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EMPIRICAL ARTICLE

The evaluation factors of adopting SoLoMo services: the hybrid fuzzy MCDM approach

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Abstract SoLoMo services are emerging mobile services, which combine different software and hardware techniques, enabling users to obtain location-based information at any time and place as well as exchange, interact, and communicate messages with other people in real time. Since SoLoMo services contain two types of the most widely used mobile applications, different users might have different needs for and expectations on these services. This study proposed a three-stage hybrid fuzzy multicriteria decision-making (MCDM) model and applied fuzzy analytic network process (FANP) and the decision-making trial and evaluation laboratory (DEMATEL) to analyze, from an angle of integral SoLoMo services, the critical factors evaluated by users in adopting SoLoMo services. In addition, this study also discussed how the users make their choices after they have weighed between the privacy consideration and the use of complete SoLoMo services. The analysis results reported that popularity degree of service, information accuracy of service, privacy risk, maintaining affection and friendship with others, and location-based store information search are the top five ones among these critical positive and negative factors considered by users while adopting SoLoMo services. Furthermore, the analysis indicated that for achieving information accuracy of service, location-based store information search, and maintaining affection and friendship with others, SoLoMo service users would tolerate more privacy risk.

Keywords SoLoMo · Fuzzy theory · Analytic hierarchy process · Analytic network process · Decision-making trial and evaluation laboratory · Privacy risk

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1 Introduction

Recently, more and more innovative developments in information and communication technology (ICT) have significantly changed the way people live, and some of them have already become an inseparable part of our lives (Salehan and Negahban 2013). People use ICT everyday for various purposes, such as searching for restaurants or store information they are interested in, and communicating with others (Lee et al. 2012; Williams et al. 2009). In former days, people relied on desktop computers at a fixed location to find or search for the information they are interested. Further, when people wanted to get any information about promotional activities in connection with some products or services, they also had to search for such information on their own initiatives. Nowadays, people only need to install and activate adequate application software (called as "App") on their mobile devices. With these Apps, users can obtain interested information at any time and any place, and can also share the information with others in real time (Kim et al. 2014). In addition, product/service promotional information would be automatically pushed to the users' mobile devices. If needed, Apps can even provide local information (e.g., weather, parking lots, and local activities) according to the user's current location. The above-mentioned examples of providing convenient services to users can be realized only through the integration of information technology with information services. These integrated and innovative services are generally referred to as social-local-mobile (SoLoMo) services (Sun et al. 2013).

SoLoMo is a concept referring to the convergence of social networking sites, global positioning system (GPS), and mobile device (Heinemann and Gaiser 2015). According to different usage contexts and requirements, SoLoMo services can provide accurate information and adaptive services that meet the user's expectations, enable the user to obtain local information at any time and place, as well as to interact with others in real time (Jiang 2013). By integrating social, information, and mobile device, SoLoMo services generally provide three important types of services, i.e., mobile social network services (SNS), mobile social services, and location-based services (LBS). With these three types of services, SoLoMo services can satisfy users' needs for socialization, localization, and mobility at one time (Gatautis and Medziausiene 2014).

While SoLoMo services integrate social, information, and mobile device to provide different kinds of information-based technological services, users' needs for and expectations on SoLoMo services might vary from person to person (Rao and Troshani 2007). For instance, some people use SoLoMo services mainly to find instant information of local stores or restaurant, while other users want to get the up-to-date discount/promotional information of the user-interested products/services as soon as possible. There are also users who mainly use SoLoMo services to make friends with others or keep in touch with family members by sharing interesting and useful information with others from time to time, no matter where they are. In fact, some users use SoLoMo services simply out of curiosity and deem them something cool and fashionable. Many currently popular social/community Apps, such as Line, WeChat, Instagram, and Snapchat, and popular LBS Apps, such as Foursquare,

TripAdvisor, and Yelp, all belong to the SoLoMo services. Owing to the fact that SoLoMo services contain these widely used mobile applications, different users might have different needs for and expectations on these services. What would be the priority of evaluation factors in general? Such priority information would be not only important for service providers while designing the App software, but also for government policy makers while trying to boost telecommunication applications.

Further, for accurately meeting users' real needs in real time, SoLoMo services would collect more and more users' personal information. In other words, if users demanded more complete functions or services from SoLoMo services, they would have to provide more private information to the service providers. However, many users are not willing to disclose too much private information in the cyberspace and accordingly, would miss the chance of enjoying the completely new experience and conveniences brought by SoLoMo services. Unfortunately, most of the SoLoMo services overlook this problem that different users might have different considerations on the disclosure of private information. In the process of installing necessary Apps, these SoLoMo services would try to get some access to the user's mobile device in a forcible way, while such access, in many cases, such as accessing the user's directory, location and the like, involves user privacy. This is why many users who care about privacy do not even try to use SoLoMo services. Therefore, privacy issues obviously have great influence on the future development and even the popularization of SoLoMo services.

In literature, there were some recent studies exploring the technical phase of this new SoLoMo concept (Zhou et al. 2014; Li et al. 2014). Furthermore, there were also some studies conducting sample surveys to discuss users' intention of usage (Pura 2005; Ho 2012; Nikou and Bouwman 2014; Zhou and Li 2014; Gao and Bai 2014; Aloudat et al. 2014), satisfaction (Park et al. 2011), or loyalty (Zhou et al. 2010) toward SoLoMo services. Besides, some researchers also applied the multicriteria decision-making (MCDM) methods to analyze the choice or consideration toward adopting different sub-types of SoLoMo service, such as mobile social network service (Jozsef Mezei and Bouwman 2011; Kim 2012; Nikou and Mezei 2013), mobile commerce (m-commerce) service (Kabir and Akhtar Hasin 2011), mobile banking (m-banking) service (Natarajan et al. 2010; Lin et al. 2012; Lin 2013), and so on. However, most of these technical researches or sample survey researches discussed only the concept of a single specific type of SoLoMo services instead of the true whole SoLoMo services that combine social, local, and mobile dimensions into a complete concept. Besides, the above studies only applied single MCDM method [e.g., analytic hierarchy process (AHP) or analytic network process (ANP)]; no study integrated several MCDM methods for analyzing major factors evaluated by users in the adoption of SoLoMo services.

In view of these facts, from an angle of integral SoLoMo services, this study applies the fuzzy analytic network process (FANP) and the decision-making trial and evaluation laboratory (DEMATEL) approaches to analyze the important positive and negative factors evaluated by users in adopting SoLoMo services. In addition, we further discuss how the users make their choices after they have weighed between the privacy consideration and the use of complete SoLoMo services.

2 Literature review

2.1 SoLoMo services

The concept of SoLoMo was first proposed in February 2011 by John Doerr (The New York Times 2011). This concept refers to the convergence of three dimensions, namely, "*social*," "*local*," and "*mobile*" in the future development of the Web (Sun et al. 2013). Through the convergence of these dimensions, three types of services are derived from the concept of SoLoMo, namely, social network services, mobile social services, and location-based services.

Social network services are web-based services allowing users to construct a public or semipublic profile in the cyberspace. The detailed personal information disclosed in the profile enables higher possibility of establishing the user's relations with others or linking the user with others, because the relations or links are possibly built on the information that shows the user and others coming from the same place, living at the same place, having the same interests and/or educational background (Zhang et al. 2013). Through integration of the user's location-based information and human relations, users can further interact with others, such as communicating, exchanging, and sharing information with others via words, pictures, videos, games, and so on (Lee and Chen 2011; Ellison 2007). Furthermore, users could exchange products/brands information in virtual communities even to make online shopping through SNS (Mahrous and Abdelmaaboud 2016). Among others, Facebook, Twitter, MySpace, and Google plus are some of the most famous applications for this type of services (Wang 2016).

Mobile social services are services combining different software and hardware, such as mobile networks, mobile devices, and various Apps, so that users can have social activities with others in real time (Smith 2005). Mobile social services are not restricted by time and place, and further they can be accessed simply via a mobile device linked to the Web. Therefore, compared to the conventional social services that use computers as a platform, the mobile social services are not only more convenient and real time in use, but also provide diversified ways of message expression (Deng et al. 2010; Gibbs 2008). Via mobile social services, users can update and share their mood and current location with others at any time and place, exchange or interact with others in real time, or search for the newest state of someone they are concerned about, so that an omnipresent social environment is realized (Schubert and Hampe 2006). In addition to the previously mentioned advantages, most of the currently available mobile social services are free for downloading and usage, making mobile social services gradually become popularized among users' interactive and message-exchanging behavior (Ogara et al. 2014).

Location-based services are services which provide users with personalized real-time information according to the place and timepoint specific to the users (Turban et al. 2009). These services allow the users to check at any time and place for all kinds of user-location-based information. For this purpose, the services will first detect geographic information of the current position of the users' handheld mobile device, and then provide users with user-location-based useful information that may

be recommendations inferred by recommender systems. Presently, LBS have been widely applied in different fields, such as emergency medical services, leisure and entertainment services, traffic information, advertisement and marketing, mobile commerce, and so on (Xu et al. 2009).

According to the three types of SoLoMo services mentioned above, this study aggregates the comparison of these services in Table 1.

2.2 Related research of SoLoMo service

In the literature, there were some studies exploring the technical phase of this new SoLoMo concept. For example, Zhou et al. (2014) used the k-Nearest Neighbors algorithm to calculate the distance between the locations of any two users, and then, recommendations of suitable potential friends were made according to the measured distance. Li et al. (2014) employed the concept of recommender systems to provide community members with information of local products based on the members' geographic locations.

Besides, there were many empirical studies to discuss users' intention or behavior of using SoLoMo services. For example, Nikou and Bouwman (2014) applied Unified Theory of Acceptance and Use of Technology (UTAUT) model and social influence concept to analyze the Chinese users' behavior toward adoption of mobile SNS. Zhou and Li (2014) conducted a research examining the continuance usage of mobile SNS in China by integrating both the perspectives of social influence and privacy concern. Lin and Liu (2012) also carried on an empirical research and argued that the intensity of SNS usage is affected by user's privacy concern, user's trust, and user's motivation. Gao and Bai (2014) developed a model

Table 1 The comparison of three SoLoMo service types

Service type	Main functions and applications	Examples of well-known services
Social network services	Personal blog	Facebook, Twitter, Google plus, Myspace
	News feed	
	Fan page	
	Multimedia content sharing	
	Find friends	
Mobile social services	Instant communication	WhatsApp, WeChat, LINE, SKOUT
	Multimedia content exchanging	
	Make new friends	
	Check in (share location)	
Location-based services	Identify a location of a person or object	Foursquare, Yelp, TripAdvisor, Airbnb
	Satellite navigation	
	Distance to destination calculated	
	Notification of local information pushed	
	Location-based transaction	

based on the IS success model, network externalities, and flow theory to identify the factors affecting mobile SNS users' continuance intention. Park et al. (2011) also conducted a research to analyze the factors affecting user satisfaction while using the instant messenger-based mobile SNS. Zhou et al. (2010) imported the IS success model and trust in their research framework to examine the influence of flow experience on users' loyalty toward mobile SNS. Furthermore, Heo and Kim (2016) developed a scale that consisted of 9 dimensions and 29 measurement items to measure the quality of mobile location-based services. Pura (2005) applied the theory of consumption value in analyzing the intention of adoption with regard to location-based services. Ho (2012) conducted a research to understand the effects of location personalization on individuals' usage intention to use location-based services. Aloudat et al. (2014) combined model's perceived service quality, perceived privacy concern, and technology acceptance to examine users' attitudinal and behavioral intention to use location-based mobile government services.

Furthermore, some research also applied MCDM methods to analyze users' choice or consideration toward adopting SoLoMo service. For example, Kim (2012) used AHP approach to assess the security risks of mobile social network service and found that the service providers' interception of data through unauthorized access is a serious risk for users. Nikou and Mezei (2013) applied AHP approach to identify the factors driving the consumers' adoption of mobile services and revealed that mobile communication services are the most preferred ones among other categories of services; furthermore, their results also indicated that the functionality of services is of the utmost importance to most consumers. Jozsef Mezei and Bouwman (2011) applied AHP approach to understand users' selection of mobile service category and showed that mobile communication services are the most important services for the majority of the consumers. Phan and Daim (2011) applied the AHP approach to find out the factors that influence the adoption of mobile services, and the results indicated that cost, service quality, and system speed are the top three influential factors. Kabir and Akhtar Hasin (2011) used the fuzzy AHP to elucidate the factors that affect the success of m-commerce service and demonstrated that content quality, system quality, and degree of personalization are three main attractive factors. Natarajan et al. (2010) used AHP approach to analyze consumers' choice criteria in using retail banking, and the results indicated that the mobile banking service is the next preferred channel for consumers. Lin (2013) also used fuzzy AHP to prioritize the criteria for m-banking service considered by low- and high-experience groups; the results indicated that the two groups are quite different in the criteria of accuracy, currency, relevance, reliability, and trustworthy while using the m-banking service.

Besides, many studies proposed hybrid decision model that combined diverse MCDM approaches to conduct research related to SoLoMo service adoption. For instance, Lin et al. (2012) combined ANP with DEMATEL to analyze the criteria affecting consumers' inclination in m-banking service and indicated that the convenient availability of information and the rapid system response are two critical criteria. Lin (2014) adopted MCDM model that combined ANP and DEMATEL approaches for determining the optimal alternative in promotion of m-banking service APP; the research indicated that focusing on service management and

ensuring safety of mobile transaction is the best solution. Lu et al. (2015) also combined ANP and DEMATEL to determine the influential criteria of m-banking services adoption for smartphone users; their result demonstrated that the Tech-facilitating conditions and the trust belief are critical criteria. Hu et al. (2015) proposed a fuzzy MCDM evaluation model that also combined ANP and DEMATEL with fuzzy technique to evaluate the mobile commerce (m-commerce) adoption for consumer needs; the results revealed that the proposed model could help companies in enhancing consumer trust toward m-commerce adoption. Table 2 summarizes the above-related research regarding SoLoMo service, which adopted MCDM approach.

2.3 Decision-making trial and evaluation laboratory

The DEMATEL approach was originated from the Geneva of the Battelle Memorial Institute in 1973. It effectively observes the levels of mutual influence among different factors and understands the complicated cause-and-effect relationship in the decision problem (Fontela and Gabus 1976). The analytic processes are described as follows.

Table 2 Summary of the related SoLoMo service research adopting MCDM approach

Research topic	Approach	References
Determining the influential criteria of m-banking services adoption for smartphone users	ANP and DEMATEL	Lu et al. (2015)
Evaluating the m-commerce adoption for consumer needs	Fuzzy ANP and DEMATEL	Hu et al. (2015)
Determining the optimal alternative in promotion of m-banking service APP	ANP and DEMATEL	Lin (2014)
Identifying the factors driving the consumers' adoption of mobile services	AHP	Nikou and Mezei (2013)
Prioritizing the criteria for m-banking service considered by different experience groups	Fuzzy AHP	Lin (2013)
Assessing the security risks of mobile social network service	AHP	Kim (2012)
Analyzing the criteria affecting consumers' inclination in m-banking service	AHP and DEMATEL	Lin et al. (2012)
Analyzing users' selection of mobile service category	AHP	Jozsef Mezei and Bouwman (2011)
Finding out the factors that influence the adoption of mobile services	AHP	Phan and Daim (2011)
Elucidating the factors that affect the success of m-commerce service	Fuzzy AHP	Kabir and Akhtar Hasin (2011)
Analyzing consumers' choice criteria in using retail banking	AHP	Natarajan et al. (2010)

- Define the correlation among evaluation factors. List the factors that may affect the decision-making problem through literature review or brainstorming, and interview with the domain experts to determine the correlation between any two factors.
- Establish direct relation matrix. As the decision problem has n evaluated factors, an $n \times n$ direct relation matrix showing the scores of influencing degree is established, which is presented as Z-matrix in formula (1). Element z_{ij} represents the degree by which the factor z_i affects factor z_j.

$$Z = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \ldots & C_n \end{array} \\ \begin{bmatrix} 0 & z_{12} & \ldots & z_{1n} \\ z_{21} & 0 & \ldots & z_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} & z_{n2} & \ldots & 0 \end{bmatrix} \end{array}. \tag{1}$$

- Calculate the prominence score. If z_{ij} is an element of matrix Z, where $i, j = 1,2, \ldots,n,$ the sum of the column and the row are denoted by D_i and R_j, respectively. Among them, D_i represents the sum of the factor i influencing other factors, R_j represents the sum of the factor j being affected by other factor, and $D_i + R_j$ represents the prominence degree of each factor in the decision-making problem.

Through DEMATEL approach, this approach is able to present the prominence of each evaluation factor in the decision problem and enable the decision maker to clearly understand what factors have mutual influences on one another. This is because, in the practical environment of decision problem, some less important factors in decision-making might have influence on the more important factors.

Further, as another function of DEMATEL, the direct relation among the evaluation factors as obtained from the analytic results can be used to plot a network structure of the evaluation framework to facilitate subsequent ANP analysis.

2.4 Analytic network process with fuzzy theory

The ANP approach was proposed by Saaty in 1996. It is a MCDM method that uses network and nonlinear structure to represent a decision problem (Saaty 2001), and is developed in response to the fact that many decision problems in the realistic environment that cannot be presented with the structured hierarchy (Saaty 1996). The main objective of ANP is to correct the traditional AHP, with which the problems of dependence and feedback might occur between the criteria or the layers (Chang et al. 2015). ANP can decompose a decision problem into multiple different types of dimensions, and each dimension can include multiple criteria (Saaty 2004). The dimensions and the criteria are correlated with one another to form a network map. In other words, before using ANP to measure the weights of the evaluation criteria, the network structure among all criteria must first be established. The evaluation network structure of ANP is shown in Fig. 1. In this structure, arrows are used to indicate their mutual influence (Wu 2008).

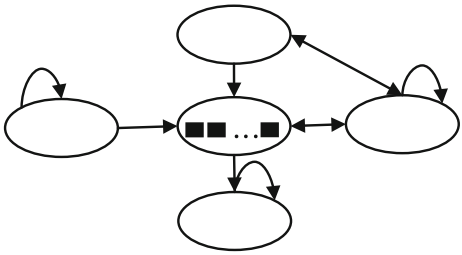

Fig. 1 Evaluation network structure of ANP

The ANP could help decision makers to find out what are the critical evaluation criteria in the complex decision problem. However, the decision of human always contains certain degree of ambiguity and vagueness; the related judgment would vary from person to person (Lin and Hsu 2011). In other words, decision makers have no clear boundaries when making decisions. Therefore, when decision makers decide the importance of criteria, the results may be biased (Tseng et al. 2008). For this reason, the combination of ANP with fuzzy theory would supplement the disadvantage of ambiguity on the two-criterion importance assessed by decision makers, and could more truly reflect the actual situation (Buckley 1985). The FANP analytic processes are described as follows.

- Conduct pairwise comparison: According to the evaluation network structure is built, adopt the 1–9 pairwise-comparison scale proposed by Saaty 2008a, b as shown in Table 3, to conduct pairwise comparison between every two criteria for the priority of each criterion. The frequency of comparisons required with n criteria is $n\ (n-1)/2$ (Shin et al. 2016).
- Build pairwise-comparison matrix: As shown in Eq. (2), on the upper triangular part of the pairwise-comparison matrix A, we place the evaluation score of the comparison result obtained by a participant. In this equation, a_{ij} represents the relative priority of criterion and i to criterion j.

$$A = \begin{bmatrix} 1 & a_{12} & .. & .. & a_{1j} \\ 1/a_{12} & 1 & . & . & a_{2j} \\ . & . & 1 & . & . \\ . & . & . & 1 & . \\ 1/a_{1j} & 1/a_{2j} & . & . & 1 \end{bmatrix}. \tag{2}$$

- Translate into triangular fuzzy numbers. Based on Table 3, we translate each score in the pairwise-comparison matrix into the triangular fuzzy numbers (F_{ij}), where $F_{ij} = (L_{ij}, M_{ij}, R_{ij})$ is the fuzzy number of criterion i to criterion j (Chiou et al. 2005).
- Calculate fuzzy weights. After getting n triangular fuzzy numbers of each participant, we can further obtain the overall triangular fuzzy numbers $F_i' = (L_i', M_i', R_i')$ of all criteria through the calculation of geometric mean. Finally, we calculate the triangular fuzzy weights (W_i) of each criterion, as shown in Eq. (3).

Table 3 Pairwise-comparison scale and the conversion of triangular fuzzy numbers

Scale	Definition	$F_{ij} = (L_{ij}, M_{ij}, R_{ij})$
1	Equal importance	$1' = (1, 1, 3)$
3	Moderate importance	$3' = (1, 3, 5)$
5	Strong importance	$5' = (3, 5, 7)$
7	Demonstrated importance	$7' = (5, 7, 9)$
9	Extreme importance	$9' = (7, 9, 9)$

$$W_i = (WL_i, +WM_i, +WR_{i)})/3 = [(L_i'/n + M_i'/n + R_i'/n)]/3. \tag{3}$$

- Normalization: The triangular fuzzy weights obtained in the previous step, it then needs to conduct normalization and obtain the final weight.
- Build the super-matrix. After getting all triangular fuzzy weights (W_i), we further put these weights into a super-matrix, as shown in Eq. (4).

$$W = \begin{bmatrix} W_{i_1 \; j_1} & W_{i_1 \; j_2} & \cdots & W_{i_1 \; j_n} \\ W_{i_2 \; j_1} & W_{i_2 \; j_2} & \cdots & W_{i_2 \; j_n} \\ \vdots & \vdots & \ddots & \vdots \\ W_{i_m \; j_1} & W_{i_m \; j_2} & \cdots & W_{i_m \; j_n} \end{bmatrix}. \tag{4}$$

- Prioritize each criterion. Through normalization of the super-matrix and complex matrix multiplication, a limit super-matrix containing the weights of the evaluation criteria can be obtained. According to these weights, the decision maker could sort the importance priority of each evaluation criterion in the decision problem.

3 Research methodology

The main purpose of this study is to analyze the priorities of critical factors that are evaluated by users in the decision of adopting SoLoMo services and further understand how users would choose when these factors are in conflict with privacy risk.

3.1 Research model

In this study, fuzzy AHP, DEMATEL, and fuzzy ANP are the three main decision-making analytic methods employed to conduct a three-step analysis as shown in Fig. 2. The three analytic steps are described as follows.

Step 1 In this study, based on the related literature and consultation with two experts, we proposed the dimensions and factors that users would normally consider while they decide to adopt SoLoMo services and established an evaluation hierarchical structure. Then, based on the hierarchical structure, we designed an AHP questionnaire and conducted a

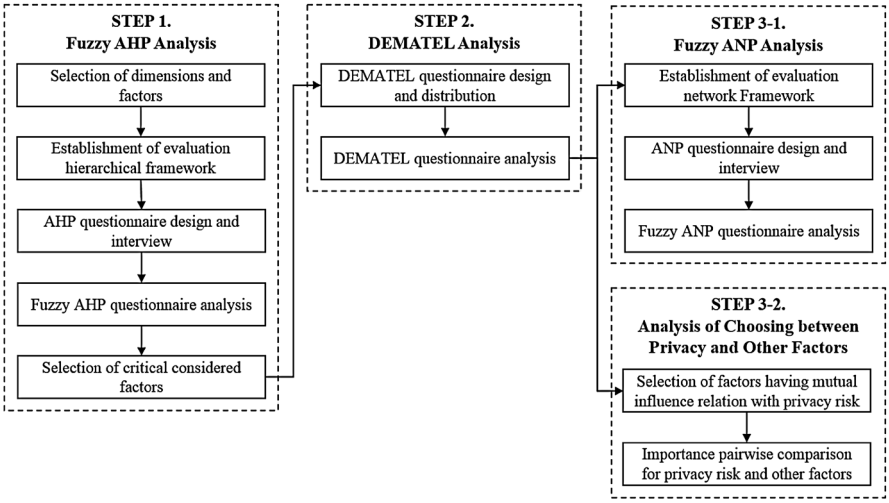

Fig. 2 Research model

questionnaire interview. Thereafter, we summarized the data obtained from all the interview questionnaires and used fuzzy AHP method to select the critical factors evaluated by users in adopting SoLoMo services.

Step 2 Based on the critical factors selected in the Step 1, we designed a DEMATEL questionnaire and conducted questionnaire distribution again. Then, we collected all the distributed questionnaires and applied the DEMATEL method to analyze the relation of mutual influence among different critical factors.

Step 3 The anlysis in the Step 3 includes two parts. In the first part, we used the relation of mutual influence among different critical factors found in the DEMATEL analysis to establish an evaluation network structure. Then, based on the network structure, we designed an ANP questionnaire and conducted a questionnaire interview. In the second part, again, based on the results from the DEMATEL analysis, we found out all critical factors that have mutual influence relation with privacy risk. We also conducted an importance pairwise comparison for these factors and privacy risk to understand how SoLoMo users would choose between the privacy risk factor and other critical factors while they have concerns about their privacy protection in adopting SoLoMo services.

4 Result analysis

4.1 Selection of dimensions and factors

SoLoMo services provide consumers with real-time location-based services and real-time social services in a manner completely different from the conventional service

provision manner that consumers had long been accustomed. In other words, SoLoMo services represent different aspects of values to consumers; the kinds of value of using SoLoMo services that the consumers can perceive is a critical issue for them to adopt these services (Zhao et al. 2011). Consumption value is the consumers' overall evaluation of the product/service utility based on perceptions of what is given and what is received (Zeithaml 1988). Sheth et al. (1991) classified the consumption values into five types, namely, functional, social, emotional, epistemic, and conditional values.

Regarding mobile services or technologies, Kim et al. (2013) indicated that there are three perceived values that would affect users' adoption of mobile technologies, including utilitarian, social, and hedonic values. Lin and Lu (2015) proposed that perceived mobile convenience, service compatibility, security risk, cognitive effort, and utilitarian and hedonic values would affect the users' intention toward the usage of mobile SNSs.

Therefore, referring to the classification of consumption value proposed by Sheth et al. (1991) and the fashion theory proposed by Miller et al. (1993), we divide the considered evaluation factors of consumers in using SoLoMo services into four value dimensions in accordance with the characteristics of SoLoMo services, namely, *"Functional Value,"* "*Fashionable Value,"* "*Social Value,"* and "*Mental Value."* Also, since SoLoMo services provide consumers with real-time location-based services connecting via wireless, some issues, e.g., the accuracy of information provided, the server availability, the quality and coverage of network connection, or even the cost and privacy/security of using the services, would be critical factors affecting users' adoption. Therefore, this study further added two dimensions, namely, *"System and Environment Quality"* and *"Cost and Risk Considerations,"* to the original four dimensions. Thus, there are totally six dimensions proposed in this study. Further, through literatures and consultation with two experts, we suggested appropriate factors under each evaluated dimension, and finally proposed 28 factors in total.

4.2 Establishment of evaluation hierarchical framework

The purpose of this study is to analyze and evaluate "critical factors, both positive and negative ones, evaluated by users in adopting SoLoMo services." In light of this purpose, we established an evaluation hierarchical structure based on the above proposed dimensions and factors. Figure 3 shows the evaluation hierarchical structure.

4.3 Participants interview and demographic analysis

Based on the evaluation hierarchical structure in Fig. 3, we further designed an AHP questionnaire and conducted interviews. The questionnaire participants were mainly users who had already been using SoLoMo services and had applied for 3/4G mobile Internet access. During the course of the questionnaire interviews, we visited fourteen organizations in Taiwan, including two universities and twelve enterprise businesses, and conducted interviews with twenty participants. The interviews were performed one-to-one with each participant; each interview lasted

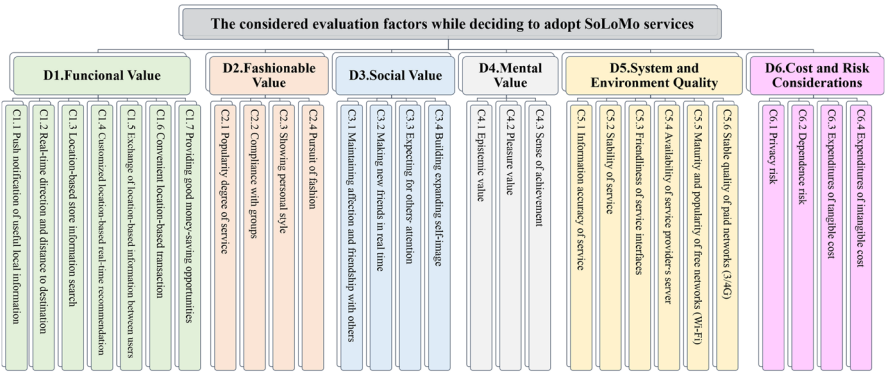

Fig. 3 Evaluation hierarchical structure

for 30–90 min. The detailed demographic information of these participants is shown in Table 4.

4.4 Fuzzy AHP analysis

The AHP questionnaire was designed in terms of the 1–9 pairwise-comparison scaling proposed by Saaty (2008a, b). Every participant was requested to make a pairwise comparison for all dimensions and factors. Regarding the questionnaire measurement, we tested the consistency index (*C.I.*) and consistency ratio (*C.R.*) values of every question, so as to ensure the consistency of every respondent's response to the questions. Saaty (1990) suggested that both the values of *C.I.* and *C.R.* should be greater than 0.1. Thus, if any question failed to pass the consistency test, the respondent would be requested to be interviewed once again, and we

Table 4 Demographic information of respondents

Profiles	Sample composition	Frequency
Gender	Male	12
	Female	8
Age	26–30	6
	31–35	8
	36–40	6
Educational background	Bachelor	6
	Master	12
	Doctor	2
Industrial classification	Military, public service, or academia	3
	Service industry	4
	Manufacturing industry	2
	Information industry	7
	Banking and insurance industry	1
	Healthcare industry	3

adjusted the scores accordingly. Each questionnaire is considered effective only when all the questions in the questionnaire passed the consistency test. After all the questionnaire scores had passed the consistency test, we further conducted the fuzzy AHP analysis to obtain the relative fuzzy weight of each factor. The analytic results are shown in Table 5.

Based on the fuzzy AHP analytic results, we tried to know further how the highly influential factors under different dimensions would mutually influence one another. For this purpose, under each dimension, we selected the factors that have relative fuzzy weights larger than a reference weight, which is obtained by dividing 1 by the total number of factors under the dimension, and conducted an analysis of the selected factors under all the dimensions using the DEMATEL method. For example, there are 7 factors under the dimension D1, and any factor under the dimension D1 has a relative fuzzy weight larger than 0.143, i.e., the quotient of dividing 1 by 7, will be selected at this stage for the mutual influence analysis. According to the aforesaid selection principle, totally 12 factors were selected for the analysis using DEMATEL, as shown in Table 6.

4.5 DEMATEL analysis

In this study, based on the selected factors through fuzzy AHP analysis, we further constructed a scoring matrix for finding the mutual relationship among the selected factors, and then used the scoring matrix as the questionnaire for the DEMATEL analysis. We invited the same participants, who had participated in the AHP questionnaire interview in the previous stage, to accept the DEMATEL questionnaire interview at this stage, so as to ensure the consistency of all factors in their relative importance and mutual influence relationships. The average length of interview for each questionnaire participant was 30 min. We adopted the 0–3 scaling proposed by Fontela and Gabus (1976) as the questionnaire scaling. The higher score represents a higher level of mutual influence between the factors.

According to the results from the DEMATEL questionnaire interview, we collected and summarized the feedback scores by all the interviewed participants and established a direct relation matrix accordingly, as shown in Table 7, to show the mutual influence among the factors. The scores s_{ij} in the matrix represent the influence level of factor i (in the row) on factor j (in the column). The higher the score, the higher would be the influence.

Further, based on the direct relation matrix of Table 7, each factor's total influential level (D_i), total influenced level (R_j), and prominence ($D_i + R_j$) can be obtained. When a prominence score is high, it means the factor has a relatively great overall influence on users in their use of SoLoMo services. After performing calculation based on Table 7, we obtained the factors' ranking based on prominence scores as shown in Table 8.

4.6 Fuzzy ANP analysis

According to the suggestion of Saaty (1990), 7 is the maximum number of factors that can be compared for achieving reasonable assurance of consistency. Other

Table 5 Relative fuzzy weights of evaluation factors

Dimension	Evaluation factor	Relative fuzzy weight	Priority
D1. Functional value (0.233)	C1.3 Location-based store information search service	0.258	1
	C1.6 Convenient location-based transaction	0.181	2
	C1.2 Real-time direction and distance to destination	0.160	3
	C1.4 Customized location-based real-time recommendation	0.138	4
	C1.5 Exchange of location-based information between users	0.111	5
	C1.7 Providing good money-saving opportunities	0.103	6
	C1.1 Push notification of useful local information	0.049	7
D2. Fashionable value (0.131)	C2.1 Popularity degree of service	0.497	1
	C2.2 Compliance with groups	0.199	2
	C2.4 Pursuit of fashion	0.187	3
	C2.3 Showing personal style	0.116	4
D3. Social value (0.208)	C3.1 Maintaining affection and friendship with others	0.411	1
	C3.2 Making new friends	0.325	2
	C3.3 Expecting for others' attention	0.143	3
	C3.4 Building expanding self-image	0.120	4
D4. Mental value (0.064)	C4.1 Epistemic value	0.505	1
	C4.2 Pleasure value	0.319	2
	C4.3 Sense of achievement	0.176	3
D5. System and environment quality (0.168)	C5.1 Information accuracy of service	0.355	1
	C5.6 Stable quality of paid networks (i.e., 3/4G)	0.223	2
	C5.3 Friendliness of interfaces	0.172	3
	C5.4 Availability of service server	0.129	4
	C5.2 Stability of service	0.081	5
	C5.5 Maturity and popularity of free networks (i.e., Wi-Fi)	0.040	6
D6. Cost and risk considerations (0.197)	C6.1 Privacy risk	0.536	1
	C6.3 Expenditures of tangible cost	0.264	2
	C6.4 Expenditures of intangible cost	0.111	3
	C6.2 Dependence risk	0.089	4

research also recommended that when carrying out pairwise comparisons, the number of factors under each dimension should be limited to be less than 7 in order to avoid excessive input requirements for decision maker, and to keep the results consistent and reliable (Zahedi 1986; Asahi et al. 1995). Thus, based on the

Table 6 Selection of critical factor for DEMATEL analysis

Dimension	Reference weight	Critical evaluation factor	Relative weight
D1	0.143	C1.3 Location-based store information search service	0.258
		C1.6 Convenient location-based transaction	0.181
		C1.2 Real-time direction and distance to destination	0.160
D2	0.250	C2.1 Popularity degree of service	0.497
D3	0.250	C3.1 Maintaining affection and friendship with others	0.411
		C3.2 Making new friends in real time	0.325
D4	0.333	C4.1 Epistemic value	0.505
D5	0.167	C5.1 Information accuracy of service	0.355
		C5.6 Stable quality of paid networks (3/4G)	0.223
		C5.3 Friendliness of service interfaces	0.172
D6	0.250	C6.1 Privacy risk	0.536
		C6.3 Expenditures of tangible cost	0.264

calculation results shown in Table 7, we set the threshold as 0.05 to limit the number of the compared factors. Further, we find out all the relations that show mutual influence scores larger than the threshold and used these relations as a basis to establish an evaluation network structure. Figure 4 shows the established evaluation network structure. In the illustrated evaluation network structure, every line indicates an existing relation, representing the factors at two ends of the line, which have a mutual influence relation between them.

Based on the evaluation network structure shown in Fig. 4, we further designed an ANP questionnaire and conducted a questionnaire interview. The same twenty persons, who had participated in the questionnaire interviews conducted in the previous two stages, were also the participants of the ANP questionnaire interview, in order to ensure the consistency in the analytic results. The average length of interview for each questionnaire participant was 30 min, although the longest was more than 1 h. We adopted the 1–9 pairwise-comparison scaling proposed by Saaty (2008a, b) as our questionnaire scaling. For example, if C1.2 is used as a basis of evaluation factor to conduct a pairwise comparison among C5.1, C5.3, C5.6, and C6.1, the pattern of question adopted is shown in Table 9.

After conducting the consistency test of each question, we performed fuzzy ANP analysis on the collected ANP questionnaires. Then, every evaluation factor in the questions obtained an eigenvalue. The eigenvalues obtained from the questions were put into a super-matrix and the super-matrix is normalized, so that each column in the super-matrix has a sum of 1. Table 10 shows the normalized super-matrix.

Through multiple times of matrix multiplication performed on the normalized super-matrix of Table 10, the eigenvalues in each row were made to converge to the same value to obtain a limited super-matrix, as shown in Table 11. In the limited super-matrix, the value in each row is also the importance weight of the evaluation factor of that row in the evaluation.

Table 7 Direct relation matrix describing mutual influence among factors

Critical factor	C1.3 Location-based store information search	C1.6 Convenient location-based transaction	C1.2 Real-time Direction and distance to destination	C2.1 Popularity degree of service	C3.1 Maintaining affection and friendship with others	C3.2 Making new friends in real time	C4.1 Epistemic value
C1.3	0.000	0.000	0.000	0.144	0.000	0.000	0.000
C1.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C1.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C2.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C3.1	0.000	0.000	0.000	0.076	0.000	0.000	0.000
C3.2	0.000	0.000	0.032	0.208	0.000	0.000	0.000
C4.1	0.008	0.048	0.016	0.160	0.000	0.080	0.000
C5.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C5.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C5.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C6.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C6.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R_j	0.008	0.048	0.048	0.588	0.000	0.080	0.000

Critical factor	C5.1 Information accuracy of service	C5.6 Stable quality of paid networks (3/4G)	C5.3 Friendliness of service interfaces	C6.1 Privacy risk	C6.3 Expenditures of Tangible cost	D_i
C1.3	0.240	0.140	0.080	0.088	0.000	0.692
C1.6	0.148	0.196	0.084	0.220	0.124	0.772
C1.2	0.208	0.100	0.076	0.060	0.000	0.444
C2.1	0.092	0.000	0.136	0.000	0.000	0.228
C3.1	0.040	0.164	0.048	0.116	0.000	0.444
C3.2	0.148	0.128	0.088	0.212	0.000	0.816
C4.1	0.024	0.040	0.180	0.040	0.056	0.652

Table 7 continued

Critical factor	C5.1 Information accuracy of service	C5.6 Stable quality of paid networks (3/4G)	C5.3 Friendliness of service interfaces	C6.1 Privacy risk	C6.3 Expenditures of Tangible cost	D_i
C5.1	0.000	0.000	0.000	0.160	0.000	0.160
C5.6	0.000	0.000	0.000	0.000	0.088	0.088
C5.3	0.000	0.000	0.000	0.000	0.008	0.008
C6.1	0.000	0.000	0.000	0.000	0.000	0.000
C6.3	0.000	0.000	0.000	0.000	0.000	0.000
R_j	0.900	0.768	0.692	0.896	0.276	

Table 8 Prominence of evaluation factor

Critical evaluation factor	D_i	R_i	Prominence
C5.1 Information accuracy of service	0.160	0.900	1.060
C6.1 Privacy risk	0.000	0.896	0.896
C3.2 Making new friends in real time	0.816	0.080	0.896
C5.6 Stable quality of paid networks (3/4G)	0.088	0.768	0.856
C1.6 Convenient location-based transaction	0.772	0.048	0.820
C2.1 Popularity degree of service	0.228	0.588	0.816
C1.3 Location-based store information search	0.692	0.008	0.700
C5.3 Friendliness of service interfaces	0.008	0.692	0.700
C4.1 Epistemic value	0.652	0.000	0.652
C1.2 Real-time direction and distance to destination	0.444	0.048	0.492
C3.1 Maintaining affection and friendship with others	0.444	0.000	0.444
C6.3 Expenditures of tangible cost	0.000	0.276	0.276

After getting the weights and the priority of critical evaluation factors through the limited super-matrix from Table 11, we found factors "C2.1 popularity degree of service" (0.146), "C5.1 information accuracy of service" (0.136), "C6.1 privacy risk" (0.110), "C3.1 maintaining affection and friendship with others" (0.091), and "C1.3 location-based store information search" (0.078) are the top five among these critical positive and negative factors considered by users while adopting SoLoMo services. A subtotal of the weights of these five factors exceeds 50 % of the total absolute weight, indicating that these five factors are highly influential on users' decisions.

4.7 Analysis of choosing between privacy risk and other critical factors

Users need to provide more kinds of private information to service providers in order to enjoy various kinds of more accurate and instant SoLoMo services. Therefore, privacy issues might have very huge influence on the future development and even the popularization of SoLoMo services. Therefore, in this study, we also used the DEMATEL method to analyze which factors with higher importance level have direct relations with privacy risk when considering the adoption of SoLoMo services, and how users will choose when weighing these factors against privacy risk.

Thus, we further used the direct relation matrix of Table 7 to locate seven critical factors that have higher mutual influence (i.e., the mutual influence score larger than 0.05) with the privacy risk. Then, we invited the same participants, who had been interviewed in the previous two analytic stages, to make a pairwise comparison of privacy risk and these critical factors and conduct fuzzy AHP analysis, in order to further understand the level of users' concerns about privacy risk when they adopt SoLoMo services. The analytic results are shown in Table 12.

According to the analytical results of Table 12, "C5.1 information accuracy of service" (0.173), "C1.3 location-based store information search" (0.167), and

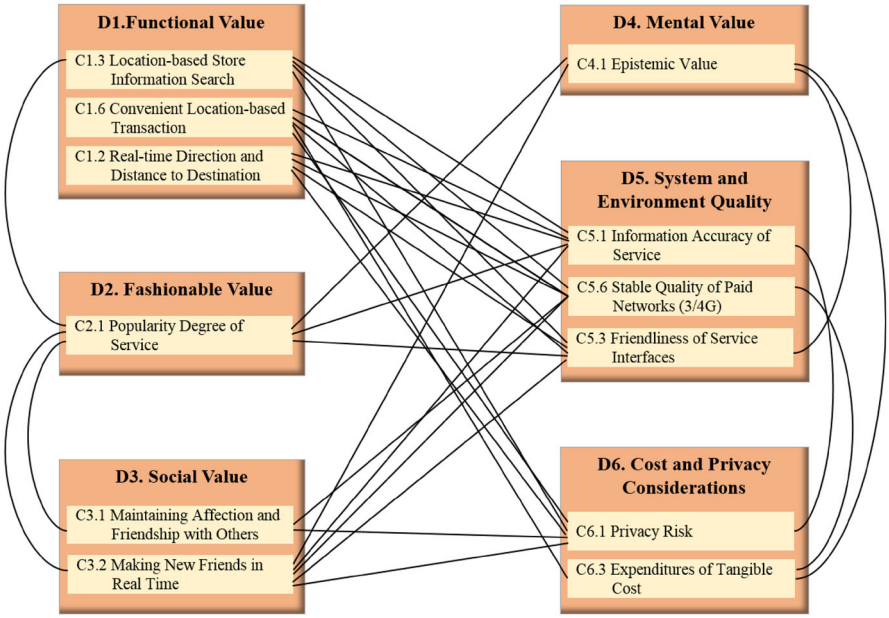

Fig. 4 Evaluation network framework

Table 9 An example of pairwise comparison in the ANP questionnaire

Important < ——— Equal ——— > Important										
Scale	9:1	7:1	5:1	3:1	1:1	1:3	1:5	1:7	1:9	Scale
C5.1	–	–	–	–	–	–	–	–	–	C5.3
C5.1	–	–	–	–	–	–	–	–	–	C5.6
C5.1	–	–	–	–	–	–	–	–	–	C6.1
C5.3	–	–	–	–	–	–	–	–	–	C5.6
C5.3	–	–	–	–	–	–	–	–	–	C6.1
C5.6	–	–	–	–	–	–	–	–	–	C6.1

"C3.1 maintaining affection and friendship with others" (0.161) are three critical factors evaluated by SoLoMo service users more important than "C6.1 privacy risk" (0.150). In other words, in order to obtain highly accurate information, store information search service and social interaction service, users are willing to provide more personal privacy-related information to SoLoMo service providers to receive and enjoy improved high-quality services.

5 Conclusions and future work

SoLoMo services are emerging mobile services, which combine different software and hardware techniques, enabling users to obtain location-based information at any time and place as well as exchange, interact, and communicate messages with other

Table 10 The normalized super-matrix

Critical evaluation factor	C1.2	C1.3	C1.6	C2.1	C3.1	C3.2	C4.1	C5.1	C5.3	C5.6	C6.1	C6.3
C1.2	0.129	0.143	0.141	0.000	0.000	0.000	0.000	0.115	0.094	0.131	0.102	0.000
C1.3	0.216	0.203	0.227	0.084	0.000	0.000	0.000	0.051	0.061	0.017	0.046	0.000
C1.6	0.155	0.154	0.132	0.000	0.000	0.000	0.000	0.077	0.109	0.049	0.048	0.359
C2.1	0.000	0.131	0.000	0.500	0.260	0.144	0.191	0.091	0.109	0.000	0.000	0.000
C3.1	0.000	0.000	0.000	0.090	0.268	0.289	0.000	0.000	0.000	0.211	0.156	0.000
C3.2	0.000	0.000	0.000	0.080	0.232	0.211	0.138	0.067	0.027	0.021	0.049	0.000
C4.1	0.000	0.000	0.000	0.062	0.000	0.076	0.500	0.000	0.100	0.000	0.000	0.071
C5.1	0.187	0.160	0.103	0.114	0.000	0.089	0.000	0.237	0.256	0.263	0.098	0.000
C5.3	0.136	0.021	0.031	0.071	0.086	0.017	0.110	0.111	0.092	0.111	0.000	0.000
C5.6	0.061	0.087	0.140	0.000	0.057	0.046	0.000	0.152	0.152	0.126	0.000	0.070
C6.1	0.116	0.100	0.176	0.000	0.096	0.127	0.000	0.099	0.000	0.000	0.342	0.365
C6.3	0.000	0.000	0.050	0.000	0.000	0.000	0.061	0.000	0.000	0.072	0.158	0.135
Sum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 11 The limited super-matrix

Critical evaluation factor	C1.2	C1.3	C1.6	C2.1	C3.1	C3.2	C4.1	C5.1	C5.3	C5.6	C6.1	C6.3	Priority
C1.2	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	6
C1.3	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.078	5
C1.6	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	9
C2.1	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	0.146	1
C3.1	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	4
C3.2	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	7
C4.1	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	11
C5.1	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	2
C5.3	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	10
C5.6	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	8
C6.1	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	3
C6.3	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	12
Sum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	–

Table 12 Priority of privacy risk and other critical factors

Privacy risk and other critical factors	Relative weight	Priority
C5.1 Information accuracy of service	0.173	1
C1.3 Location-based store information search	0.167	2
C3.1 Maintaining affection and friendship with others	0.161	3
C6.1 Privacy risk	0.150	4
C3.2 Making new friends in real time	0.139	5
C1.2 Real-time direction and distance to destination	0.112	6
C1.6 Convenient location-based transaction	0.098	7

people in real time. Since SoLoMo provide users with different types of application services, users having different needs would have different considerations and expectations while adopting these services.

This study conducted a research from an angle of considering the complete range of SoLoMo services and applied the hybrid fuzzy MCDM method to find out what are the critical factors, both positive and negative ones, as evaluated by users while adopting SoLoMo services. In addition, since the use of SoLoMo services will involve a large quantity of personal private data, we also explored how SoLoMo service users make tradeoff decisions between the privacy risk and other important factors.

5.1 Implications for academia

The following are the contributions to academia from this study. First, we proposed a three-stage hybrid fuzzy MCDM model for analyzing the influencing factors of SoLoMo users. According to the analytic procedures of this model, we first applied fuzzy AHP method to find out the critical factors considered important by SoLoMo users and delete factors that have lower influence on the objectives of decision making. By doing so, the interview can avoid the bias in participants' answers due to too many related decision factors, and thus it is able to reduce the possibility of incorrect analytic results so caused. Then, the DEMATEL method is used in the second stage to establish the mutual influence relation among all critical factors for use as a basis of fuzzy ANP analysis to be used in the third stage. Further, the importance of weights and the priorities of all critical factors found from the fuzzy ANP analysis can also be compared with the results from the fuzzy AHP analysis.

Second, combining the consumption value theory, the fashion theory, and information system practices, we proposed six dimensions of evaluation factors for the decision of SoLoMo service adoption. The evaluation dimensions established in this study can be applied in other new types of IT services to analyze and study consumers' intention to adopt the new IT services, such as the consumers' intention to use mobile commerce, and in-App purchase,.

Third, while currently there are some studies focusing on users' intention or behavior in using location-based services and social mobile services, there is almost no study that analyzes the factors evaluated by users while deciding to adopt SoLoMo services. This study according to our best of knowledge might be the first

study that applies the methods of decision science to analyze these critical evaluation factors.

5.2 Implications for practice

This study also has several practical implications for SoLoMo service providers by drawing their attentions to some specific factors that might encourage consumers to use or deter consumers from using SoLoMo services. The priorities of influencing factors also have important implications for the government in the formulation of telecommunication policy.

First, according to the fuzzy AHP results as shown in Table 5, it can be found that the two dimensions of functional value (D1) and social value (D3) of SoLoMo services are the most important to users. These results are actually anticipatable. Since SoLoMo services are integrated services that combined two major features, namely, location based and mobile social, users would first be attracted by the functional and social features provided by SoLoMo services and then further consider whether to adopt the services. In view of this fact, it is suggested that SoLoMo service providers should understand more about the motivations and real needs of users to use SoLoMo services and take users' motivations and real needs as a reference and basis for developing SoLoMo-related Apps[3]. Furthermore, service providers should also note the higher prioritized evaluation factors in each dimension Table 5. For example, "location-based store information search" (C1.3) is the most important in functional value (D1); "maintaining affection and friendship with others" (C3.1) is the most important in social value (D3).

Second, the direct relation matrix obtained via the DEMATEL analysis (Table 7) as well as the prominence score of each factor (Table 8) provides us useful insights on the mutual influences among the factors. It is found that three factors, "information accuracy of service" (C5.1), "privacy risk" (C6.1), "stable quality of paid networks (i.e., 3/4G)" (C5.6) have higher total influenced scores (scores *R*). That is, many other factors would need these architecture supports: good system and environment quality as well as stable mobile Internet connection, and a complete private information-protection mechanism, for users to use these services/functions without concerns. On the other hand, two factors, "making new friends in real time" (C3.2) and "convenient location-based transaction" (C1.6), have higher total influential scores (scores *D*). That is, there are many pre-conditions for achieving satisfactory levels of these two functions, e.g., friendly interface, high information accuracy, etc.

Third, the analysis results in Table 11 indicate that "service popularity degree" (C2.1) is a factor that is highly important and has decisive influence on users in their adoption of SoLoMo services. Presently, more and more location-based services and mobile social services have been developed. Therefore, when searching app stores for SoLoMo-related Apps, users would often check the rating, comments, or feedback given by other users to the interested Apps or check the Apps' download statistics as reference to decide the use of those Apps. In view of this fact, it is suggested that the SoLoMo service providers should create their specific app fans pages on different social networking sites, such as Facebook, Google Plus, and so

on. Alternatively, SoLoMo service providers can create an app official account on LINE, WeChat, and so on to provide a social networking platform, on which users can share and exchange their usage experiences. By taking advantage of the powerful propagation potential of online communities, different Apps might become famous and get numerous users soon.

Furthermore, according to the analytic results in Table 11, in addition to the above important factors, "information accuracy" (C5.1) is another crucial factor to users when they consider the adoption of SoLoMo services. In other words, the ability of various kinds of SoLoMo services/Apps to provide users with up-to-date and most accurate information forms an extremely important factor that encourages users' willingness to use the services. However, "privacy risk" (C6.1) is the tradeoff factor that comes together with the requirement of information accuracy. In view of the fact that privacy risk is a great concern to users when they consider the adoption of SoLoMo services, this study also analyzed how the users make their choice after they have weighed between the privacy consideration and other critical factors that directly have mutual influence with the privacy risk. The analysis results in Table 12 indicate that users are willing to undertake the possible privacy risk from using SoLoMo services if the services can provide them with the up-to-date and most accurate information. However, some warning words should be given to service providers: the above analytic results do not mean that users can completely ignore the privacy risk just to get required information via SoLoMo services.

Currently, in order to provide accurate information that meets users' instant requirements or needs, it necessitates the SoLoMo service providers to collect more kinds of personal private information from the users. For this purpose, many SoLoMo services/Apps would request to access a lot of personal private data from the users' mobile devices in the process of installing these Apps, such as users' location, consumption habits records, and directories of mobile devices, some of which might be unnecessary for the current operation of services. Many users are even unaware of the leakage of their privacy-related messages during the usage of these Apps. This situation will inevitably reduce users' trust in SoLoMo service providers or even cause users to abandon the use of SoLoMo services/Apps as well as the convenience brought by such services/Apps. In general, users' concerns about privacy protection vary from person to person. Even for the same user, his/her willingness to give permission to the access of his/her private information will change in different usage situations. Therefore, SoLoMo service providers should respect user's personal privacy and allow users to selectively permit or deny SoLoMo service providers' requests for accessing their private information when they use the services. If possible, such opt-in/opt-out should be flexible depending on users' own needs in different usage contexts. Furthermore, government legislation is also needed to prescribe the whole procedure of collection, storage, protection, and reuse of the privacy data. In other words, only the SoLoMo services/Apps that can provide users with up-to-date and most accurate information as well as a complete privacy protection mechanism can obtain users' acceptance and adoption.

Fourth, from the analytic results of Table 11, we also find "maintaining affection and friendship with others" (C3.1) and "location-based store information search" (C1.3) as two major functions of SoLoMo services that receive the highest attention from users and are the most widely used by users. Besides, from the analysis of choosing between privacy risk and other critical factors (see Table 12), it is also found users are willing to undertake the possible risk from personal private information leakage and exposure in exchange for the ubiquitous convenience and sociability brought by the above-mentioned two service functions. This finding indicates the high importance of these two functions of SoLoMo services. Since these two major functions of SoLoMo services can provide users with location-based and real-time information search service and social service, presently, more and more consumers use SoLoMo services as a tool to search for user-interested local stores and restaurants, to contact family members and friends, and to share information with others. In view of this fact, SoLoMo service providers can cooperate with all kinds of stores to ensure high information richness when users use SoLoMo services to search for stores or restaurants. Further, when developing location-based app services, SoLoMo service providers can also closely associate these location-based App services with the mobile social-related App services, so that users can share their feelings experienced in the course of dining or shopping with others in real time, which also creates a helpful advertising effect for the stores.

5.3 Limitations and future work

Despite the meaningful findings of this study, there are several limitations, yet that future research should further address. First, the analytic results from this study indicate that users of different ages or occupations are different in their usages of and needs for SoLoMo services. However, the number of participants of the questionnaire interviews conducted in this study is only twenty, which means the sample size for the questionnaires is too small to divide the participants into different groups for analysis and comparison. In future studies, questionnaire interviews can be conducted for different user groups to compare and find whether there is any difference among different consumer groups in their evaluation factors while adopting SoLoMo services.

Besides, the privacy issue is a big challenge to the popularization of SoLoMo services. This study also proves that privacy risk is indeed a great concern among users in using SoLoMo services. However, there are many different types of private information: personal private data, personal location, dating relationship, etc. Users' perceived privacy risk levels and users' willingness to disclose private information may vary with the types of private information. Therefore, future studies can particularly focus on the privacy issues to analyze the antecedent factors that possibly cause privacy risks in using SoLoMo services.

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