2005). Digital services provide flexibility and ease to the citizens to use government and private services (Nazimoglu and Özsen, 2010; Robinson, 2017). The literature review has been structured

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with a brief review of digital services after that how the multi-dimensional risk affects the use of digital services.

2.1 Digital services

In the literature several authors (Buchanan and McMenemy, 2012; Higgs *et al.*, 2013; Barrett *et al.*, 2015) has given several definitions of digital services but the most generic definitions of digital services are "services or resources accessed and/or provided via digital transaction." (Williams *et al.*, 2008). The quality of life of the citizens of the city gets increased with the use of digital services (Lee *et al.*, 2013). As the use of digital services increases the risk associated with it also increases (Nidumolu, 1995; Shin and Hwang, 2017; Shin and Jin Park, 2017). The users of the digital services will be reluctant to share their personal information online fearing the misuse of their personal data (Shin *et al.*, 2017; Shin, 2013; Kerviler *et al.*, 2016). The inherent flexibility of digitizing was unleashed, and the digital services gained the capability of storing, processing and communicating in many types of information (Chatterjee *et al.*, 2017; Chatterjee and Kar, 2018a). The digital network could support any information service. The new entrepreneur trying the level best to harness the flexibility of digital service. The result of it lead to new variety of services such as searching, social networking, information sharing, internet commerce, gaming, pooling, music distribution, video production, etc. As the digital services has flexibility, it can be expanded to reach any length and breadth while this is no possible with the face-to-face physical services (Tilson *et al.*, 2010).

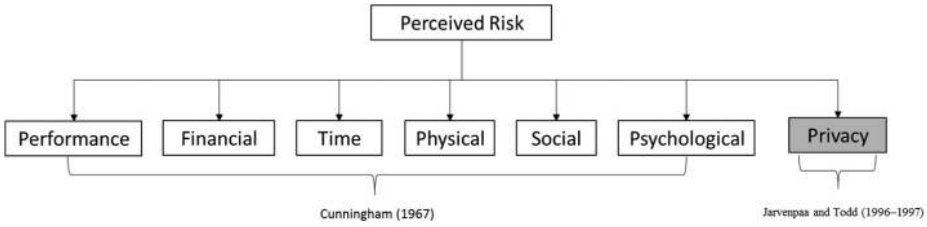
According to Lu *et al.* (2005), internet services are those services which can be accessed through mobile technology. The widely used examples of digital services are purchasing of product or services (Hsu *et al.*, 2014), access to bank through internet (Ndubisi and Sinti, 2006; Roy *et al.*, 2017; Claessens *et al.*, 2002; Calisir and Gumussoy, 2008), etc. The categorization of digital services has been done by Froehle and Roth (2004) based on the interaction among the service provider, consumer and internet. Further Froehle and Roth (2004) have described the interaction between service provider and the consumer by keeping internet as constant. If the interaction between the service provider and the consumer is face to face then it has two types, first is technology-assisted consumer contact and second is technology-facilitated consumer contact. If the interaction between the service provider and the consumer is face to screen then also it has two types, first is technology-mediated consumer contact and the second is technology-generated consumer contact. Further Williams *et al.* (2008) highlights that the categorization of digital services can be done based on the delivery, maturity, malleability and pricing. The categorization done by Williams *et al.* (2008) needs further assessment. As per Government of India the categorization of digital services has been done in six categories based on statutory and non-statutory services. The categorization has been named as Category A, B, C, D, E and F. All the above-mentioned categorization of digital services needs to be adopted by the citizens of the city (Ergazakis *et al.*, 2011). So, to adopt the digital services, the risk perceived by the consumer should be removed by identifying it in the first stage (Featherman and Pavlou, 2003; Lim, 2003; Lee, 2009). This is the reason why the prioritization of multi-dimensions of risk is needed for the adoption of digital services. The exploration of adoption of digital services in emerging economies like India has witnessed a lot of challenges in the recent times (Chauhan *et al.*, 2018; Chatterjee and Kar, 2018a, 2018b; Chatterjee *et al.*, 2018a, 2018b).

2.2 Risk in digital services

Bauer (1960) has defined the risk for the first time as "a combination of uncertainty plus serious of outcome involved". After that, Peter and Ryan (1976) defined it as "the expectation of losses associated with the purchase and act as an inhibitor to purchase behavior". The risk which is perceived by the consumer is generally felt as the uncertainty

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Figure 1 Hierarchical categorization of perceived risk



Source: Adapted from Cunningham (1967) and Jarvenpaa and Todd (1996/1997)

with respect to the negative consequences of using a product or service (Featherman and Pavlou, 2003). Cunningham (1967) for the first time has identified the dimensions of risk as performance, financial, time, physical, social and psychological risk and is shown in Figure 1. Later, Jarvenpaa and Todd (1996/1997) add the privacy risk dimension to the multi-dimensions of perceived risk. Featherman and Pavlou (2003) supports the fact that the multi-dimensions of risk have been used to understand the perception of consumers to understand the adoption of digital services.

Since the consumer is sensitive about sharing their personal information while using digital services (Belanche-Gracia *et al.*, 2015; Chatterjee and Kar, 2015; Singhal and Kar, 2015; Chatterjee *et al.*, 2018a, 2018b), it is difficult to convince the consumers to share their personal information until the risk gets minimized (Milne *et al.*, 2017). The consumers also have the fear that the data they share with the organization is not safe and can be theft (Featherman *et al.*, 2010; Faisal *et al.*, 2007; Özkan *et al.*, 2010; Mou and Shin, 2018). Table I provides the approaches used for the evaluation of different dimensions of risk. The approaches used are flexible towards the evaluation of perceived risk.

Table I Literature suggesting methodology or approaches used for evaluation of perceived risk

Authors (Year)	*Methodology or approaches used*
Agarwal and Teas (2001)	Survey; Hypothesis testing; Experimental; Multiple Regression Analysis
Agarwal and Teas (2004)	Survey; Hypothesis testing; Experimental; Multiple Regression Analysis
Alalwan *et al.* (2016)	Survey; Hypothesis testing; Empirical Test; Structural Equation Modeling
Bettman (1973)	Survey; Hypothesis testing; Empirical Test; Regression analysis
Cases (2002)	Survey; Statistical processing; Empirical study
Cocosila *et al.* (2009)	Survey; Hypothesis testing; Empirical test; Structural Equation Modeling (SEM); Partial Least Squares (PLS). Simple regression
Cox and Rich (1964)	Survey; Hypothesis testing; Exploratory study
Dowling and Staelin (1994)	Survey; Hypothesis testing; Empirical test; Ordinary Least Square Regression
Featherman and Pavlou (2003)	Survey; Hypothesis testing; Empirical test; Structural Equation Modeling (SEM)
Gefen *et al.* (2008)	Empirical method
Glover and Benbasat (2011)	Survey; Empirical study; Structural Equation Modelling; Multiple Regression Analysis; Partial Least Square
Grewal *et al.* (1994)	Survey; Hypothesis Testing; Empirical test; Experimental
Kerviler *et al.* (2016)	Survey; Hypothesis testing; Ordinary Least Square Regression
Lee *et al.* (2016)	Theoretical Framework
Lee (2009)	Survey; Hypothesis; Empirical study; Structural Equation Modelling; Regression Analysis
Lim (2003)	Survey; Focus group discussion
Mitra *et al.* (1999)	Survey; Hypothesis testing; Empirical test
Peter and Ryan (1976)	Survey; Exploratory

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The need to conduct the ranking of multi-dimensions of risk for digital services has increased because of the adoption of digital service (Lu *et al.*, 2005). Several studies have already realized the importance of powerful methods such as AHP (Saaty, 1980) and ANP (Saaty, 2004) for such prioritization of factors affecting a problem domain. The prioritization and ranking of risk has been done in the past using AHP and ANP (Bharathi, 2017; Wang *et al.*, 2009). We attempt to prioritize the determinants of risk for digital services using the generalized version of the ANP, a method which has been introduced recently.

3. Research methodology

In general, multi criteria decision-making (MCDM) is used to evaluate the problems which involves prioritization among a finite number of alternatives (Kumar and Dash, 2017; Mardani *et al.*, 2015; Yang and Tzeng, 2011; Cheng *et al.*, 2005). In this scenario, MCDM techniques provide the ranking of different alternatives and the best alternatives be always recommended as the best solution to the decision makers (Wang *et al.*, 2009). As many problems involves the uncertainties so we find the probabilities value/weightage of all the different alternatives of the element (Sommestad *et al.*, 2011; Zhu *et al.*, 2016). Prioritization of risk involves the multiple conflicting criteria with finite set of alternatives (Wang *et al.*, 2009). Different MCDM technique such as analytic hierarchy process (AHP) (Khatwani and Kar, 2017; Zeshui and Cuiping, 1999), analytic network process (ANP) (Jharkharia and Shankar, 2007; Cheng *et al.*, 2005), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Kumar and Dash, 2017; Kermani *et al.*, 2016), ELimination and Choice Expressing REality (ELECTRE) (Shojaie *et al.*, 2018; Ergazakis *et al.*, 2011), Preference Ranking Organization METHod for Enrichment of Evaluations (PROMETHEE) (Senthil *et al.*, 2018; Mardani *et al.*, 2015) and VIKOR (Wan *et al.*, 2013; Mardani *et al.*, 2015) has been applied in prioritization problems.

Since ANP is limited to the input preferences as crisp judgments, which is often unfavorable in practical applications (Zhu *et al.*, 2015). This study has proposed the usage of GANP (Zhu *et al.*, 2015) approach as a methodology to solve and evaluate the priority of multi-dimensions of risk in the context of digital services. GANP is an extension of ANP and it allows multiple forms of preference such as crisp, interval, hesitant and stochastic. GANP uses the concept of complex comparison matrix (CCMs) of decision maker's preferences and then Geometric Mean Method (GMM) is applied to derive the priorities from CCMs. GANP is used to obtain the weights of the different dimensions of risk. The obtained weights are used to evaluate the priority of the risk.

While reviewing the literature, it has been noticed that authors (Wang *et al.*, 2009; Zhu *et al.*, 2016; Dong *et al.*, 2010) have used the different methodologies to evaluate the prioritization of risk. Some of the selected methodology used by authors to evaluate perceived risk has been shown in Table I. The preferences of different dimensions of risk have been taken through the questionnaire. The questionnaire has been circulated to experienced user who is using digital services. The analysis has been done using GANP proposed by Zhu *et al.* (2015). The initial CCM has been formed using Saaty (1980) basic scale. Since no study in the past has used the prioritization of risk using GANP developed by Zhu *et al.* (2015). The uses of AHP are restricted to only those alternatives which are not connected to each other and do not influence each other. The new proposed methodology also highlights the prioritization of multi-dimension of risk in the domain of digital services. There are plenty of flexible approaches used to evaluate the prioritization of preferences or judgments.

3.1 Computational methodology: generalized analytic network process

The generalized analytic network process (GANP) has been developed by Zhu *et al.* (2015). It has the following steps as given below.

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- *Step 1:* Construct a hierarchy with its control criteria to make a base for judgment. After that, construct a network hierarchy and its cluster with all associated elements.
- *Step 2:* Identify the interaction between the clusters and the elements of cluster.
- *Step 3:* Construct the CCMs of the hierarchal network identified in step 2 with respect to its feedback and dependencies.
- *Step 4:* Check the Consistency of CCMs. If found not within the acceptable limit, apply algorithm to improve it until acceptable.
- *Step 5:* Derive priorities from CCMs using Row Geometric Mean Method (RGMM).
- *Step 6:* Construct the unweighted supermatrix.
- *Step 7:* Convert the unweighted supermatrix to weighted supermatrix (or called stochastic matrix)
- *Step 8:* Evaluate the limiting priorities of all the elements using stochastic matrix.
- *Step 9:* Evaluate the final priorities of the construct from the limiting priorities.

3.1.1 Analytic network process. The ANP is the more generic form of AHP. The priorities in the ANP are established using pairwise comparison and judgment. The structure of ANP is feedback of the network clusters and nodes within the clusters.

3.1.2 Complex comparison matrix. It is a comparison matrix which is developed by taking the preferences of the decision makers. If considered from stochastic point of view, the CCM is developed to evaluate the priorities.

3.1.3 Generalized analytic network process. GANP is an extension of ANP and it allows multiple forms of preference such as crisp, interval, hesitant and stochastic. GANP uses the concept of CCMs of decision maker's preferences and then Geometric Mean Method (GMM) is applied to derive the priorities from CCMs. GANP is used to obtain the weights of the different dimensions of risk. The obtained weights are used to evaluate the priority of the risk.

3.1.4 Row geometric mean method. RGMM is on the most extended form of AHP prioritization process. The method defines the consensus indexes to evaluate consensus degree among the decision makers.

4. Data analysis and result

The data have been collected from the experienced consumers in online as well as offline mode. The survey has been done in the National Capital Region of India. Questionnaire has been administered to more than 400 consumers and 110 responses have been received resulting in 27.5 percent response rate. Out of 110 responses, only 100 responses have been selected for further study rest 10 responses have been discarded because of incomplete responses. Now the GANP method has been applied step by step as follows.

- *Step 1*: Construct a hierarchy with its control criteria to make a base for judgment. After that, construct a network hierarchy and its cluster with all associated elements.
- *Step 2*: Identify the interaction between the clusters and the elements of cluster.
  The criteria to evaluate the priority of multi-dimensions risk have been fixed. The model in Figure 2 shows the dependencies and feedback within and between the clusters. The network table of the cluster is shown in Table II and network table of elements of cluster is shown in Table III.
- *Step 3*: Construct the CCMs of the hierarchal network identified in step 2 with respect to its feedback and dependencies.

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A survey question has been designed to collect the influence of multi-dimensional risk element. It also determines how much one risk elements effects the other. The CCMs are shown in Table IV.

- *Step 4*: Check the Consistency of CCMs. If found not within the acceptable limit, apply algorithm to improve it until acceptable.
  All the CCMs are identified to be within the acceptable limit of consistency which is less than 0.1.

Figure 2 The network of multi-dimensional risk assessment

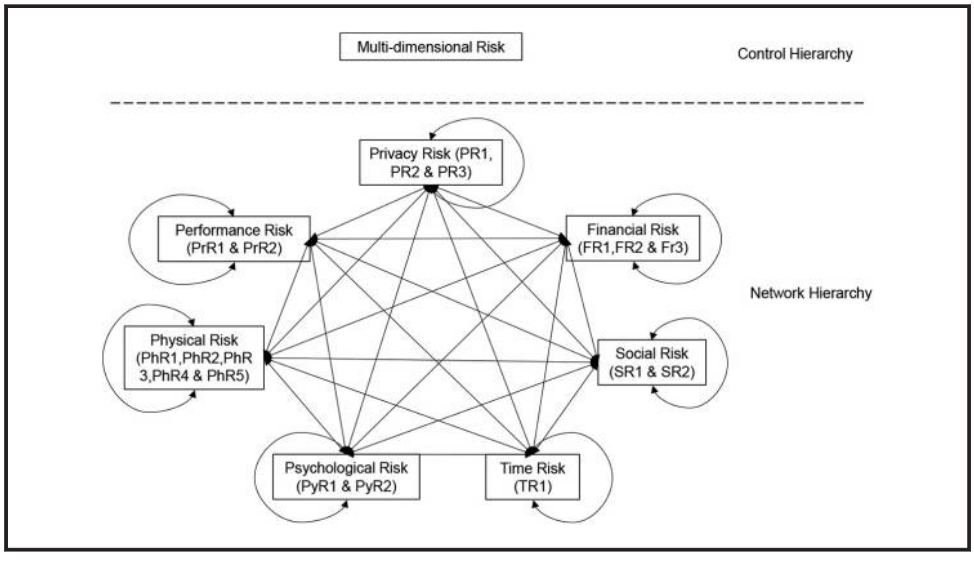


Table II Multi-dimensional risk with its definition and factor

Sl. No.	*Risk dimension*	*Definition*	*Risk factor*
1	Privacy risk (PR)	The risk associated with the loss of personal information without your permission (Luo *et al.*, 2010)	PR1: Compromise of personal information PR2: Uses of personal information without your knowledge PR3: Control of my account by hackers
2	Performance risk (PrR)	The possibility that the services or products is not delivering the desired benefits as it was advertised and designed (Luo *et al.*, 2010)	PrR1: Delivery of performance as promised PrR2: Transaction made by service provider correctly
3	Financial risk (FR)	The price associated with the purchase of products or services and the subsequent maintenance cost associated with it (Luo *et al.*, 2010)	FR1: Loss of money. FR2: Loss of financial Information FR3: financial risk of bank account
4	Physical risk (PhR)	The risk associated with the safety of consumers while using product or services (Luo *et al.*, 2010)	PhR1: Threat to health PhR2: live for long time PhR3: Cause of illness PhR4: Exposed by harmful radiation PhR5: Risk of brain damage
5	Social risk (SR)	The risk associated with the use of product or service leads to embarrassment in social media (Luo *et al.*, 2010)	SR1: Negative effect of others thinking SR2: Social loss by family and friends
6	Psychological risk (PyR)	The risk that using of the product or services will decrease the self-image of the consumer (Luo *et al.*, 2010)	PyR1: Self-image of person. PyR2: Psychological loss because of fitment
7	Time risk (TR)	The lost time associated with bad purchase decision such as researching and purchasing a product or services (Luo *et al.*, 2010)	TR1: Times loss because of inconvenience

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Table III The Network table of cluster

	PrR	*PR*	*PyR*	*SR*	*TR*	*PhR*	*FR*
PrR	✓	✓	✓	✓	✓	✓	✓
PR	✓	✓	✓	✓	✓	✓	✓
PyR	✓	✓	✓	✓	✓	✓	✓
SR	✓	✓	✓	✓	✓	✓	✓
TR	✓	✓	✓	✓	✓	✓	✓
PhR	✓	✓	✓	✓	✓	✓	✓
FR	✓	✓	✓	✓	✓	✓	✓

Table IV The Network table of elements

	PrR1	*PrR2*	*PR1*	*PR2*	*PR3*	*PyR1*	*PyR2*	*SR1*	*SR2*	*TR1*	*PhR1*	*PhR2*	*PhR3*	*PhR4*	*PhR5*	*FR1*	*FR2*	*FR3*
PrR1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PrR2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PR1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PR2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PR3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PyR1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PyR2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SR1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SR2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
TR1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PhR1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PhR2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PhR3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PhR4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PhR5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
FR1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
FR2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
FR3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

- *Step 5*: Derive priorities from CCMs using Row Geometric Mean Method (RGMM).
  The priorities of the cluster have been determined. The priorities between the clusters determine which cluster is more important than the other. The obtained priorities of cluster PR, PrR, FR, PhR, SR, PyR, TR are shown in Table V.
- *Step 6*: Construct the unweighted supermatrix.
  The unweighted super matrix has been obtained by the geometric mean associated with the main eigenvalue. The unweighted super matrix has been shown in Table VI.
- *Step 7*: Convert the unweighted supermatrix to weighted supermatrix (or called stochastic matrix)
  In a network model, elements of a cluster from different elements of another cluster will have more/less priority than the other. Since the un-weighted super matrix is non-stochastic by columns. As per Saaty (2004), all the cluster which affects each other will have to be prioritized with the use of priority matrix of the cluster. The weight associated with the certain cluster weights the corresponding elements of the cluster. Thus, the weighted supermatrix is generated from unweighted super matrix. The weighted super matrix or stochastic matrix is shown in the Table VII.
- *Step 8*: Evaluate the limiting priorities of all the elements using stochastic matrix.
  The limiting priorities of all the elements are obtained from the weighted supermatrix or stochastic matrix until the input converge. The value of all the elements of the cluster is between 0 and 1. The total sum of all the priority value is 1. Table VIII shows the priority value of different dimensions of risk (Table IX).

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Table V CCMs of the Network hierarchy according to the dependence and feedback identified

	PrR1	*PrR2*	*PR1*	*PR2*	*PR3*	*PyR1*	*PyR2*	*SR1*	*SR2*	*TR1*	*PhR1*	*PhR2*	*PhR3*	*PhR4*	*PhR5*	*FR1*	*FR2*	*FR3*
PrR1	1	1	1	1	0.2	0.2	0.3	1	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
PrR2	1	1	1	1	0.2	0.2	0.3	1	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
PR1	1	1	1	1	0.2	0.2	0.3	9	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
PR2	1	1	1	1	0.2	0.2	0.3	1	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
PR3	5	5	5	5	1	1	3	2	3	3	5	3	5	5	5	3	3	1
PyR1	5	5	5	5	1	1	3	5	3	3	5	3	5	5	5	3	3	1
PyR2	3	3	3	3	0.3	0.3	1	3	1	1	3	1	3	3	3	1	1	0.3
SR1	1	1	0.1	1	0.5	0.2	0.3	1	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
SR2	3	3	3	3	0.3	0.3	1	3	1	1	3	1	3	3	3	1	1	0.3
TR1	3	3	3	3	0.3	0.3	1	3	1	1	3	1	3	3	3	1	1	0.3
PhR1	1	1	1	1	0.2	0.2	0.3	1	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
PhR2	3	3	3	3	0.3	0.3	1	3	1	1	3	1	3	3	3	1	1	0.3
PhR3	1	1	1	1	0.2	0.2	0.3	1	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
PhR4	1	1	1	1	0.2	0.2	0.3	1	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
PhR5	1	1	1	1	0.2	0.2	0.3	1	0.3	0.3	1	0.3	1	1	1	0.3	0.3	0.2
FR1	3	3	3	3	0.3	0.3	1	3	1	1	3	1	3	3	3	1	1	0.3
FR2	3	3	3	3	0.3	0.3	1	3	1	1	3	1	3	3	3	1	1	0.3
FR3	5	5	5	5	1	1	3	5	3	3	5	3	5	5	5	3	3	1

Table VI The Priorities of the cluster

	PrR	*PR*	*PyR*	*SR*	*TR*	*PhR*	*FR*
PR	0.312	0.297	0.324	0.297	0.227	0.296	0.280
PrR	0.145	0.126	0.129	0.138	0.138	0.088	0.116
FR	0.139	0.167	0.157	0.199	0.198	0.140	0.142
PhR	0.202	0.237	0.186	0.207	0.212	0.299	0.232
SR	0.099	0.078	0.076	0.049	0.105	0.071	0.077
PyR	0.062	0.062	0.084	0.076	0.076	0.068	0.104
TR	0.038	0.030	0.041	0.030	0.041	0.034	0.046

Table VII The Unweighted supermatrix

	PrR1	*PrR2*	*PR1*	*PR2*	*PR3*	*PyR1*	*PyR2*	*SR1*	*SR2*	*TR1*	*PhR1*	*PhR2*	*PhR3*	*PhR4*	*PhR5*	*FR1*	*FR2*	*FR3*
FR3	0.077	0.052	0.064	0.045	0.046	0.038	0.027	0.038	0.028	0.022	0.038	0.034	0.027	0.031	0.041	0.059	0.051	0.052
FR2	0.032	0.065	0.079	0.074	0.064	0.036	0.031	0.058	0.037	0.037	0.018	0.014	0.014	0.022	0.022	0.052	0.060	0.087
FR1	0.045	0.067	0.062	0.057	0.047	0.029	0.022	0.026	0.035	0.035	0.052	0.038	0.026	0.061	0.055	0.044	0.035	0.059
PhR5	0.024	0.041	0.059	0.151	0.069	0.029	0.029	0.049	0.029	0.035	0.029	0.035	0.029	0.084	0.028	0.060	0.030	0.048
PhR4	0.073	0.052	0.107	0.134	0.049	0.033	0.027	0.041	0.027	0.037	0.023	0.023	0.023	0.032	0.027	0.045	0.032	0.040
PhR3	0.060	0.069	0.124	0.054	0.101	0.039	0.027	0.023	0.022	0.026	0.047	0.032	0.032	0.032	0.032	0.059	0.038	0.058
PhR2	0.056	0.075	0.072	0.097	0.071	0.032	0.028	0.032	0.016	0.022	0.037	0.029	0.022	0.033	0.033	0.061	0.051	0.064
PhR1	0.043	0.077	0.102	0.061	0.052	0.041	0.045	0.033	0.023	0.023	0.052	0.045	0.023	0.034	0.022	0.046	0.025	0.046
TR1	0.032	0.042	0.070	0.114	0.118	0.020	0.029	0.022	0.022	0.026	0.064	0.048	0.036	0.056	0.042	0.054	0.016	0.034
SR2	0.040	0.040	0.117	0.095	0.058	0.027	0.023	0.034	0.034	0.033	0.058	0.071	0.024	0.041	0.047	0.058	0.025	0.060
SR1	0.040	0.039	0.052	0.085	0.089	0.042	0.022	0.024	0.027	0.033	0.052	0.053	0.027	0.052	0.048	0.073	0.020	0.023
PyR2	0.062	0.061	0.116	0.096	0.069	0.062	0.043	0.036	0.018	0.030	0.041	0.049	0.017	0.030	0.018	0.051	0.029	0.035
PyR1	0.057	0.043	0.097	0.037	0.074	0.040	0.033	0.064	0.032	0.021	0.041	0.031	0.026	0.067	0.048	0.050	0.017	0.042
PR3	0.043	0.050	0.045	0.071	0.075	0.034	0.041	0.058	0.048	0.034	0.045	0.034	0.028	0.028	0.034	0.050	0.029	0.034
PR2	0.042	0.061	0.097	0.096	0.133	0.022	0.022	0.022	0.036	0.035	0.051	0.027	0.017	0.024	0.021	0.033	0.033	0.047
PR1	0.097	0.100	0.116	0.149	0.064	0.032	0.022	0.027	0.022	0.022	0.055	0.032	0.022	0.022	0.022	0.038	0.019	0.047
PrR2	0.029	0.019	0.097	0.071	0.101	0.017	0.020	0.026	0.035	0.022	0.083	0.039	0.044	0.032	0.035	0.061	0.030	0.045
PrR1	0.065	0.062	0.044	0.062	0.093	0.033	0.034	0.030	0.029	0.021	0.043	0.029	0.020	0.038	0.039	0.056	0.041	0.056

- *Step 9*: Evaluate the final priorities of the construct from the limiting priorities.
  Now by aggregating the limiting priority of all the elements of different dimensions of risk, we get the final priority value of different dimensions of risk. The main result of the data analysis is the final priority Table X.

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Table VIII the Stochastic matrix

	PrR1	*PrR2*	*PR1*	*PR2*	*PR3*	*PyR1*	*PyR2*	*SR1*	*SR2*	*TR1*	*PhR1*	*PhR2*	*PhR3*	*PhR4*	*PhR5*	*FR1*	*FR2*	*FR3*
FR3	0.084	0.059	0.085	0.073	0.064	0.046	0.033	0.054	0.049	0.025	0.044	0.045	0.037	0.039	0.052	0.070	0.062	0.072
FR2	0.049	0.069	0.110	0.082	0.075	0.043	0.039	0.077	0.050	0.050	0.021	0.014	0.014	0.025	0.025	0.060	0.073	0.112
FR1	0.063	0.086	0.063	0.071	0.058	0.035	0.027	0.030	0.054	0.058	0.085	0.046	0.033	0.075	0.070	0.046	0.039	0.052
PhR5	0.027	0.054	0.067	0.154	0.077	0.031	0.033	0.059	0.031	0.047	0.038	0.041	0.031	0.100	0.034	0.062	0.038	0.067
PhR4	0.087	0.057	0.125	0.160	0.056	0.056	0.049	0.048	0.028	0.045	0.024	0.024	0.024	0.037	0.032	0.047	0.035	0.058
PhR3	0.065	0.079	0.134	0.068	0.128	0.041	0.030	0.024	0.023	0.027	0.051	0.035	0.035	0.035	0.035	0.063	0.052	0.069
PhR2	0.062	0.082	0.076	0.124	0.092	0.035	0.033	0.035	0.020	0.035	0.048	0.033	0.027	0.038	0.038	0.077	0.062	0.073
PhR1	0.055	0.082	0.107	0.083	0.079	0.050	0.055	0.043	0.026	0.024	0.074	0.059	0.027	0.063	0.023	0.053	0.031	0.058
TR1	0.039	0.048	0.097	0.123	0.125	0.024	0.037	0.029	0.025	0.035	0.068	0.053	0.038	0.063	0.054	0.066	0.019	0.049
SR2	0.040	0.046	0.121	0.105	0.062	0.029	0.025	0.036	0.042	0.043	0.062	0.084	0.029	0.047	0.051	0.062	0.035	0.072
SR1	0.046	0.054	0.059	0.091	0.113	0.059	0.027	0.025	0.029	0.048	0.066	0.073	0.031	0.074	0.062	0.085	0.021	0.028
PyR2	0.065	0.066	0.121	0.113	0.086	0.068	0.047	0.044	0.019	0.051	0.046	0.062	0.018	0.040	0.019	0.055	0.029	0.043
PyR1	0.065	0.044	0.106	0.052	0.096	0.047	0.050	0.071	0.034	0.025	0.063	0.035	0.028	0.071	0.054	0.070	0.017	0.061
PR3	0.055	0.058	0.050	0.095	0.105	0.038	0.045	0.068	0.072	0.039	0.081	0.045	0.033	0.033	0.039	0.062	0.035	0.038
PR2	0.052	0.076	0.102	0.107	0.139	0.024	0.025	0.026	0.050	0.045	0.075	0.037	0.019	0.038	0.023	0.040	0.047	0.066
PR1	0.118	0.108	0.122	0.153	0.078	0.034	0.023	0.031	0.024	0.024	0.058	0.038	0.023	0.023	0.023	0.042	0.020	0.051
PrR2	0.047	0.021	0.112	0.082	0.124	0.018	0.023	0.034	0.041	0.036	0.094	0.050	0.051	0.047	0.041	0.069	0.034	0.067
PrR1	0.073	0.080	0.049	0.076	0.096	0.047	0.040	0.048	0.051	0.026	0.064	0.034	0.023	0.043	0.049	0.062	0.056	0.073

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Table IX Limiting priorities of all the variable

Priority variable	*Type of risk*	*Brief description*	*Priority value*
PR1	Privacy risk	Compromise of personal information	0.095
PR2		Uses of personal information without your knowledge	0.101
PR3		Control of my account by hackers	0.092
PrR1	Performance risk	Delivery of performance as promised	0.061
PrR2		Transaction made by service provider correctly	0.065
FR1	Financial risk	Loss of money	0.061
FR2		Loss of financial Information	0.039
FR3		Financial risk of bank account	0.062
PhR1	Physical risk	Threat to health	0.059
PhR2		Live for long time	0.045
PhR3		Cause of illness	0.029
PhR4		Exposed by harmful radiation	0.049
PhR5		Risk of brain damage	0.040
SR1	Social risk	Negative effect of others thinking	0.043
SR2		Social loss by family and friends	0.037
PyR1	Psychological risk	Self-image of person	0.040
PyR2		Psychological loss because of fitment	0.037
TR1	Time risk	Times loss because of inconvenience	0.038

Table X Final priority of the multi-dimensions of risk

Priority of variable	*Type of risk*	*Priority value*	*Rank*
PR	Privacy risk	0.096	1
PrR	Performance risk	0.063	2
FR	Financial risk	0.053	3
PhR	Physical risk	0.043	4
SR	Social risk	0.040	5
PsR	Psychological risk	0.039	6
TR	Time risk	0.038	7

5. Discussion

In this section, we connect and discuss the implication of our findings with that for academic research, practice and policy making, to strengthen how our study has significance to all the three stakeholders.

5.1 Implications for academia

The contribution of this study is interesting to academia in two-folds. First, the study highlights how the prioritization of multi-dimensions of risk for digital services has been done empirically. To the best of our knowledge, there has not been any existing literature, which has attempted to prioritize the determinants of risk for digital services by analyzing consumer feedback from service encounters. Especially, given that the findings are based on service encounters in an emerging economy, the contribution becomes important considering digital transformation initiatives in such economies with similar levels of ICT diffusion.

Literature surrounding digital services and governance of such services highlight how the information shared in such platforms need to be protected (Mueller, 2017). It has been found that privacy risk, performance risk and financial risk were the first, second and third most important dimensions of risk but Cases (2002) findings says that privacy, source and performance risk were the first, second and third important dimensions of risk. Time risk, financial risk and social risk were the sixth, seventh, and eight positions in the ranking of multi-dimensions of risk this contrasts with our findings which interestingly highlight that social, psychological and time risk are the fifth, sixth and seventh ranked in the multi-dimension of perceived risk.

In another study by Alalwan *et al.* (2016), it has been found that the performance, financial, social, time and security risk affect the adoption of e-banking services negatively. Further the study also highlights that the top most important dimension of risk is security, financial and performance risk whereas social risk and time risk are fourth and fifth ranked risk. In another study conducted by Forsythe and Shi (2003) by taking only four dimensions of perceived risk prioritizes performance risk as the top most important dimensions of perceived risk followed by financial, psychological and time risk while doing online shopping.

By taking a closer look at the ranking of multi-dimensions of risk (Luo *et al.*, 2010) it has been found that the privacy, performance and financial risk are the dominant cluster of risk which is different from the findings by Featherman and Pavlou (2003) which highlights that the dominant cluster of risk are time, psychological, privacy and financial risk. The difference in the cluster is mainly because of the maturity of the process and technology. By connecting the findings with the findings of Lee (2009), it is concluded that the privacy risk and financial risk are the main driving factor for the adoption of digital services. To increase the uses of digital services the privacy risk and performance risk perceived by the consumer should be decreased. The usefulness and ease of use of digital services also increase the penetration of digital services. To increase the usefulness and ease of use of digital services by the consumer, the social risk and psychological risk faced by the consumer should also be minimized.

Second, in the past literature, prioritization of different factors has been done using methods like AHP (Shojaie *et al.*, 2018; Lee and Kozar, 2006; Kar and Rakshit, 2015; Kar and Pani, 2014) but there is no study has been done which applied the GANP method to prioritize the multi-dimension of risk while using digital services. The GANP method has been developed first by the Zhu *et al.* (2015). The proposed methodology is very recent and highlights its application in the domain of risk and digital services. The approach can be adopted in the future for prioritization problems in academic studies. This study presents an application of GANP to determine the priority of multi-dimension risk for digital service. GANP is the

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method to solve the problem which consists of multiple alternatives. This method focuses more on to identify flexibility in the criteria for decisions and how much weight should be given to each criterion. The example of making the hierarchal model for different dimensions of risk and how it has been given weighted and prioritized. As the GANP method is very complex in nature and it consists of CCMs so the decision makers have given all the decision-making criteria along with its weightage to compute and prioritize the multi-dimensions of risk. The priorities evaluated using GANP is always better than the intuitive decisions taken by the decisions makers. The application of GANP has been used to solve the real-life problems since the real-life problems consists of various complexity. The major contribution of this paper is the application of GANP to prioritize the multi-dimensions of risk for digital services. The GANP methods not only provide the results to the decision makers but also enable the decision maker to reexamine the decision-making criteria and its weightage.

5.2 Implications for practice

This paper analyses from the user's point of view and how it influences the organization. The research model is novel in nature since it uses the GANP as its methodology to prioritize the multi-dimension of risk based on the criteria given for each dimension of risk. The GANP methodology has been used to obtain the priority index value from each stakeholder who represents the users. This GANP model evaluates how each elements of the risk effects each other and how it can be measured. The output of this study will be used by the policy makers, entrepreneurs, consultants as well as big enterprise. The risk managers can use the result of this study to decide which dimensions of risk have more priority than the other when digital services are consumed by the users. To reduce the failure of digital services consumed by the users, necessary measures can be taken by considering the most important to the least important dimension of risk. Further, this methodology provides a way to simplify the complex multi-criteria decision-making problem. This approach can be used for quantification of subjective judgment as well which are needed for the evaluation of different providers. This methodology not only support group decision making but also helps in various consideration during decision process.

5.3 Implication for policymaking

The policy makers also get impacted by the success and failure of digital services. This method also provides the policy maker to analyze and choose the different dimensions of risk based on the requirement as needed. The policy makers can also carry out adequate identification of stakeholders. Since then the policymakers can carry out adequate planning, managing and controlling of the stakeholders. The ranking of the risk provides flexibility to the policy makers as well. The GANP has the capability of handling the interdependencies.

6. Conclusion

The study concludes by highlighting the prioritization for the major determinants of risk for digital services based on the end users' perspectives. It establishes that privacy risk is the most important determinant for overall risk perceived by users for a digital service. Subsequently, the users perceive performance risk and financial risk to be the second most important driver for the perception towards overall risk for digital services. Last, but not the least, determinants of risk like physical risk, social risk, psychological risk and time risk are also perceived to be important by the users of digital services. For establishing this prioritization through an empirical survey, the study also highlights the application of the relatively new GANP method, for estimating priorities among decision makers and for estimating trade-offs among alternatives.

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7. Limitation and future research directions

The sample size in this study is small to make it generalizable in different context of the services. The application of GANP also showcased the empirical research. As the normalization of priority data has been done which influences the final priority of the multi-dimension of risk. Normalization of the process also biases the original result. One of the limitations of using GANP is that the rules become quite larger with respect to the data to be analyzed. The bias in the sample and accuracy of data also affect the results. The aggregation of decision maker preferences creates bias in the result.

In future, the study can also be empirically validated the GANP method with different categorization of digital services. The method on how to remove the above-mentioned limitation can also be done as future work. The sample size can also be increased by taking it from different domain of experts. Different MCDM technique such as AHP, ANP, technique for order of preference by similarity to ideal solution (TOPSIS), elimination and choice expressing reality (ELECTRE), preference ranking organization method for enrichment of evaluations (PROMETHEE) and VIKOR (Mardani *et al.*, 2015) can also be applied to verify and validate the empirical result found in this study. Since the decisions made in the real world are affected by the political factor, so this can also be considered as a future work.

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