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RESEARCH ARTICLE

A Customer-Driven Evaluation Method for Service Innovation in Banking

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ABSTRACT In the era of fierce competition under the evolution of advanced technologies, service innovation plays a decisive role in the survival of organizations. The service innovation evaluation problem becomes necessary for organizations to review their innovation performances for making according policies to develop innovative services to satisfy customer needs. This paper addresses the problem by developing a new methodology for evaluation of service innovation in banking organizations from the customer perspective. As service innovation is typically characterised by multiple indicators that are qualitative in nature with their performance being assessed subjectively by customers, we first formulate the evaluation problem of service innovation using customer surveys as that of multi-criteria decision making under uncertainty and then develop an evaluation model based on the evidential reasoning approach by means of Dempster-Shafer theory of evidence for solving it. We conducted an empirical study of three banks in Vietnam to illustrate the effectiveness and applicability of the proposed methodology. It has been shown that the evaluation outcome could provide banks with their competitive advantages compared with competitors in terms of service innovation.

INDEX TERMS Service innovation, banking, customer-driven evaluation, evidential reasoning, multi-criteria analysis.

I. INTRODUCTION

Under the increasingly competitive pressure, the evolution of new technologies, along with high volatility in customer demands for new values in their daily consumed services, service innovation (SI) has emerged as a sustainable development strategy of organizations, aiming to generate new values of services by redesigning or improving services or methods in innovative ways in response to varied customer demands and lead to customer satisfaction [1], [2], [3], [4], [5]. SI benefits organizations by building satisfied customers [6], [7]. SI was found to be a factor influencing customer choices in the hotel and leisure industry [8]. In the banking sector, SI gains an essential ground for banks to provide better and differentiated services to their customers, achieve competitive advantages, maximize profitability, and continuously survive in this dynamic industry [9]. Since banks almost offer similar core services such as deposits, loans, money transfers, international payment, electronic banking; therefore, to effectively compete and grow, banks strive to innovate their services to produce unique solutions and offer innovative services different from competitors in order to retain existing customers as well as attract new customers. In today's highly technological world, banks are not left out of the technological applications of new technologies such as machine learning, blockchain, artificial intelligence (AI), and

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big data, and have been progressively investing in information management systems, information and communications technologies, or cooperation with Fintech companies to accelerate SI to serve customers faster and better, enhance operational efficiency, and increase fragility, security, and transparency [9], [10], [11], [12], [13], [14]. Once customers are satisfied with services that a bank offers, they will be loyal to using the bank's services as well as give positive feedback to others, and therefore help the bank acquire new customers easily at a low cost. Because customers are final consumers of innovative services, they will be the ones who can contribute valuable assessments for banks to boost the performance of SI. In addition, customer interaction was claimed to play an crucial role in SI processes by acting as catalysts, providing decisive feedback and contributing to internal marketing of the new service ideas in financial, cleaning and security, and information and communications technologies services [15]. Thus, in this study, we tend to rely on customers' perspective to evaluate SI. The understanding of customer perceptions on the performance and the importance of SI attributes as well as SI levels relative to competitors is necessary for banks to determine how best they are in offering innovative services to customers, know their strengths and weaknesses, and thereby effectively formulate corresponding innovation strategies to better develop, launch and deliver new services around customer needs in order to ultimately satisfy customers, promote the branding image of the banks in customers' mind, and achieve sustainable growth.

Although there have been a certain number of studies carried out to investigate innovations in service sectors, it is observed that the field of SI is less investigated than product innovation, and therefore more research on SI is needed [16]. In the literature, various studies for evaluating SI have been proposed from customers' perspective, but mainly focused on testing the relationship between SI and related variables such as customer satisfaction, customer loyalty, and customer co-creation. The list of these studies is presented in section II-C. In the banking context, some studies have been conducted to investigate SI [9], [17]; however, Yusheng and Ibrahim [9] claimed that research on innovation in financial services has not yet received massive attention compared with other sectors. Especially, analysis in SI research still lacks SI level evaluation problems, particularly from customers' perspective for banking services. Therefore, customer assessments and their preferences of SI in banking are still in question.

This paper aims to fill the gap in SI literature by developing a new evaluation method for SI in banking using customer surveys. To this end, we first identify the main indicators of SI based on the literature survey and formulate the problem of SI evaluation using customers' assessments as that of multiple attribute decision making under uncertainty. Due to the qualitative nature of SI indicators and difference in their experience with service usage, customers' judgement on SI indicators are unavoidably associated with uncertainty and ignorance. Then, we therefore adopt the evidential reasoning approach [18], [19] that can appropriately handle the uncertainty and ignorance in subjective human judgments in multiple attribute decision making to develop an evaluation method for SI of banking institutions. The proposed method is applied to a case study of three banks in Vietnam where there is still nascent research into SI evaluation in the banking context. For this point, this study also contributes to fill a contextual gap in the literature as research on SI are heavily biased to data originating in developed economies [20], meaning SI in developing economies like Vietnam are still understudied. Practically the findings of this study will serve as a useful tool for bank managers to review the performance of SI indicators following customer judgments, recognize important innovations in banking services proposed by customers, and then can decide on which innovations should be prioritized to upgrade in order to leverage their rankings regarding SI in customer perceptions.

The remainder of this paper is structured as follows. Section II reviews theories of SI, SI in banking industry and related works in SI. Section III presents preliminaries including basics of the Dempster–Shafer theory of evidence and questionnaire design used for data collection. Section IV provides the proposed methodology for evaluation of SI in banking from customers' perspective, and then the empirical results of using our SI evaluation method in the case study of three banks in Vietnam are presented in Section V. Finally, Section VI wraps up the paper with conclusions and points out limitations as well as suggestions for future research.

II. LITERATURE REVIEW

A. SERVICE INNOVATION

Today, the concept of ''innovation'' is widely discussed in academic studies and practical situations though there seems to be some differences in its definitions. Innovation was interpreted as purposeful and organized changes in business practices that might bring new opportunities for enhancing economic and social benefits [21]. Du Plessis [22] referred innovation as the application of new ideas and knowledge to generate new products/services and processes to upgrade business outcomes. In the same line with Du Plessis, Love et al. [23] briefly considered innovation as the commercialization of new knowledge. Similarly, Straub [24] argued that innovation is the successful development of new, improved, or more competitive products/services or organizational structures. In addition, Ferreira et al. [25] claimed that innovation is the designing and launching of new products, processes, and systems to meet the changes in technologies and competing markets. Generally, innovation can be defined as the changes in business processes to design new or significantly improved products/services in order to increase business performance. Innovation includes a variety of types; for example, product innovation, SI, process innovation, architectural innovation, management innovation, organizational innovation, and external relational innovation [26], [27].

This study clarifies the definitions of SI and its measurement. In the dynamic economy today, SI has become

a mainstay across service sectors for enhancing customers' satisfaction and loyalty by fulfilling their needs in a more valuable and profitable manner, keeping a company's competitive advantage, ensuring long-term business performance, and creating economic growth [4], [16], [28], [29], [30], [31]. Table 1 shows various definitions of SI. In general, SI can be defined as a process of adopting new service concepts, new processes of delivering services, or new technologies to provide customers with new values.

It is suggested from the existing literature suggests that the definitions of SI are quite diverse, which implies that the measures for SI are context-dependent to reflect the nature of the investigated service. Kiani et al. committed that there are significant differences among different service sectors in conceptualizing and implementing SI activities [16]. It is also revealed that the conception of SI varies from country to country depending on different cultural environments [40]. Besides that, because there are different stakeholders involved in the process of designing service concepts and delivering services [41], the measurement of SI may also vary depending upon different evaluation perspectives; for instance, from managers' or customers' perspectives. Depending on the understanding and information that evaluators have about SI, the constructs and their measurement items for SI may change. SI was assessed by managers in service firms in US and Indian [31] based on the extent to which a service is new to the company, allows the company to enter a new market, creates a new product line for the company, is new to the market, offers new features and competitive products, requires changes in the customer's buying behavior. Hertog et al. [29] proposed a conceptual framework for managing SI measured with six dimensions of service concept, customer interaction, value system, revenue model, organizational delivery system, and technological delivery system with the final goal of creating new service experiences and service solutions to bring customers new values. These dimensions were adopted in [16] to measure SI in Pakistani cellular companies using self-administered questionnaire survey done by 312 middle managers of five cellular companies in Pakistan. For several SI measures reflected by managers, customers might lack the relevant internal information and therefore find it difficult to assess them. Therefore, the other research measuring SI under customers' perspective has applied different measurement constructs. In the research of Su about SI in ethnic restaurant in Taiwan [42], customer perceptions of SI were measured by servicescape, service delivery, and product combination. Chang and Lee [43] measured SI in Taiwanese insurance sector in four aspects: service concept, client interface, service delivery system, and technology options under customers' perspective. Similarly, in the study of Mahmoud et al. [44] about the associations between SI, customer value creation, and customer satisfaction in the telecommunication sector, SI is rated in terms of three dimensions, new service concept innovation, new service process innovation, and new technological system innovation. Edvardsson [45] also stated that service development process focuses on developing service concept, service system, and service process. In practice, a service company can innovate every single dimension or a combination of the several dimensions as above mentioned. However, the significance of the dimensions will vary across service sectors.

B. SI IN BANKING INDUSTRY

The expansion of advanced technologies from the industrial revolution 4.0 has been profoundly changing the activities of the banking industry in general, especially the development and delivery process of banking services in particular. As technologies are widely used in life today, customers become proficient in using technological devices such as computers and smartphones, continuously seeks for new value experiences, prefer personalized products/services, and easily switch banks. The popularity of internet banking, mobile banking, robots and self-service technologies in the banking industry, especially under the outbreak of the Covid-19 in early 2020 when no close contact is required to prevent the spread of the virus [46], has made the competitive advantages of banks no longer defined by physical presence of branches, but by technological strength, diversity, flexibility, ease of use, and convenience of banking services. Therefore, banks need to strengthen the exploitation of new technology applications to modernize, innovate, and customize their services according to customer demands to bring greater experiences to customers, retain existing customers, and attract new customers in order to attain long-term success and sustainable development [12], [47].

Digital banking has emerged as a prominent development trend in the banking industry when a wide range of financial transactions and banking operations can be performed online through technological devices, especially under the competition from non-banking financial institutions and Fintech companies. By the end of 2020, there were about 256 digital banks worldwide, an increase of 4 times compared to 2018 [48]. Banks continuously launch new digital banking versions to spread their networks in the areas of deposits, withdrawals, and other activities, which results in a positive effect on financial inclusion [49], [50]. New technologies including big data, artificial intelligence, robotic process automation, biometric technology, and blockchain have also been commonly applied to reform existing banking services and operations. Banks successfully apply big data to smartly analyze a very large data set and quickly extract useful information about customers' habits and consumption patterns from various sources such as credit transactions, debit transactions in order to create customer profiling, promote product cross selling, detecting risks and frauds, and much more [51]. Other operations such as customer consultation and service instruction are also automated using AI or robot technology [46], which helps to reduce human labor, reduce costs, enrich user experience, and actively support the modernization and digitization of banks. Biometric technology

TABLE 1. Definitions of SI.

Author	Definition
Oke (2007) [32]	"New developments in activities undertaken to deliver core service products for various reasons, e.g. to make those core service products more attractive to consumers."
Cheng and Krumwiede (2010) [33]	"Fundamental change in services that represent revolutionary changes in technology or service benefits."
Ordanini and Parasuraman (2010) [34]	"Offering not previously available to the firm's customers—either an addition to the current service mix or a change in the service delivery process."
Enz (2012) [35]	"The introduction of novel ideas that focus on services that provides new ways of delivering a benefit, new service concepts, or new service business models through continuous operational improvement, technology, investment in employee performance, or management of the customer experience."
Thakur and Hale (2013) [31]	"New services and/or new ways of delivering services"
Breunig et al. (2014) [36]	"New service experience or service solution that consists of one or several of the following dimensions: a new service concept, new customer interaction, new value system/business partners, new revenue mode or new organizational or technological service delivery system"
Tajeddini and Trueman (2014) [37]	"The adoption of new concepts, processes, or technologies to provide customers superior products or services to satisfy the changing customer needs, and thereby sustain organizational competitive advantages."
Skålén et al. (2015) [38]	"The creation of new value propositions by means of developing existing or creating new practices and/or resources, or by means of integrating practices and resources in new ways."
Ndubisi et al. (2020) [39]	"The development of new processes, technologies, products, and services that meet market preferences."
Woo et al. (2021) [4]	"Customer-oriented activities aimed at providing new value and benefit to customers through technology, and promoting cooperation between the firm and its customers."

is increasingly adopted by banks as the sole reliable means to authenticate customers to ensure security, prevent fraud, and reduce risk in online transactions [52]. In addition, blockchain technology is considered an emerging technology that is highly resistant to fraud and thereby increases security and transparency in banking operations [10]; therefore, it has been increasingly used by banks in payment services, money transfers, trade finance, or identifying and verifying the client's identity. In addition, cooperation with Fintech companies is becoming an emerging trend in the banking sector. This strategic partnership will help take advantage of both sides. While banks have the upper hand in understanding core banking services, owning customer relationships, and maintaining trust with customers through a customer database system and proven analytical models built and perfected over many years, Fintech companies have specialized advantages in technology platforms and therefore can yield innovative solutions that will potentially disrupt the banking industry [14], [53]. To this end, innovation will continue to accelerate, and leading banks will be the ones that make the most of modern technologies for creating breakthrough innovations to gain a competitive advantage in the era of digital transformation.

C. PREVIOUS STUDIES ON SI

Most prior studies on SI have been devoted to test the relationships between SI and related issues such as customers' choices in the hospitality industry in the United State [8], behavioural intention and customer experience in ethnic restaurants in Taiwan [42], customers' attraction, satisfaction, and retention among commercial banks in Botswana [17], customer value creation and customer satisfaction in Ghanaian telecommunication industry [44], service delivery and customer satisfaction and loyalty in the banking sector of Ghana [9], customer value co-creation intention in the context of Vietnamese banks [54], business customer performance and loyalty in the safety industry in South Korea [4], business performance in Australian small and medium enterprise service firms [55], market performance in Chinese electronics industry [56], new product performance in various service firms in Taiwan [30]. The other part of the literature focuses on determining the determinants for SI such as service strategies [57], strategic orientation [56], customer co-creation [58], team culture and knowledge sharing behaviour [2]. However, studies about the SI level evaluation problems are still nascent, especially in the banking context under our observations.

The SI level evaluation can be measured by different evaluators with different perspectives such as managers, experts, or customers. Managers will deeply understand about their organizations and can provide quantitative data for certain attributes that outsiders cannot get these information while experts will have a more general view and can make objective comments on different organizations. Customers are those who consume services and therefore their assessments are very meaningful for managers to develop appropriate innovations to meet their needs. Customer satisfaction is one of the

most critical factors for the success in business [59], [60]. For that reason, in this study, we decide to focus on customers' overall evaluation of the SI of banks. The understanding of SI levels compared with rivals from customers' perspective is important for banks to propose strategic management policies.

As mentioned in Section II-A, SI can be dimensionalized into multiple criteria; therefore, the SI evaluation problem can be considered as a multi-criteria decision-making (MCDM) problem. MCDM is typically to rely on the aggregated assessments to rank a finite set of alternatives characterised by multiple attributes/criteria possibly with imprecise or uncertain information [61], [62]. In related research about innovation-related problems, previous authors also used MCDM approach to derive the composite indicators. In MCDM, weighting and aggregating of criteria are two major tasks in calculating composite indicators [63]. For example, in a research about innovation processes of French manufacturing firms by Boly et al. [64], innovation capacity was measured by 15 innovation management practices each of which was subdivided into multiple criteria. The statistical method of value test was adopted to compute the weights of innovation management practices in four classes of innovative firms (proactive, preactive, reactive, passive), and then weighted sum was used to calculate the aggregated evaluations on innovation capability of the firms. Ngo et al. [65] recently developed an integrated method for evaluating the innovation capability of banks in Vietnam under uncertainty. In their study, innovation capability was also considered as a multidimensional concept and innovation capability evaluation was considered as a MCDM problem which requires taking into consideration multiple innovation management practices measured by multiple measurement items. The weight of innovation management practices and their corresponding measurement items were determined based on the Analytic Hierarchy Process and the overall evaluation on the innovation capability of banks were the summed performance assessments on criteria weighted by their importance. As SI can be decomposed into multiple criteria, this study also adopt the MCDM approach to evaluate the SI of banks.

III. PRELIMINARIES

In this section we first briefly recall basic concepts and important operators in Dempster-Shafer theory of evidence and then describe the questionnaire design used for data collection in this research.

A. BASICS OF DEMPSTER-SHAFER THEORY OF EVIDENCE

The Dempster-Shafer theory of evidence [66], [67] (also referred to as the theory of belief functions) is one of the most popular theories for modeling and reasoning with uncertainty and imprecision. Let Ω be the *frame of discernment* that is a finite set of elementary hypotheses representing possible answers to a given question. A *mass function* (also called *basic probability assignment* or *basic belief assignment* [68]), is defined as a mapping $m : 2^{\Omega} \to [0, 1]$ satisfying

$$m(\emptyset) = 0, \text{ and } \sum_{A \in 2^{\Omega}} m(A) = 1 \tag{1}$$

where 2^{Ω} is the power set of Ω and, for any $A \in 2^{\Omega}$, the quantity $m(A)$ can be interpreted as a measure of belief to the hypothesis that "the true answer is in A", given the available evidence.

Two important operations in the Dempster-Shafer theory are *discounting* and *Dempster's rule of combination* [67]. The discounting operation is used when a source of information provides a mass function m, but knowing that this source has probability α of reliability. Then the original evidence is discounted at a *discount rate* of $(1 - \alpha)$ resulting in a new mass function m^{α} defined by

$$m^{\alpha}(A) = \alpha \times m(A), \quad \text{for any } A \subset \Omega \tag{2}$$

$$m^{\alpha}(\Omega) = (1 - \alpha) + \alpha \times m(\Omega) \tag{3}$$

Consider now two pieces of evidence on the same frame Ω represented by two mass functions m_1 and m_2. Dempster's rule of combination is then used to combine these pieces of evidence to generate a new mass function, denoted by $m_{\oplus} = (m_1 \oplus m_2)$ (also called the orthogonal sum of m_1 and m_2), which is defined, for any $A \in 2^{\Omega} \setminus \emptyset$, as follows

$$m_{\oplus}(A) = \frac{\sum_{B \cap C = A} m_1(B) m_2(C)}{1 - \sum_{B \cap C = \emptyset} m_1(B) m_2(C)} \tag{4}$$

where

$$\sum_{B \cap C = \emptyset} m_1(B) m_2(C) \triangleq m_{\oplus}(\emptyset) \tag{5}$$

is the combined mass assigned to the empty set before normalization. Note that the orthogonal sum combination is only applicable to such two mass functions that verify the condition $m_{\oplus}(\emptyset) < 1$.

According to Smets' two-level view in the Transferable Belief Model [68], when a decision needs to be made, a mass function m encoded the available evidence must be transformed into a so-called *pignistic probability function* $BetP_m : \Omega \to [0, 1]$ defined by

$$BetP_m(\omega) = \sum_{A \subseteq \Omega, \omega \in A} \frac{m(A)}{|A|} \tag{6}$$

where $|A|$ is the cardinality of A.

B. QUESTIONNAIRE DESIGN AND CONSTRUCT MEASUREMENT

The questionnaire used for data collection in customer-oriented evaluation of banking service innovation comprises three sections: customers' experience in service usage, customers' evaluation on SI indicators, and customers' perception on the importance of these indicators.

In the first section of the questionnaire, three questions are asked to capture customers' experience as follows:

TABLE 2. Constructs and measurement indicators for SI.

Constructs	Measurement indicators
New service concept innovation	SI1: Creative service packages SI2: Customized service options according to customer needs
	SI3: Differences in service concept and design as compared to previous services
	SI4: Differences in service experiences as compared to previous services
	SI5: Differences in service concept and design, as compared to other banks' services
New service process innovation	SI6: Efficient online support processes SI7: Automated service options
	SI8: Adopting of new media to interact with customers
	SI9: Attractive marketing campaigns at special occasions and events
	SI10: Quick and simple support services via call center
New technological system innovation	SI11: Constantly updating of new features SI12: Modern technology equipment and infrastructure
	SI13: Pioneering new technologies on the market
	SI14: Service development based on the latest technology applications
	SI15: Always striving to improve service quality

P_1 : Which bank(s) have you been using?
P_2 : How long have you been using the services of the bank(s)?
P_3 : Which service(s) of the bank(s) have you been using?

Such information of customers' experience will be used to estimate the belief over the customers' evaluation on SI indicators. Besides that, demographic variables consisting of gender and age are also included.

The second section is for responders to rate the performance of the evaluated banks on SI measurement indicators using a five-point Likert scale: *very dissatisfied* (VD), *very dissatisfied* (D), *neutral* (N), *satisfied* (S), *very satisfied* (VS), denoted by $\mathcal{L}_{SI}$. Table 2 shows three constructs of SI, namely, new service concept innovation, new service process innovation, new technological system innovation, each of which is measured by five measurement indicators adapted from [44]. This scale was adapted and validated by [9] and [54], which ensures its validity and reliability.

Finally, the third section asks responders to rate the importance of 15 measurement indicators when selecting new banking services, using a five-point Likert scale that ranged from 1 – *not important at all* to 5 – *very important*, denoted by $\mathcal{L}_I$.

The questionnaire is distributed to a population $\mathcal{P}$ of customers for data collection. Depending on the number of banks that responders have been using, the average time to complete the questionnaire is from 5 minutes to 15 minutes.

Once the database of customer evaluation on SI indicators has been built, it will be utilized to generate so-called customer-oriented evaluation profiles for SI of banks by means of mass functions in Dempster-Shafer theory of evidence [66], [67] serving as the knowledge for the following evaluation of banks' innovation.

IV. A CUSTOMER-DRIVEN EVALUATION MODEL

Having collected the data using the questionnaire as designed above, we now develop a model for evaluation of SI in banks. As SI is characterised by multiple indicators, the proposed model is essentially a multi-attribute evaluation method, yet capable of handling inherent uncertainty and imprecision due to qualitative nature of SI indicators and subjectivity in human judgments. To this end, the customers' assessment data are used to build evaluation profiles for SI indicators of a bank by means of mass functions in the Dempster-Shafer theory of evidence [67], and then the Dempster's rule of combination is applied for multi-indicator aggregation to produce the overall performance for the bank's SI. The outline of the proposed model is illustrated in Fig. 1. Particularly, it consists of five steps: 1) estimating the belief on customers' assessment based on their profile data; 2) modeling customers' assessments as customer-oriented evaluation profiles for SI indicators; 3) determining the relative importance of SI indicators reflecting their contribution to SI; 4) combination of multi-indicator assessments for an overall assessment of SI taking the relative importance of SI indicators into account; and 5) establishing a ranking among banks in terms of their SI performance based on the so-called pignistic transformation [68] and expected utility. In the following, we will describe these steps in detail.

Step 1. **Estimating the belief over customers' evaluation**
Firstly, the data of a customer c's experience collected by using questions P_1, P_2 and P_3 will be used to estimate the belief over customer c's evaluation as follows.
Let us denote $\mathcal{L}_1 = \{1, \ldots, n_1\}$, $\mathcal{L}_2 = \{1, \ldots, n_2\}$, and $\mathcal{L}_3 = \{1, \ldots, n_3\}$ the sets of possible answers to P_1, P_2, and P_3, respectively, where $k \in \mathcal{L}_1$ is the number of banks that a customer has been using, $k \in \mathcal{L}_2$ is the period of time in months that a customer has been using services and $k \in \mathcal{L}_3$ is the number of services that a customer has been using. Assume that the answers of a customer c to P_1, P_2 and P_3 are n_c^1, n_c^2 and n_c^3, respectively. We then define the belief over c's evaluation by the following relation:

$$\beta_c = \alpha + (1) - \alpha)\frac{1}{3}\left(\frac{n_c^1}{n_1} + \frac{n_c^2}{n_2} + \frac{n_c^3}{n_3}\right)$$

where $\alpha \in [0, 1]$ is interpreted as the belief over c when we do not have information about c's profile, for example $\alpha = 0.5$. That is, by definition, the more experience a customer has with using banking services, the higher belief β_c is in the customer's judgments.

Step 2. **Defining the mass function for customers' evaluation on SI indicators:**
For each SI indicator SI_i $(i = 1, \ldots, K)$, we now model customers' evaluation on SI_i of a bank B taking the belief in their judgment into account based on the so-called mass function in Dempster-Shafer

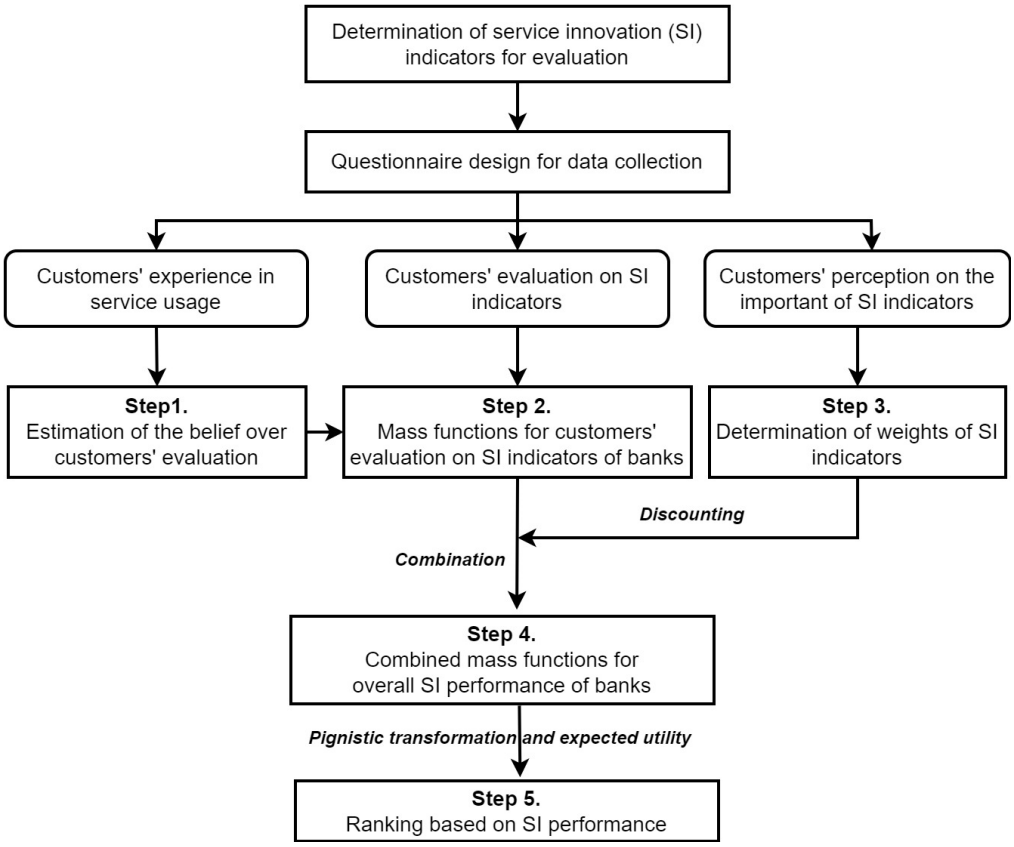

FIGURE 1. Outline of the proposed evaluation model.

theory of evidence [67] defined as

$$m_i^B : 2^{\mathcal{L}_{SI}} \to [0, 1]$$

such that

$$m_i^B(\{l\}) = \frac{1}{N_B} \sum_{c:\ c(SI_i)=l} \beta_c, \text{ for } l \in \mathcal{L}_{SI} \tag{7}$$

$$m_i^B(\mathcal{L}_{SI}) = 1 - \sum_{l \in \mathcal{L}_{SI}} m_i^B(\{l\}) \tag{8}$$

and

$$m_i^B(L) = 0, \text{ for any } L \in 2^{\mathcal{L}_{SI}} \setminus (\{l\}_{l \in \mathcal{L}_{SI}} \cup \{\mathcal{L}_{SI}\})$$

where N_B is the total number of customers who provide evaluation for bank B and $c(SI_i) = l$ means that the performance of bank B at SI_i is rated at l by customer c.

Intuitively, the $m_i^B(\{l\})$ represents the average belief of the population for the performance of bank B with respect to SI_i being at the level l, while $m_i^B(\mathcal{L}_{SI})$ quantifies the ignorance resulting from missing evaluations due to a lack of knowledge.

As such, for K SI indicators we obtain a tuple of K mass functions

$$\left[m_1^B, m_2^B, \ldots, m_K^B\right] \tag{9}$$

referred to as customer-oriented evaluation profile of SI for bank B.

Step 3. **Determining relative importance of SI indicators:**

Next, we use the data of customers' perception on the importance of SI indicators for estimating their relative importance. For each SI indicator SI_i, we first define its expected importance denoted by w_i as follows.

$$w_i = \sum_{l \in \mathcal{L}_I} \frac{|c : c(SI_i) = l|}{N} \times l \tag{10}$$

where $N = |\mathcal{P}|$, the number of customers participating in data collection. The relative importance of SI_i is then defined by normalization as

$$\overline{w}_i = \frac{w_i}{\sum_i w_i} \tag{11}$$

That is, we obtain the following weighting vector for K SI indicators used in SI evaluation:

$$[\overline{w}_1, \overline{w}_2, \ldots, \overline{w}_K] \tag{12}$$

Note that the weighting vector (12) reflecting relative importance of SI indicators is incorporated into the model of SI evaluation for banks participating in the comparison.

Step 4. **Defining the overall performance of banks by the mass function:**

Having obtained the customer-oriented evaluation profile (9) for a bank B and the weights associated with SI indicators as respectively described in Step 2 and Step 3 above, we are now ready to aggregate these mass functions representing SI indicators' evaluations taking their weights into account to derive an overall performance of SI for bank B by means of the so-called discounting operation and Dempster's rule of combination as follows.

First, by considering m_i^B as the belief quantified from the source of evidence SI_i and interpretation of weight $\overline{w}_i$ as the "degree of contribution" of SI_i in evaluating SI of bank B, the discounting operation is applied to m_i^B with the weight $\overline{w}_i$ to obtain a new mass function, denoted by $\overline{w}_i \otimes m_i^B : 2^{\mathcal{L}_{SI}} \to [0, 1]$, that is defined by

$$\overline{w}_i \otimes m_i^B(\{l\}) = \overline{w}_i \times m_i^B(\{l\}), \text{ for } l \in \mathcal{L}_{SI}$$
$$\overline{w}_i \otimes m_i^B(\mathcal{L}_{SI}) = (1 - \overline{w}_i) + \overline{w}_i \times m_i^B(\mathcal{L}_{SI})$$

Then, Dempster's rule of combination is applied to combine all new mass functions $\overline{w}_i \otimes m_i^B$, for $i = 1, \ldots, K$, to obtain an aggregate mass function, denoted by m^B, that is formally defined as

$$m^B = \bigoplus_{i=1}^{K} \overline{w}_i \otimes m_i^B \tag{13}$$

where $\oplus$ is Dempster's rule of combination as defined in (4). Finally, the resulting mass function m^B is considered as the aggregated belief for the overall SI performance of bank B.

Step 5. **Making a ranking among banks:**

Finally, to establish a ranking among banks in terms of their SI performance, we first employ the pignistic transformation (6) for m^B's to obtain approximate distributions for the overall evaluations of banks' SI performance. Namely, the pignistic transformation of m^B results in the following distribution $p^B : \mathcal{L}_{SI} \to [0, 1]$ such that

$$P^B(l) = \sum_{A \subseteq \mathcal{L}_{SI}, l \in A} \frac{m^B(A)}{|A|} \tag{14}$$

Then, the expected performance of bank B on SI is determined by

$$u_{SI}(B) = \sum_{l \in \mathcal{L}_{SI}} P^B(l) \times u(l) \tag{15}$$

for ranking, where $u : \mathcal{L}_{SI} \to [0, 1]$ is a utility function as used in [65].

In the following section, we shall employ this model to evaluate the SI of three banks in Vietnam as a case study to illustrate its effectiveness and applicability.

V. EMPIRICAL STUDY

A. SAMPLE AND DATA COLLECTION

As above-mentioned in section II-A, the measures for SI may vary depending on the context of the investigated service. To develop an understandable and relevant questionnaire for measuring SI in banking, we have consulted with academic experts in service science, bank officers, and bank customers. The questionnaire was first reviewed by two professors with long years' experiences in service science and knowledge science research to ensure content validity. It was then translated into Vietnamese and adjusted through discussion with five experienced banking officers, and finally modified so that the words were clearer and more suitable for the practical context. With the suggestions from these officers, we also included some examples along with the measurement indicators for their clarity and specificity. The targeted responders are customers who have been using the services of at least one of three banks in Vietnam, anonymously called Bank A, Bank B, and Bank C. A pilot study was conducted with five bank customers to ensure that they all understood the study and could answer all questions in the questionnaire. After the pre-testing, we had two banking officers working in each evaluated bank help asking their customers to participate in the survey, using an online questionnaire via Google Form. Each banking officer was given a "Thank You" voucher for online shopping of 500,000 VND for their support in data collection. They were also promised to share the research findings for use in improving their innovation policies.

Adopting a convenience sampling technique, the questionnaires were distributed to 60 customers of each bank. The survey process was conducted over a period of one month. Of 180 distributed questionnaires, 145 responses were collected, with a completed response rate of 80.56%. However, only 113 responses were valid and retained for analysis (after excluding 32 invalid responses because the participants answered all questions the same). In particular, there are 6 customers using the services of Bank A, Bank B, and Bank C, 8 customers using the services of Bank A and Bank B, 3 customers using the services of Bank A and Bank C, 18 customers using the services of Bank B and Bank C, 21 customers using the services of Bank A, 32 customers using the services of Bank B, and 25 customers using the services of Bank C, which is graphically displayed in Fig. 2. In term of demographic variables, the majority of responders were female (53.982%) and older than 30 years old (52.212%). Table 3 shows the demographic profile of the participants in this survey.

B. EMPIRICAL RESULTS

Fig. 3 shows the distributions of the belief over customers' evaluations for the SI indicators of the three banks. In general, most of the evaluations of customers using the services of Bank B and Bank C obtain high belief values. As describe by equation computing the belief of a customer's evaluation in section III-B, the belief value is decided by the number of

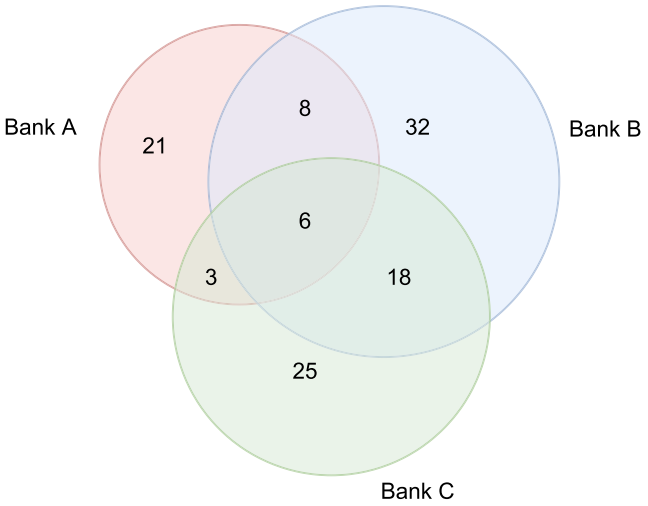

FIGURE 2. Distribution of customers by banks.

TABLE 3. Demographic variables.

Category	Frequency	Percentage (%)
Gender		
Male	52	46.018
Female	61	53.982
Total	113	100
Age		
$\leq$30	54	47.788
$\geq$31	59	52.212
Total	113	100

banks, the time of usage, and the number of services that the customer has been using. It can be referred from Fig. 2, the probability of customers using the services of Bank B or Bank C and also using the services of the remaining two banks is high. In addition, based on the collected data, the averaged time period that customers have been using the services in the case of Bank B is the highest while the averaged number of services that customers of Bank C have been using is the highest.

Following the Step 2 above for defining the mass function for customers' evaluation on SI indicators, we obtain the distributions for customers' evaluation on the 15 SI indicators of the three banks in the sample as shown in Table 4.

Then, the expected and relative importance of the 15 SI indicators can be obtained according to (5) and (11) respectively as shown in Table 5).

Now the overall evaluations regarding the SI of the three banks can be obtained using the discounting and combination operations presented in the Step 4.

In the case of Bank A, the evaluations for the 15 SI indicators were first discounted using the discounting operation with the discounting rates of their corresponding relative weights as shown in Table 5. For instance, Table 6 shows the discounted masses for SI1, SI2, SI3, SI4, SI5, SI6, SI7, SI8, SI9, SI10, SI11, SI12, SI13, SI14, and SI15 of Bank A the corresponding discounting rates of 0.056, 0.053, 0.061, 0.064, 0.063, 0.072, 0.070, 0.064, 0.062, 0.074, 0.071, 0.072, 0.070, 0.071, and 0.077, respectively. The assessments for the SI indicators at the remaining banks were then discounted in the same manner. The discounted assessments of Bank A were next combined using Dempster's rule of combination to get the aggregated assessment of each bank. By performing the same computations for Bank B and Bank C, we had the aggregated assessments on the SI of all three banks (see Table 7).

Finally, for the purpose of ranking the three banks in term of SI, the pignistic transformation and utility function were applied to derive crisp numbers representing their SI overall performance. Fig. 4 displays the distributions of the aggregated evaluations on the SI overall performance of the three banks and their approximations via pignistic transformation. The expected overall performances of Bank A, Bank B, and Bank C on SI were finally specified to be 0.627, 0.641, and 0.666, respectively. As a final result, Bank C has the highest SI performance among the three banks, Bank B is ranked second, and Bank A stands last.

VI. DISCUSSION AND CONCLUSION

A. SUMMARY

The fierce competition in banking industry forces banks to pay attentions to developing customer-oriented SI based on understanding customer views about their services and customer preferences on innovations in banking services and thereby creating appropriate innovations in response to their customer needs. This study contributes a new method to solve the SI evaluation problem in the banking context based on customer surveys. The SI evaluation based on customer perceptions in this study can support a bank in reviewing their SI with regard to new concept, new process and new technological system, recognizing important innovations that much affect customer selections for new banking services, and knowing its position in customers' mind compared to its rivals. Based on such evaluation, the bank can understand its strengths and weaknesses in the SI process so that it will prioritize to develop the certain innovations to effectively improve its ranking in terms of SI.

In particular, the proposed method considers the different belief in different customers' assessments. This can be regarded as an advantage of the proposed method because most previous research based on customers' evaluations [69] weighted customers' assessments equally. It is reasonable that customers who have been using more bank(s) and/or using the services the evaluated bank(s) for a longer time, and/or using more services of the bank(s) should have higher weight in deciding the performance of SI indicators of the bank(s) as they have better understanding of the bank(s). Customers' assessments on each SI indicator are modeled as a mass function that capture the uncertainty in evaluating the performance of SI indicators. Relying on the opinions of 145 banking customers in Vietnam, it was explored that the most important factor affecting customers' selection for new banking services is new technological system innovation, the next is new service process innovation, and after that

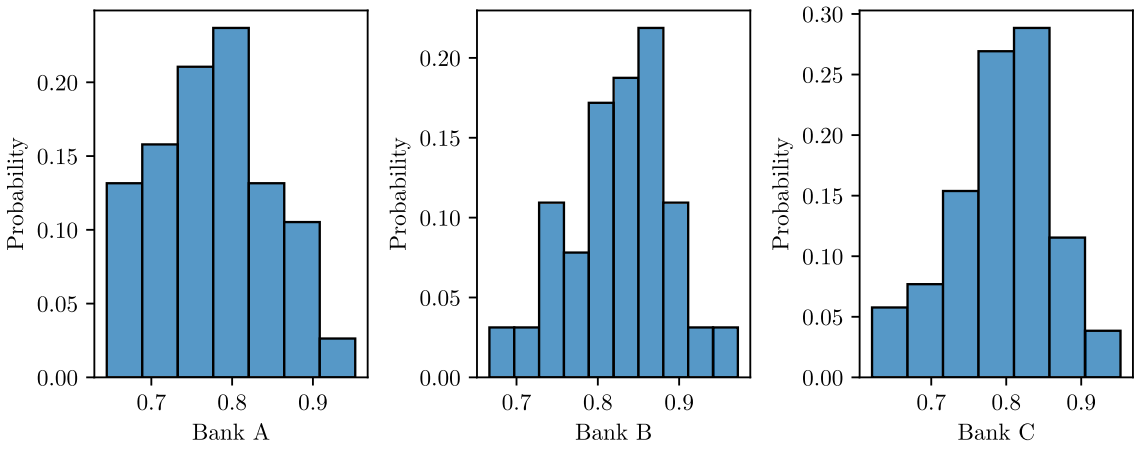

FIGURE 3. Distributions of the belief over customers' evaluation.

TABLE 4. Evaluation matrix of SI indicators for three banks in Vietnam.

Indicators	Bank A	Bank B	Bank C
SI1	(D,0.111),(N,0.365),(S,0.352),($\mathcal{L}_{SI}$,0.172)	(D,0.078),(N,0.423),(S,0.242),(VS,0.081),($\mathcal{L}_{SI}$,0.175)	(D,0.046),(N,0.400),(S,0.303),(VS,0.077),($\mathcal{L}_{SI}$,0.174)
SI2	(D,0.131),(N,0.364),(S,0.289),(VS,0.045),($\mathcal{L}_{SI}$,0.172)	(D,0.103),(N,0.434),(S,0.206),(VS,0.082),($\mathcal{L}_{SI}$,0.175)	(VD,0.014),(D,0.032),(N,0.355),(S,0.316),(VS,0.109),($\mathcal{L}_{SI}$,0.174)
SI3	(D,0.021),(N,0.363),(S,0.444),($\mathcal{L}_{SI}$,0.172)	(D,0.026),(N,0.335),(S,0.435),(VS,0.029),($\mathcal{L}_{SI}$,0.175)	(D,0.017),(N,0.332),(S,0.397),(VS,0.080),($\mathcal{L}_{SI}$,0.174)
SI4	(N,0.409),(S,0.372),(VS,0.047),($\mathcal{L}_{SI}$,0.172)	(N,0.304),(S,0.479),(VS,0.042),($\mathcal{L}_{SI}$,0.175)	(D,0.048),(N,0.285),(S,0.383),(VS,0.110),($\mathcal{L}_{SI}$,0.174)
SI5	(D,0.022),(N,0.499),(S,0.284),(VS,0.023),($\mathcal{L}_{SI}$,0.172)	(D,0.039),(N,0.433),(S,0.310),(VS,0.043),($\mathcal{L}_{SI}$,0.175)	(D,0.097),(N,0.344),(S,0.288),(VS,0.097),($\mathcal{L}_{SI}$,0.174)
SI6	(D,0.063),(N,0.449),(S,0.293),(VS,0.023),($\mathcal{L}_{SI}$,0.172)	(VD,0.012),(D,0.090),(N,0.354),(S,0.313),(VS,0.056),($\mathcal{L}_{SI}$,0.175)	(VD,0.014),(D,0.033),(N,0.393),(S,0.242),(VS,0.143),($\mathcal{L}_{SI}$,0.174)
SI7	(D,0.045),(N,0.430),(S,0.285),(VS,0.069),($\mathcal{L}_{SI}$,0.172)	(D,0.039),(N,0.349),(S,0.367),(VS,0.069),($\mathcal{L}_{SI}$,0.175)	(D,0.033),(N,0.268),(S,0.380),(VS,0.145),($\mathcal{L}_{SI}$,0.174)
SI8	(D,0.153),(N,0.472),(S,0.156),(VS,0.047),($\mathcal{L}_{SI}$,0.172)	(D,0.051),(N,0.377),(S,0.317),(VS,0.081),($\mathcal{L}_{SI}$,0.175)	(D,0.066),(N,0.328),(S,0.306),(VS,0.126),($\mathcal{L}_{SI}$,0.174)
SI9	(VD,0.020),(D,0.064),(N,0.458),(S,0.264),(VS,0.023),($\mathcal{L}_{SI}$,0.172)	(VD,0.026),(D,0.053),(N,0.408),(S,0.286),(VS,0.052),($\mathcal{L}_{SI}$,0.175)	(D,0.083),(N,0.406),(S,0.290),(VS,0.047),($\mathcal{L}_{SI}$,0.174)
SI10	(VD,0.020),(D,0.105),(N,0.479),(S,0.224),($\mathcal{L}_{SI}$,0.172)	(VD,0.023),(D,0.170),(N,0.391),(S,0.202),(VS,0.039),($\mathcal{L}_{SI}$,0.175)	(VD,0.048),(D,0.094),(N,0.382),(S,0.192),(VS,0.110),($\mathcal{L}_{SI}$,0.174)
SI11	(D,0.045),(N,0.353),(S,0.429),($\mathcal{L}_{SI}$,0.172)	(D,0.053),(N,0.321),(S,0.412),(VS,0.040),($\mathcal{L}_{SI}$,0.175)	(D,0.033),(N,0.251),(S,0.397),(VS,0.145),($\mathcal{L}_{SI}$,0.174)
SI12	(N,0.461),(S,0.368),($\mathcal{L}_{SI}$,0.172)	(D,0.053),(N,0.345),(S,0.362),(VS,0.065),($\mathcal{L}_{SI}$,0.175)	(D,0.080),(N,0.299),(S,0.339),(VS,0.109),($\mathcal{L}_{SI}$,0.174)
SI13	(VD,0.021),(D,0.021),(N,0.571),(S,0.193),(VS,0.022),($\mathcal{L}_{SI}$,0.172)	(D,0.088),(N,0.426),(S,0.284),(VS,0.026),($\mathcal{L}_{SI}$,0.175)	(D,0.033),(N,0.330),(S,0.335),(VS,0.128),($\mathcal{L}_{SI}$,0.174)
SI14	(D,0.043),(N,0.417),(S,0.368),($\mathcal{L}_{SI}$,0.172)	(D,0.053),(N,0.399),(S,0.334),(VS,0.039),($\mathcal{L}_{SI}$,0.175)	(N,0.364),(S,0.352),(VS,0.111),($\mathcal{L}_{SI}$,0.174)
SI15	(D,0.063),(N,0.330),(S,0.413),(VS,0.022),($\mathcal{L}_{SI}$,0.172)	(D,0.053),(N,0.337),(S,0.382),(VS,0.053),($\mathcal{L}_{SI}$,0.175)	(VD,0.014),(D,0.032),(N,0.257),(S,0.376),(VS,0.146),($\mathcal{L}_{SI}$,0.174)

TABLE 5. Expected importance and relative importance of SI indicators.

Indicators	SI1	SI2	SI3	SI4	SI5	SI6	SI7	SI8	SI9	SI10	SI11	SI12	SI13	SI14	SI15
w_i	358	340	390	414	407	466	450	411	398	477	457	463	448	458	496
$\overline{w}_i$	0.056	0.053	0.061	0.064	0.063	0.072	0.070	0.064	0.062	0.074	0.071	0.072	0.070	0.071	0.077

TABLE 6. Discounted evaluations for SI indicators of Bank A.

Indicators	Discounted mass
SI1	(D,0.006),(N,0.02),(S,0.02),($\mathcal{L}_{SI}$,0.954)
SI2	(D,0.007),(N,0.019),(S,0.015),(VS,0.002),($\mathcal{L}_{SI}$,0.956)
SI3	(D,0.001),(N,0.022),(S,0.027),($\mathcal{L}_{SI}$,0.95)
SI4	(N,0.026),(S,0.024),(VS,0.003),($\mathcal{L}_{SI}$,0.947)
SI5	(D,0.001),(N,0.032),(S,0.018),(VS,0.001),($\mathcal{L}_{SI}$,0.948)
SI6	(D,0.005),(N,0.033),(S,0.021),(VS,0.002),($\mathcal{L}_{SI}$,0.94)
SI7	(D,0.003),(N,0.03),(S,0.02),(VS,0.005),($\mathcal{L}_{SI}$,0.942)
SI8	(D,0.01),(N,0.03),(S,0.01),(VS,0.003),($\mathcal{L}_{SI}$,0.947)
SI9	(VD,0.001),(D,0.004),(N,0.028),(S,0.016),(VS,0.001),($\mathcal{L}_{SI}$,0.949)
SI10	(VD,0.001),(D,0.008),(N,0.036),(S,0.017),($\mathcal{L}_{SI}$,0.939)
SI11	(D,0.003),(N,0.025),(S,0.031),($\mathcal{L}_{SI}$,0.941)
SI12	(N,0.033),(S,0.026),($\mathcal{L}_{SI}$,0.94)
SI13	(VD,0.001),(D,0.001),(N,0.04),(S,0.013),(VS,0.002),($\mathcal{L}_{SI}$,0.942)
SI14	(D,0.003),(N,0.03),(S,0.026),($\mathcal{L}_{SI}$,0.941)
SI15	(D,0.005),(N,0.025),(S,0.032),(VS,0.002),($\mathcal{L}_{SI}$,0.936)

new service concept innovation. Previous studies revealed that customers emphasized on the importance of technology factors when they select banking services [70], [71], [72], [73]. Particularly, Katircioglu et al. concluded that banks should continually invest into contemporary technologies to facilitate banking procedures by the extensive provision of automated teller machine services and the availability of telephone and internet banking as they were found to be the most important factors behind bank selection in Romania [71].

TABLE 7. Aggregated evaluations on SI for three banks in Vietnam.

Bank	Overall performance on SI
Bank A	(VD,0.003),(D,0.042),(N,0.384),(S,0.268),(VS,0.015),($\mathcal{L}_{SI}$,0.288)
Bank B	(VD,0.003),(D,0.049),(N,0.327),(S,0.285),(VS,0.039),($\mathcal{L}_{SI}$,0.297)
Bank C	(VD,0.005),(D,0.036),(N,0.284),(S,0.283),(VS,0.091),($\mathcal{L}_{SI}$,0.301)

Kamakodi and Khan identified the availability of banking services beyond technology such as e-banking was identified as a key factor in Indian customers' decision to switch banks [72]. Andaleeb et al. emphasized technology adoption was a critical customer-centric banking practice that aids to offer better services and achieve higher customer satisfaction in Bangladesh [73]. Finally, the evidential reasoning in term of Dempster-Shafer's theory was employed to combine customers' assessment in terms of 15 SI indicators to gain the aggregated assessment on the SI levels of the evaluated banks. Our proposed method can also be adapted for various evaluations of SI in different service sectors with some modifications in the questionnaire to suit the contexts of each service sector.

An empirical study of three banks in Vietnam was conducted to demonstrate the applicability and effectiveness of the proposed method. In the case study of the three banks

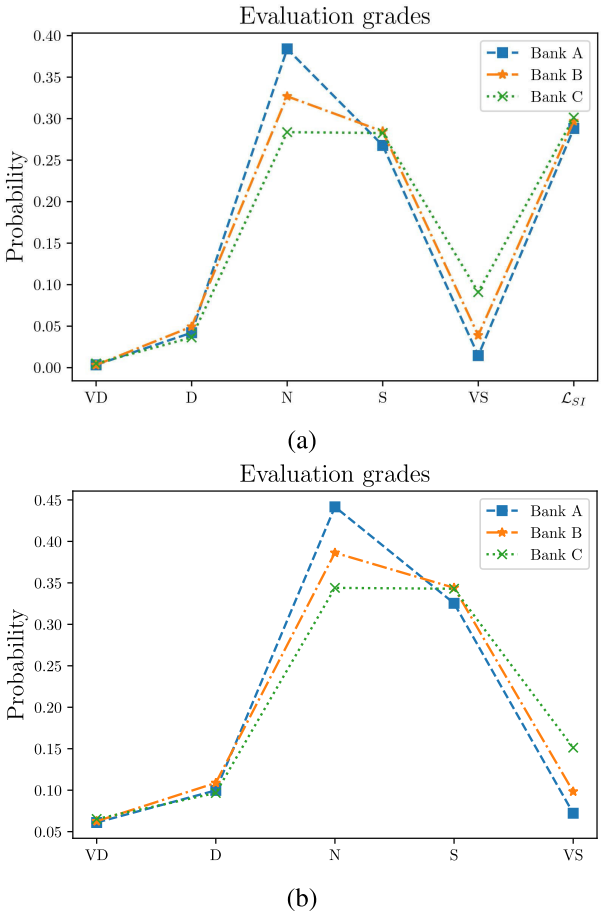

FIGURE 4. SI overall evaluations of three banks in Vietnam: (a) Aggregated evaluations (b) Approximate evaluations via pignistic transformation.

(called as Bank A, Bank B, and Bank C), Bank C was ranked as the best with regard to SI level, Bank B is in the second position, and Bank A is the worst.

The evaluation outcomes on the performance of SI indicators can help the three banks determine their competitive advantages compared to their competitors. Particularly, we regard the highest and lowest performance five SI indicators of a bank assessed by customers as internal strengths and weaknesses of that bank, respectively. For each SI indicator, the bank with the highest performance among the three banks is regarded as having external strengths and on that indicator while the remaining two banks are regarded as having external weaknesses on that indicator. Table 8 shows the performance of SI indicators at the three banks acquired by applying the pignistic transformation and utility function to the data in Table 4. Table 9 shows the overall competitiveness of the three banks on 15 SI indicators based on combining the internal and external strengths and weaknesses. The banks having more overall competitive strengths will have a higher overall ranking. Therefore, Bank C has the highest overall competitiveness, the next is Bank B, and Bank A has the worst overall competitiveness. The analysis results in Table 9 is consistent with the ranking by applying our proposed method.

TABLE 8. Performance of SI indicators at three banks in Vietnam.

Indicators	Bank A	Bank B	Bank C
SI1	0.633	0.644	0.666
SI2	0.631	0.628	0.680
SI3	0.679	0.688	0.702
SI4	0.683	0.713	0.705
SI5	0.641	0.654	0.660
SI6	0.636	0.645	0.673
SI7	0.658	0.684	0.723
SI8	0.587	0.671	0.685
SI9	0.616	0.634	0.642
SI10	0.585	0.581	0.612
SI11	0.670	0.681	0.728
SI12	0.660	0.677	0.685
SI13	0.602	0.630	0.702
SI14	0.652	0.657	0.705
SI15	0.671	0.678	0.714

B. MANAGERIAL IMPLICATIONS

The proposition of our framework for evaluating SI in banking and its application in the case of banks in Vietnam infers several serious managerial implications as follows:

Firstly, it is essential to notice that the SI evaluation in banking requires the consideration of multiple criteria, not just a sole criterion. Our study can provide bank managers with a comprehensive framework to scrutinize their organizational SI process, be aware of their strengths and weaknesses, and then put more effort toward improving the areas of deficiencies in order to ultimately upgrade their SI levels.

Secondly, the research findings delineate the most important innovations in the process of developing their new services that banks should focus on. It is worth noting that technology-related SI indicators are the highest in importance, so banks should prioritize efforts to improve these indicators first, thereby quickly leveraging their SI levels. As we can see from Table 9, Bank C has overall competitive strengths on the new technological system innovation indicators that are the most important innovations based on customer perceptions. It may be referred that the investment in innovating technologies has helped Bank C achieve the highest overall SI level among the three banks.

Thirdly, by looking at the mass functions representing the customers' assessments of SI indicators at each bank (see Table 4), bank managers can identify which SI indicators are not perfect in customers' mind. Since SI is abstract and qualitative in nature, customers might have conflicting ratings on the same SI indicators at a bank resulting from their different perspectives and understanding of the bank. The bank should then inspect issues related to those SI indicators, and do interviews with customers to clarify the areas where they perform poorly so as to perfect their development process of innovative services.

Finally, it is suggested that banks should apply the proposed framework and analyze the results multiple times because the performance of banks concerning SI indicators in conjunction with the importance of those indicators will change time by time under the dynamic environment. By comparing the banks' current SI status against themselves

TABLE 9. Competitive strengths and weaknesses of three banks in Vietnam.

	Internal			External			Overall		
Indicators	Bank A	Bank B	Bank C	Bank A	Bank B	Bank C	Bank A	Bank B	Bank C
SI1		X	X	X	X	O		X	
SI2	X	X		X	X	O	X	X	
SI3	O	O	O	X	X	O			O
SI4	O	O	O	X	O	O		O	O
SI5			X	X	X	O			
SI6			X	X	X	O			
SI7		O		X	X	O			
SI8	X			X	X	O	X		
SI9	X	X	X	X	X	O	X	X	
SI10	X	X	X	X	X	O	X	X	
SI11	O	O	O	X	X	O			O
SI12	O			X	X	O			
SI13	X	X	O	X	X	O	X	X	O
SI14			O	X	X	O			O
SI15	O	O	O	X	X	O			O

O: Competitive strength; X: Competitive weakness

in the past and against other banks, they can see how they have improved and draw and learn from mistakes and successes from their own and rivals.

C. LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Inevitably, this study has certain limitations. One of the limitations is a small sample size that includes only three banks in Vietnam and the opinions from about 60 customers for each bank, which may require caution when generalizing the research findings to the whole banking system. Hence, further investigations on a larger sample size need to be done to validate the findings. In addition, SI is a complex construct, so it may not be sufficient to only rely on only qualitative criteria and only customers' perspective to evaluate SI. According to Constantiou et al., making organizational decisions should be based on quantitative evidence along with intuitive judgments for substituting, supplementing, interpreting, and reframing the quantitative evidence [74]. In further works, other authors should integrate the evaluations from different viewpoints such as from experts, bank managers, and customers on both quantitative and qualitative criteria to adequately describe the SI of banks and drive the ranking of banks without controversy. However, it may take time and effort to collect quantitative data because this data can only be collected from bank managers, but they are rarely allowed to disclose such kind of data due to the strict confidentiality of information in the banking system. Additionally, this study formulates the weights of SI indicators in crisp numbers. Notably, there were also different opinions from customers on the importance of each SI indicator and therefore the importance weights could be represented in the uncertain form like probability distributions. Further research should be undertaken to develop new methods capable of handling such uncertainty and then driving the aggregated assessments based on uncertain performance ratings and uncertain weights.

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