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Abstract

This study adopts the diffusion of innovation theory as to develop the smart product service system (SPSS) model in banking industry due to prior studies are lacking in identifying the attributes. The SPSS hierarchical model with seven aspects and 22 criteria are determined enriching the existing literature and that identify appropriate strategies to achieve operational performance. The SPSS functions are bearing high uncertainty and system complexity; hence, the hybrid method of fuzzy Delphi method and fuzzy decision-making trial and evaluation laboratory to construct a valid SPSS hierarchical model and identified the causal interrelationships among the attributes. The results show that the institutional compression, digital platform operation, and e-knowledge management are the causing aspects that having influence to the SPSS model. For practices, the forcible compression, cyber-physical systems, industrial big data, cloud service allocation and sharing, and transparency improvement are the most importance criteria playing a decisive role in a successful SPSS. This provides guidelines for banking industry practice in Taiwan encouraging the miscellany of digital technology accomplishment for sustainable target.

Keywords: smart product-service systems; digital technology; sustainable innovation; fuzzy Delphi method; decision-making trial and evaluation laboratory (DEMATEL); diffusion of innovation theory

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1. Introduction

Sustainability is a desired target of social development that intensely enhanced the needs of fulfilling the product service system (PSS) (Annarelli et al., 2020; Kang et al., 2021). The PSS, as sustainable business models on vendible set of products and services able to cooperatively pleasing customers' requirements with varying ratio of economic and social advantages, are providing firms great opportunities to achieving better services (Reim et al., 2015; Tseng et al., 2019). Still, there is missing a conceptual vision of primary objective and framework as PSS are facing challenges in instigating industry 4.0 technologies to create innovative management services (Annarelli, 2020; Yu et al., 2021; Chen et al., 2020). Pirola et al. (2020) proposed focusing on how technology is embedded from an architectural point of view in a PSS is critical to avoid business obstacles. Wang et al. (2020) claimed the cutting-edge information technology gets PSS possible to admittance and acquire efficient operations. Yet, the speedy elaboration of advanced smart technologies such as artificial intelligence, internet-of-things, and cyber-physical system, have instigated a potential smart connected market leading to a new trend of SSP called smart product-service system (SPSS).

In Taiwan, the over-banking phenomenon suffers intense rivalry and low interest ratio less than 1.5 percent causing the existing banks deteriorate from inferior loans quality and a low profits level (Huang et al., 2018; Ho et al., 2020; Yu et al., 2021). The government has tossed the foremost financial reorganization with the intention of progressing the banking industry performance, and the productivity and efficiency improved the financial services. There are needs for a series of financial innovation to improve the industry operational performance and restructure the service system. Tsao and Thanh (2021) argued that technical and monetary needles such as the investment return and the technology adoption could be used as tools to reduce the risk in operational procedures. Cheng et al. (2020) suggested Taiwan banks could enhance their performance by increasing the credit mobilization by utilizing information technology efficiency (Suppatvech et al., 2019, Tao et al., 2018, Chen et al., 2020). In banking industry, the SPSS possibly delivers innovative propositions value, through gathering, extracting and scrutinizing operational data based on the smart technologies such as real-time state monitor, operational patterns on performances and output optimization, thus improving the resource utilization.

In the literature, Zheng et al. (2018) proposed a systematic design for SPSS innovation in business-to-customer archetypal targeting in achieving personal consumer satisfaction and reduce the environmental effect. Li et al. (2021) developed an intelligent platform toward SPSS means based on the a blockchain-and internet-of-things for the sustainability. Kang et al. (2021) settled an auction-based cloud service allocation for logistics PSS sharing. However, those SPSS development and adaptation are still deemed to be traditional and mostly focused on PSS product-oriented design requirements (Wang et al., 2019; Yu et al., 2021). There is lack in identifying the SPSS model based on the service-oriented context that guides firms to create more value while targeting for sustainability (Tseng et al, 2019, Pirola et al., 2020; Annarelli et al., 2020). Information and communication technology is confirmed to the evolvement of SPSS in the interconnection of physical components and services for value creation (Li et al., 2021; Tseng et al., 2019). SPCC has to be clarified further discussed its attributes' development process.

In this study, a smart technologies viewpoint is utilized to enhance SPSS models and to improve business design. It is critical to define and convey the digital competencies from a managerial perspective, knowledge, methods and tools are required (Alippi and Ozawa, 2019; Pirola et al., 2020). Innovations in the solution business, that is, different SPSS required to examined through the lens of a suitable theory. This study adopts the diffusion of innovation theory (DOI) as a theoretical foundation to develop the SPSS model in banking industry. The theory has been broadly used to explore attributes that effect firms' decision to approve an innovation or a new technology (Parveen, 2008). Ho et al. (2020) proposed the DOI suggests individuals only choose to adopt a technology that enhance firms' advantages such as trialability, observability, and compatibility. Schmidt-Costa et al. (2019) suggested the theory designates noticeable on structural learning effect to improve the installation capability, resources employment that gathers the technology knowledge. Indeed, the innovation actions aim right at diffusing in a slight study substance, demonstration, and development refer as doing or working on the innovation itself (Tseng et al., 2019).

In term of SPSS, the prior studies have discussed several value innovation aspects. Agyekumhene et al. (2018) argued the potential of digital platforms for firms to handle some communication and information problems related to uncertainties impeding value chain. Siegel et al. (2018) proposed the aptitude of intelligent decision-making and information interaction allows to provide extra services to augment the competitive advantages as well as optimize business operation. Belingheri and Neirotti (2019) claimed coordination and integration is the requirements to the entire revolution and innovation process on facilitating the digital-based services design and implementation. Li et al. (2021) dedicated the needs to avert security errors as prevent security flaws while improving delivery services and transport connectivity is critical. However, existing literature are explored the value propositions and holistic approach to develop in-depth advances in SPSS assessment to measure and analyze the conveyance criticisms steadiness is still underdeveloped (Chen et al., 2020; Pirola et al., 2020; Kang et al., 2021).

In addition, Kropp and Totzek (2020) argued that the institutional compressions could help to shape SPSS as reproducing actions and maintaining legitimacy in an ordinary reaction between firms and high uncertainty due to information technology functionality as well as the complexity of the system and interorganizational networking. Pirola et al. (2020) recommended a knowledge management development in operational strategy to identify process of digital technologies supporting decision-making. The firms' information possibly generates key data on performance output help to guarantee the SPSS transformation to a more formalized structure (Agyekumhene et al.; 2018; Annarelli et al., 2020). Thus, the SPSS incorporation brings a non-negligible innovative potential, securing competitiveness while allowing firm to tackle more sustainable offerings, so as ensure a better exploitation of physical resources and deliver more satisfactory proficiency

Yet, the SPSS functions are bearing higher uncertainty, system complexity because of the dynamic environment and incremental innovations. Kropp and Totzek (2020) stated that the system complexities and SPSS requirements are a novelty of apparatuses for the gathering, conducting and evaluating data. van der Laan and Aurisicchio (2020) claimed to access the SPSS performance, an appropriate method to reduces uncertainty to the result prospect is needed. This study proposes the hybrid method of fuzzy Delphi method (FDM) and fuzzy decision-making trial and evaluation laboratory (FDEMATEL) to construct a valid SPSS hierarchical model and identified the causal interrelationships among the attributes. The FDM is initially involved to validate the proposed hierarchical model, the unnecessary attributes are screen out, ensuring the validity for the proposed model (Bui et al., 2020). The fuzzy decision-making trial and evaluation laboratory (FDEMATEL) to indicate the critical SPSS attributes and explore the causal-interrelationships among them. The method converts the linguistic preference to quantitative data to solve complex problems among the network system (Tseng et al., 2019). The attributes are classified into cause-and-effect groups, and visually present analysis result based on the driving and dependence power (Tsai et al., 2020). The hybrid method the FDM and FDEMATEL is used and this study's objectives are as follows:

- To develop a SPSS attribute set using linguistic preferences;
- To composed a hierarchical model and examine the causal-interrelationships among the SPSS attributes;
- To indicate the crucial attributes for successful SPSS performance and present improvement implications for practicing.

This study offers theoretical contributions and practical recommendations for financial institutes that want to achieve sustainable goals. (1) The theoretical contribution is to determine and structure a SPSS hierarchical model that enrich the existing literature, and identify appropriate strategies to achieve operational performance. (2) Practical guidelines are provided important implications for banking industry practice in Taiwan, in terms of encouraging the miscellany of SPSS innovation to accomplish sustainable targets.

The rest of this study is structured into five sections. the SPSS literature, theoretical background, methodological recommendations and measurement attributes are presented in the next section. The section three and four address the detail of methods, afterward the analysis results. The section five provides the theoretical discussions and managerial implications. Finally, the conclusion, limitations and future study recommendation are conferred in the last section.

2. Literature review

This section provides the theoretical background of DOI, SPSS literature and proposed measure. Moreover, the proposed methods are discussed.

2.1. Theoretical background

DOI defined as the transformation process of innovation from a new product/service or business model to generate the adoption and acceptance of a market though reducing effort and improving the benefits (Rogers, 2003). The theory as the procedure where an innovation is communicated among the stakeholders within a social system through certain networks over time. Hall (2009) proposed the product/service innovations diffusion refers to new or extensive activities to enhanced the basic materials, in-between products refine, new mechanisms improvement, or transitioning new product features; especially, a new product/service or business model of installation capability, resources utilization, adopters' technology gathered knowledge, and the financial incentive influences to choose between innovation options (Schmidt-Costa et al.,2019). The innovation coefficient engenders a faster SPSS diffusion pattern, the more information available and widespread among stakeholders on this business model is to make decision in adopting the innovation.

However, the benefits of an innovation are hard to forecast exactly; further, many innovations necessitate a long time to become available and are extensively implemented, stirring the expedition to distinguish the elements that effect this process. The absence of up-to-date information is a crucial factor forming incapacity to respond to appropriate innovation (Agyekumhene et al., 2018). But more information is available in the course of time letting reconsideration of the innovation involving and returned expectation, in other words, diffusion is understood as a learning process about the innovation. The learning process is collective time through time, and the gathering knowledge effect then manages to foster connotations and associates thus improving new adoptions (Schmidt-Costa et al., 2019). SPSS extension needs to involve the digital technology to build the innovative business model.

In understanding the DOI; for instance, Kropp and Totzek (2020) adopted the diffusion of innovation to examine on how institutional pressures deliver communal prospects for legitimate performance and system appearances effect business-to-business on client acceptance of SPSS. Ho et al. (2020) provided a deeper compassion of enabling diffusion of innovations factors in the adoption of mobile banking obstructing. Yet, smart device access limitation still remains unclear on how to overcome the locally low relevant digital information and literacy (Agyekumhene et al., 2018). This study proposes a SPSS hierarchical model based on the diffusion of innovation theory to structure influences the innovation capacity under the impacts of the diffusion process.

2.2. Smart product service system

A SPSS are a conversion of the definition of PSS business model to the digital context, which is related to the e-service, apart from relationship to the physical environment, with intelligent product presence (Boehm and Thomas, 2013; van der Laan and Aurisicchio, 2020). SPSS is defined as a package of smart connected product generating smart services by leveraging the media and tool is delivered to market for filling customers' needs as well as providing more social and environmental benefits (Valencia et al., 2015). Chowdhury et al. (2018) proposed SPSS is smart technology empowered PSS interpreted as a value scheme driven by digital resource, and a business model obstructing digital frontier substances. Chen et al. (2020) and Siegel et al. (2018) identified SPSS as a smart technology-driven value creation business strategy where numerous merchantable values are raised from the connections between smart connected products together or between the smart connected product to users, environment, infrastructure, and operational activity. The SPSS remarkably signifies on the digitalization and connectivity (Liu et al., 2018); yet, specified information and communication technologies are inserted within the smart connected product itself, conjoining elements needs for value co-creation to satisfy shareholders rather than a simple embellishment to the traditional PSS (Zheng et al., 2019).

Certainly, Li et al (2021) stated the advanced communication and information technologies promotion has activated the SPSS evolvement, where a smart connected product plays a critical role in the interconnection of digitalized value co-creation services and physical components. The SPSS enables those key elements in user activity predictable, perceptible, controllable and optimizable by applying the internet-of-things, big data and artificial intelligence technology for acquisition, computation, processing, analysis, decision, visualization, and optimization (Li et al., 2017; Rymaszewska et al., 2017; Siow et al., 2018). Liu et al. (2018) claimed a SPSS structural model needs to consist four layers on smart devices, data management, networking, and applications. Suppatvech et al. (2019) proposed the SPSS has to regard as of value innovation sources, where the smart data are created for creating prospect innovative value propositions to connected stakeholders related to the ecosystems. In fact, more players involved in SPSS development, the more co-creating value is needed leads to competences for developing SPSS are urgent, and more technologies and tools are required for the collaborative development of intelligent SPSS (Liu et al., 2018; Herzog and Bender, 2017).

In this milieu, the overall model of such information systems and platforms for SPSS needs to compose numerous technological apparatuses for the digital transition (Liu et al., 2019). Mittag et al. (2018) presented a reference SPSS model must include data analysis, service procedures, physical products, profits architypes, and application circumstances. Cenamor et al. (2017) and Chen et al. (2020) stated there are complementally needs to address the level of SPSS beyond the technological architecture, which functional added value is capable to provide the platform tactic to efficient design and execution of advanced service offerings, formerly to simplify synchronization and competence among smart service mechanisms. Pirola et al. (2020) argued the important role of the SPSS cover various decision-making phases of the configuration procedures to distribute virtualization supporting proficiency improvements, information service delivery provision, or engineering change environment. Further, the consciousness of SPSS can benefit sustainability to a bulky scope from big-data scrutiny and forecasting (Zhang et al., 2019). Overall, this requires to establish and manage a SPSS business ecosystem that tolerates for acquiescent cooperation and open innovation with new business models in order to making the traditional PSS upgradable with new functionalities and closer to sustainability goals (Chen et al., 2019; Kang et al., 2021).

2.3. Proposed method

There is still blur in which conditions for firms to successfully imply SPSS. The firm's innovation is challenged by high uncertainty and complexity in terms of system functionality and inter-organizational networking. In the literature, Pirola et al. (2020) analyzed the SPSS concept using semi-systematic literature review on the combination of PSS and digital technologies. Li et al. (2021) developed an intelligent SPSS platform based on a qualitative approach of a blockchain and internet-of-things for the sustainability. Particularly, Agyekumhene et al. (2018) used diagnostic to approach, configurating interaction Digital platforms for smallholder credit access within an institutional and agro-ecological challenges under the lack of maize agriculture provision. Tsao and Thanh (2021) developed on robust type-2 fuzzy programming to solve a blockchain-SPSS microgrid renewable energy design problem that bank offers a loan to firm to install renewable generation units and the firm provides a credit period for its manufacturers to incite requirement. However, despite these digitizations has been considered as main enabler and powerful driver for servitization (Coreynen et al., 2017), the complexity in information exchange integrates a wide-range of stakeholders among inter-organizational network that increases potential error sources.

Meanwhile, in the evaluation process, there is a lack of experience and references that could confirm reliability and validity of SPSS model. The uncertainty on value can result in retention and inconsistent data quality (van der Laan and Aurisicchio, 2020). This study used the FDM and FDEMATEL to indicate the valid SPSS model and explore the causal-interrelationships among the attribute. On one hand, Tseng and Bui (2017) used the FDM to reduce expert opinion uncertainty while reinforcing attributes and increase outcome reliability and validity. Bui et al. (2020) applied the FDM to reduce uncertainty of expert evaluation when ensuring the survey accuracy and guarantee the analyses quality. This method accomplishes group decision-making consensus and confront the attributes selections by including or removing experts' judgments than helps decision makers reduce the decisions time. On the other, the FDEMATEL is then employed to determine the causal-interrelationships among the attributes by transforming the qualitative information in experts' linguistic references and visualize them into a cause-and-effect diagram (Tsai et al., 2020).

Initial, fuzzy set theory is applied to quantify ambiguous perceptions of subjective human judgments in uncertain conditions into crisp values, and then the DEMATEL technique is used to analyze and construct the intercorrelations among complex aspects and criteria. For instance, Tseng et al. (2019) studied the causal-interrelationships among an attribute set to create a theoretical structure and practical extents by adopting FDEMATEL. Chen et al. (2020) explored innovative value propositions for SPSS using a novel graphics-based rough-FDEMATEL method to evaluate the interrelationship and importance degree of the identified attributes. This hybrid approach not only allows experts to transfer their judgments based on knowledge and experience but also simplifies a complex problem by addressing the inherent uncertainty of survey procedures (Tsai et al., 2021). As a result, a causal SPSS system using hierarchical model with linguistic preferences is determined and critical attributes for a successful performance is identified in this study.

2.4. Proposed measures

This study proposed an attribute set of 8 aspects and 41 criteria including institutional compression (A1), digital platform operation (A2), security structure (A3), intelligent integration (A4), servitization system innovation (A5), e-knowledge management (electronic knowledge management) (A6), coordination and integration (A7), organization capacity and performance (A8) (shown in Table 1).

Institutional compression (A1) shapes the SPSSs adoption as replicating standard behavior for firms to response to uncertainty under the legitimacy maintain (Kropp & Totzek, 2020). The aspect highlights the position of external environmental influences and suggests that firm acceptance decisions are not fully internal coherent but also formed by socio-cultural factors and the organizational legality requirement. More explicitly, firms face three kinds of institutional compressions to imitate to communal instructions and behaviors to preserve legality: derivative compression, normative compression, and forcible compression. These compressions impulse firms to replicate others, which could be utilized by customers, suppliers, partners, competitors, or governments. The derivative compression (C1) is related to the firm's competitors' behaviors that restriction firm's perception from structural alignment with successful industry pioneers. The normative compression (C2) relates to the interconnections between firm and its customers, suppliers, and competitors, from cooperative prospects within structural context to establishes legal behavior (Heugens & Lander, 2009). Particularly, firms are more likely to notice its acceptance as legality behavior if an innovation is by time extensively implemented in the market. Furthermore, the forcible compression (C3) is defined as a set of official or casual obliges initiating from political organization or regulators (Ho et al., 2020). This makes firm difficult to endure the survivals as it is dependent on main partners such as customers or suppliers. Those compressions are influence firms' perception on innovative adoption as a requirement by powerful stakeholders.

To increase the SPSS ecosystem collaboration, the SPSS are linked to digital platform operation (A2) to abridge book keeping, chronicles and data management progressions, and support the business skills provision through relationships with business partners (Agyekumhene et al., 2018). Such platforms no longer are addressed at the unique level of individual firm, but refers to a non-limited data management and expected to incorporate cooperative functionalities so that support networking actors and intensify open innovation strategies (Frishammar et al., 2019). The digital platforms are argued to show potential assistances to fulfill the information and communication gaps as well as obstruct traditional value chain credit provisions under uncertainty. From a digital viewpoint, the data organization performs essentially with cloud infrastructures, those internet-of-thing solutions and reliable data management (Pagoropoulos et al., 2017). Wherein, smart connected products gathering (C4) is accountable for precisely classifying and assembly tolerable data from various sources and is an important criteria of definitive service revolution. Data-interacting (C5) represents the fundamental value of the platform supported by intelligence technologies and plays as the interactions between the user interface and data accessibility. Therefore, each SPSS requires a reliable infrastructure under the digital platform operation. The cyber-physical systems (C6) is resulted as the intersection between intangible Internet environment and physical devices to facilitate physical devices on promoting artificial communication, remote synchronization, and intelligent, high-level control (Alippi and Ozawa, 2019). Big data processing and cloud-computing (C7) involves calculating immense differentiated data stored in the database from various providers processed by the professional tier that are interconnected and loaded back as data-value delivering (C8), which contains the relevant data application for business management to diverse stakeholders (Li et al., 2020). The aspect is compromised to assist coordinated sensitivity and awareness to firms' circumstances and the expansion of recorded databases are capable of measuring judicious success factors like environmental impact or cost expenses to reduce risks by prediction implementation through big data analysis. This required a synchronized digital platform to accomplish and control SPSS model that allocates for resilience partnership and new business models' innovation.

Yet, platform security structure (A3) on detailed operation and security structures are not fully exemplified. As data exchange and financial flow to process the business complement are known as inconsistent establishment, false administration, and unveracious information leads to unavoidable disruption and legal proceedings on information assurance and truthful resources (Yang et al., 2020). Resolutions for the management and security of the collected data are required and SPSS assessment to evaluate and solution offerings and reduce risk and uncertainty are needed to construct the service delivery and transformation of smart products (Pirola et al., 2020). Thus, data security (C9) as distributed network where no trusted authority is needed to maintain the verification of relevant parties is needed. Application security (C10) such as hack-resistant blockchain, tamper-proof, and incontrovertible verification process network benefits from agile and decentralized approach with high transparency, where various parties are remunerated for their productivities, as well as for exertion performed is proposed (Min, 2019). Still, the networks interconnection, data storage certainly confronted impulsive security susceptibilities and privacy jeopardies. Smart contracts (C11) is required for dealing with poor networks interconnection issues in the platform where rules are originally fixed, and cryptographic substances are stable to alleviate the flaws caused by deceptive execution and delayed payments. Information storage (C12) issues to enables massive data to be stored reasonably and utilize in a traceable, secure, and sustainable way are included to prevent security flaws while improving delivery services and transference connectivity (Li et al., 2020).

With the advancement of smart connected products, the intelligent interaction technologies (A4) played a fundamental role in digitalization services, aiming to make a SPSS (Valencia et al., 2015). The aspect refers to SPSS capabilities of data interaction and intelligent decision-making allows firms to provide additional services and optimize their business operation (Siegel et al., 2018). Specially, effective information interaction (C13) suggestively offers a connection to effectively apprehend useful data and share it in a convenient method for sophisticated computing, and automatically transformed corresponding information to particular stakeholders. Real-time monitoring management (C14) aims to understand the administration position and essential data and information analysis, including comparative, instantaneous and consistent proceed the planning schedules, funds usage, and decisions related to legislation instruction in real time offer adequate assistance to supply chain. However, unexpected disorders occur are hampering the timely recognition of changes and rapid response to emergencies. Adequate decision support (C15), where insight visualization can contribute to decision-making, is critical for decision-makers to obtain adequate support management failure in a dynamic environment (Badi and Murtagh, 2019). These innovations are argued to help the SPSS to facilitate predictive analytics.

The servitization system innovation (A5) refers to a shift from an exclusive focus on products or an exclusive focus on services toward integrated systems or bundles of products and services, with services playing an ever more relevant role as compared with products (Annarelli et al., 2020). The aspect not only makes stipulations and criteria based on agreements in the same way that a conventional deal does, but they enforced those obligations automatically. Intelligent clauses (16), which intended to facilitate, verify, or enforce contractual obligations by embedding contractual clauses in the computer system and then automating contract execution (Min, 2019). Flexible production (C17) establishes a database and conducts classified management to realize accurate control of inventory demand and supply situation in the upstream and downstream of supply chain so as to adjust the production volume flexibly. safety reservation (C18) establishing a safety reservation, which can act as a buffer in the event of an interruption, giving the supply chain time to take action to recover (Li et al., 2020). This allowing companies to be more conscious of costs related to different PSS offerings and, then, helping them to make the right offering and achieve profit when moving towards SPSS (Pirola et al., 2020).

Knowledge management is the persuasion of individuals or organizations to cooperatively and systematically capture, create, store, share, and employ knowledge to achieve better outcomes (Lim et al, 2017). In the new era of knowledge-based economy, E-knowledge management (A6) extends traditional knowledge management to enabling encapsulate and secure a firm’s knowledge via an electronic-media mechanism. The aspect is heightened by information and technology solution, offering dispensation for knowledge leverage to share and re-use by the e-Knowledge procedures and standardization, as well as faster learning intentions. In which, the industrial big data (19) is an important e-knowledge management tool for SPSS to intensify additional value proposed to general reference framework of business implementation

(Kang et al., 2021). This request a cloud service allocation and sharing (C20), integrated with a shop-floor observing service and an amplified reality, is designed as condition-based for SPSS protective maintenance (Mourtzis et al., 2017). Moreover, internet-of-things provision (C21) also helps the firms to expand their advantages in the market, improving higher effectiveness and efficiency offered to clients since new technologies let them to recognize, control, and guaranteeing a continuous and effectual product/services in real time (Annarelli et al., 2020). Additionally, SPSS lifecycle knowledge management (C22) approaches, and technologies can help firms to fold and accomplish SPSS knowledge along its lifecycle and provide salvage functions about related elements of production, servicization and installation, processing method, and technical guidelines, where concerning employees could consult based on their expertise under the absent of valuable data (Li et al., 2020). Thus, data share management abilities (C23) are essentially crucial for SPSS distribution and associations among knowledge-intensive business services to strengthen innovation (Lafuente et al., 2019).

While, smart equipment configuration (C24) aims to strengthen the interacting and sensing capability to handle the complexity in the pre-defined arrangement of the SPSS equipment (Wang et al., 2020). Yet, before this complex equipment are installed, a preparation needs to be done to manage the environment parameters, and process the product/service resources. As a result, operational data collection (C25) on a substantial number of real-time and multi-source operations category used by various of equipment, customers, and operating conditions are inevitably engendered for active protective maintenance, such as equipment operations status, failure protocol, alarm event, and maintenance records (Wang et al., 2020). This require shareholder-generated data (C26), generated from related communication within the system, to be gathered as from particular stages (Li et al., 2020). Indeed, smart technologies are convenient to accumulating knowledge through use of e-services such as e-health, e-government, e-learning. The data is transferred then processing and storage in cyberspace centers, and provide enriched information to using members though e-social links for e-mobility and fintech, which also use it to explain service functionality. Inclusively, the e-knowledge management is argued to have a significant impact on socio-economic developments and social inclusion (Roblek et al., 2020).

Coordination and integration (A7) remain a crucial challenge requiring for parallel incorporation structures in the context of innovation and development process and necessity for firm in facilitating the digital-based services design and implementation (Belingheri and Neirotti, 2019, Cenamor et al., 2017). The aspects include firms' interactions (C27) as external stakeholders effectively influence SPSS deployment and collaborations among business services and strengthen innovation (Pagoropoulos et al., 2017; Lafuente et al., 2019). Digital platforms for trust in credit provision (C28) aims to provide cooperation control and institutional trust by fluctuating the basic confidence from integrating knowledge and information systems through increasing the societal communication and facilitate inter-personal trust among relationship building (Agyekumhene et al., 2018). In addition, there is need of functional service offerings to enable coordination and competence among smart service constituents (Cenamor et al., 2017). Thus, monitoring and accountability (C29) is claimed to share trustworthiness among firms and service providers in capacity to directly guarantee resource constraints (Agyekumhene et al., 2018). This leads service providers too rely on direct contact with trusted entities, leading to trust and control dynamic Information in credit cooperation (C30) are highlighted as required factors for credit cooperation to indicate the relationship gaps in the lack of communication and information as well as to experience on supporting trust building for credit cooperation (Agyekumhene et al., 2018). So that cooperative information improvement (C31) can satisfying the gaps shaped by diffuse-resourced delay services by offering locally information, and improving transparency (C32), as the documentation credibility, accelerate further agreement with creditors, making them a more effective intermediary among the system (van der Laan and Aurisicchio, 2020).

Records of organization capacity and performance (A8) may engender key data helps to begin the formalized transition of firms and its partners. The SPSS simplify support critical business provision as such digital records are related to the firms' ability to meet financial institute requirements in collaborative funding arrangements (Reim et al., 2015). Particularly, service infrastructure (C33) and dedicated human resources (C34) are seen as important criteria given distinctive nature and ease to retrieve operational activities in the market (Annarelli et al., 2020). Service quality evaluation procedures (C35), associated to the distinguishing organizational culture, institute the obstacle between firms and its competitors wishing to replicate the business model (Annarelli et al., 2020). SPSS decisions assessment tools (C36), as quantitative and qualitative SPSS design, is used predict the business value and economic of a product/service solution (Pirola et al., 2020). Digital-oriented capabilities (C37) embeds the SPSS in several ways as networking smart products and service systems to provide new functionalities leveraging on digital architectures such as internet-of-things, cloud computing (Chowdhury et al., 2018; Zheng et al., 2018).

Financial institution, who want to maximize returns to balance the debts, aims at trading power (C38) and is unfavorable to firms with weak and have limited bargaining power (Agyekumhene et al., 2018). However, the lack of information limits experience demonstration in management ability as such production capability and performance (C39) making banks have to trust firms' ability to deal with operational challenges in highly volatile contexts. However, firms are hampered by communication obstacle causing distrust among the network as firms feel that they have to suffer the operational risks and debt alone (Agyekumhene et al., 2018). Marketability for ease of debt repayment (C40) is proposed with the needs of confirmation on firms' willingness and ability to apply the loans requirement since information is mostly limited, trust and cooperation tends to be low. The ability of firms may base on training assessment (C41) to produce reliable quantities from value chain cooperation and enhance smart capabilities to strengthen the business performance and maintenance operations (Zheng et al., 2019). Aiming to explore the application of SPSS systematically discussion, and the transformation on sustainability, advanced digital information technology infrastructure needs to be explored.

INSERT Table 1 HERE - Proposed SPSS hierarchical model

3. Methods

The industrial background and the detail of used method are discussed as follows:

3.1. Industrial background

Banking industry in Taiwan is complex as involving various money market activities and indirect financing such as commercial banks, Savings Bank and the Postal Remittances, financial holding systems, foreign banks with local branches, and bills finance firms, and credit cooperatives. Taiwan has 36 commercial banks, most of them are relatively large in terms of their assets, net worth, and branches network (Taiwan Banking Bureau, 2020). However, the industry is limited in creating a synergy among financial entities. In order to accelerate the integration progress, enlarge the business scope, and increase the financial institutions competitiveness, the Financial Holding Company Act was propagated in 2001. There are 16 financial holding companies were set up in Taiwan until 2019 under the government financial consolidation based on market mechanism. The primary role of the government is to foster a transparent and fair environment for financial alliance.

With the growth of financial institutions, large banks become larger, yet, the banking market is still characterized as over-banking. The total credit cooperatives are gradually declined and the loans market share is dropped due to the credit cooperatives reorganization and commercial banks obtaining credit collectives events. Most banks are either consolidated by financial holding companies or face the crisis of being ostracized. Moreover, the Taiwan banking industry's competition degree has increased, which resulted in a low level of profits and high level of non-performing loan (Huang et al., 2018). The banks in financial holding systems keeps getting bigger with highly competitive advantages, while the others are facing bankruptcy for not having a specialized niche and in the urgent need to raise their operations and maintain their market share (Yu et al., 2021). With the growth in financial technology in Taiwan, numerous new financial products have been implied such as credit cards, trusts, cash cards, wealth management, and the quality of those products are continuously improving. Yet, the internationalization and liberalization of financial market have required banks to expand their financial products/services to make more sources of profit (Cheng et al., 2021). This suggests to enhance their performance activities through various channels by utilizing information and technology, making the need for constructing a SPSS model become a matter of concern.

In this study, a committee of 30 experts is approached to guarantee the evaluation processes reliability. A face-to-face interview which questionnaire is accomplished to ensuring the aspects clearly understand on terms and provided information in the evaluation procedure. Overall, the experts in the group had more than 12 years of experience working in and studying in field of banking industry; it included 12 experts from academia, 13 experts from commercial banks and private financial institutions, and 5 experts from related government authorities that involve in financial management policy.

3.2. Fuzzy Delphi method

The combination of fuzzy set theory and traditional Delphi method is proposed to handle the experts' linguistic preference uncertainty and achieve the judgments proficiency (Ishikawa et al., 1993). The technique recompences to diminish the respondent's quantity, survey cost and time; and optimum experts' evaluation (Bui et al., 2020).

The respondent ais ask to evaluate important value of attribute b is a as $j = (x_{ab}; y_{ab}; z_{ab})$, $a = 1,2,3, \dots, n$; $b = 1,2,3, \dots, m$. The attribute b weight j_b is computed as $j_b = (x_b; y_b; z_b)$, where $x_b = min(x_{ab})$, $y_b = (\prod_1^n y_{ab})^{1/n}$, and $z_b = max(z_{ab})$. The linguistic terms are then transformed into the triangular fuzzy numbers (shown in Table 2).

INSERT Table 2 HERE - FDM linguistic terms transformation table

The D_b as convex combination value is using an α cut as follow:

$u_b = z_b - \alpha(z_b - y_b), l_b = x_b - \alpha(y_b - yx_b), b = 1,2,3, \dots, m$ (1)

The α is adjusted from 0 to 1 based on the experts' perception. In this study, the $\alpha = 0.5$ regarding to the normality of the environment.

The $D_b$exact value is the generated as follows:

$D_b = \int(u_b, l_b) = \delta[u_b + (1-\delta)l_b]$ (2)

Where δ denotes the evaluators' the positivity level.

Finally, the threshold $\gamma = \sum_{a=1}^{n}(D_b/n)$ is employed to refine the important attributes. If $D_b \geq \gamma$, attribute b is considered to be valid. Otherwise, it is removed from the hierarchical model.

3.3. Fuzzy decision-making trial and evaluation laboratory

FDEMATEL use the defuzzification to convert the linguistic qualitative information into triangular fuzzy number. The left and right values are calculated by the minimum and maximum fuzzy numbers (Oprocovic and Tzeng, 2004). The total weighted values is computed using the fuzzy membership functions $\tilde{e}_{ij}^{k} = (\tilde{e}_{1ij}^{k}, \tilde{e}_{2ij}^{k}, \tilde{e}_{3ij}^{k})$. The crisp values are then arranged into a total direct relation matrix. The cause and effect groups that contain certain attributes represent the structured interrelationship and important effects are mapped into diagram as a visual analytical result.

An attribute set is proposed, $F = \{f1, f2, f3, \cdots, fn\}$, pairwise interrelationships is adopted to generate the mathematical relation. Particularly, this study obtaining and accumulating the crisp values using linguistic scales from VL (very low influence) to VHI (very high influence) (shown in Table 3). If there are k experts, the $\tilde{e}_{ij}^{k}$ indicates the fuzzy weight of attribute i^{th} affects on the attribute j^{th} provided by expert k^{th}.

INSERT Table 3 HERE - FDEMATEL triangular fuzzy number linguistic scale

The fuzzy numbers are abridged as:

$F = \left(f\tilde{e}_{1ij}^{k}, f\tilde{e}_{2ij}^{k}, f\tilde{e}_{3ij}^{k}\right) = \left[\frac{(e_{1ij}^{k} - min e_{1ij}^{k})}{\Delta}, \frac{(e_{2ij}^{k} - min e_{2ij}^{k})}{\Delta}, \frac{(e_{3ij}^{k} - min e_{3ij}^{k})}{\Delta}\right]$ (3)

where $\Delta = max\ e_{3ij}^{k} - min$ e

The left (l) and right (r) normalized values are obtained as follows:

$\left(l_{ij}^{n}, r_{ij}^{n}\right) = \left[\frac{(fe_{2ij}^{k}}{\left(1 + fe_{2ij}^{k} - fe_{1ij}^{k}\right)}, \frac{fe_{3ij}^{k}}{\left(1 + fe_{3ij}^{k} - fe_{2ij}^{k}\right)}\right]$ (4)

The total normalized crisp values (nc) is generated as follows:

$nc_{ij}^{k} = \frac{[l_{ij}^{k}\left(1 - l_{ij}^{k}\right) + (r_{ij}^{k})^2]}{(1 - l_{ij}^{k} + r_{ij}^{k})}$ (5)

Next, the synthetic values notation is accumulated from k respondents as follows:

$\tilde{e}_{ij}^{k} = \frac{(nc_{ij}^{1} + nc_{ij}^{2} + nc_{ij}^{3} + \cdots + nc_{ij}^{3})}{k}$ (6)

The $n \times n$ direct relation initial matrix of (IM) is acquired using a pairwise comparison. The $\tilde{e}_{ij}^{k}$ is specified as the effective level of attribute i on attribute j, customized as $IM = [\tilde{e}_{ij}^{k}]_{n\times n}$.

The normalized direct relation matrix (U) is generated as:

$$U = \tau \otimes IM$$
$$\tau = \frac{1}{\max_{1\le i\le k} \sum_{j=1}^{k} \tilde{e}_{ij}^{k}} \quad (7)$$

From the normalized direct relation matrix, the interrelationship matrix (W) is obtained:
$$W = U(I-U)^{-1} \quad (8)$$
where W is $[w_{ij}]_{n\times n}$ $i,j = 1,2,\cdots n$

the sum of rows and columns values of the interrelationship matrix is computed the driving power (α) and dependence power (β) as follows.
$$\alpha = [\textstyle\sum_{i-1}^{n} w_{ij}]_{n\times n} \ = [w_i]_{n\times 1} \quad (9)$$
$$\beta = [\textstyle\sum_{j-1}^{n} w_{ij}]_{n\times n} \ = [w_j]_{1\times n} \quad (10)$$
The attributes are positioned in a cause – effect diagram derived from the $[(\alpha+\beta),(\alpha-\beta)]$ as horizontal and vertical axes. The $(\alpha+\beta)$ displays the attributes importance level, the higher $(\alpha+\beta)$ value attribute has, the more important it is. The attributes are grouped into causal and effected groups based on $(\alpha-\beta)$ values. If the $(\alpha-\beta)$ is higher than 0, the attribute assigns in the cause group; in contract, it belongs to effect group.

4. Results

This section reveals the result of FDM and FDEMATEL analysis. The valid SPSS hierarchical is provided and causal interrelationships among the attributes are determined.

4.1. Fuzzy Delphi method results

This study proposed 41 criteria based on eight aspects in the hierarchical model. The result is shown in Table 4 with their weight and threshold to refine the valid attributes. The initial attribute set in Table 1 is evaluated by collecting the experts' judgment. The linguistic terms are converted into corresponding triangular fuzzy numbers (shown in Table 2). The FDM is applied to refine the valid attributes using equation 1-2, with the threshold $\gamma = 0.329$ (shown in Table 4). There are 22 out of 41 criteria that are accepted. The servitization system innovation (A3) is removed from the model since all of its criteria are eliminated after the evaluation process. The valid SPSS hierarchical model remains seven aspects including institutional compression (A1), digital platform operation (A2), intelligent interaction (A4), E-knowledge management (A6), coordination and integration (A7), organization capacity and performance (A8) (shown in Table 5)

INSERT Table 4 HERE – FDM evaluation result

INSERT Table 5 HERE – Valid SPSS hierarchical model

4.2. FDEMATEL results

In the FDEMATEL analysis, the TFNs are normalized using equations (3)-(6) for handling the uncertainty denotations and transform those linguistic preferences into synthetic crisp values notation (shown in Table 6).

INSERT Table 6 HERE – Synthetic crisp values notation for aspects

The synthetic crisp values are then obtained into an interrelationship matrix using equation (7)-(8). The driving and dependent powers using the equations (9)-(10) to inspect the interrelationships and through that generate a cause-and-effect diagram. The interrelationship matrix has 7 aspects is transformed into causal interrelationships (shown in Table 7). The α and β are in turn calculated as the total value of rows and columns. If $\alpha - \beta$ is positive, aspects are allocated in the cause group; otherwise, they are classified in effect group. A Causal interrelationship for aspects is then generated by mapping the dataset on $[(\alpha + \beta), (\alpha - \beta)]$.

INSERT Table 7 HERE – Interrelationship matrix and causal interrelationship among aspects.

Figure 1 shows the aspects' causal interrelationship that the institutional compression (A1), digital platform operation (A2), and e-knowledge management (A6) are classified in the cause group, while the effect group comprises the security structure (A3), intelligent interaction (A4), coordination and integration (A7) and organization capacity and performance (A8). Precisely, the aspects of digital platform operation (A2), and e-knowledge management (A6) are the main aspects influencing SPSS as they have strong and medium interrelationship to other aspects in the network. Both digital platform operation (A2) and e-knowledge management (A6) shows strong influences to (A4) and (A8), while the institutional compression (A1) also strongly effects to the organization capacity and performance (A8).

INSERT Figure 1 HERE – Causal interrelationship diagram for aspects

Similarly, the causal interrelationship among criteria is obtained in Table 8. The cause and effect diagram are generated in Figure 2. The results show that C2, C3, C6, C7, C14, C15, C19, C20, C24, C27, C28, C32, and C39 are the cause criteria, whereas the C9, C11, C12, C13, C21, C31, C34, C37, and C38 belong to the affected group. The forcible compression (C3), cyber-physical systems (C6), industrial big data (C19), cloud service allocation and sharing (C20), and transparency improvement (32) are highest importance criteria in the cause group.

INSERT Table 8 HERE – Causal interrelationship among criteria.

INSERT Figure 2 HERE – Causal diagram for criteria.

5. Implication

This study theoretical and managerial implications are discussed in this section.

5.1. Theoretical implication

E-knowledge management (A6) are one of the causing SPSS aspects that having important on socio-economic developments and social inclusion (Roblek et al., 2020; Annarelli et al., 2020). The aspect is primarily driven by advanced information technology desired to push the new technology, intellectual capital to improve manpower, physical resources, assets utilization. The e-knowledge management obtainability motivates firm to initiate new capabilities of effectively collect, storage and shared knowledge across the network, and avoid tensions from competitors, thus making more profit. The aspect strongly influences the intelligent interaction, and organization capacity and performance. This is highlighted as information and technology product/service to deliver indulgence for effective use of knowledge leverage procedures, standardization, and fast learning of digital technologies, supporting on firm performance implementation that through new technology to achieve more information and knowledge and exploit it (Pirola et al., 2020; Li et al., 2020). The digital knowledge as an information resource system is suggested to be the main decision-making reference for the SPSS innovation activities since it is not only focus on internal data but also be more contingent on external information. The aspect intensely drives an increased recognition of better SPSS design for procedures charting and information flow of the importance data and information and in an organization's operations.

This study confirmed that digital platform operation plays critical role toward SPSS. The aspect is a combination of core platforms, cloud, digital, internet-of-things, Artificial intelligence, machine learning, and security. The SPSS is built based on the integration of intelligent platform with innovation and industrial practice where innovative virtualization process supports efficiency improvements of service delivery or engineering change management (Li et al., 2021; Pirola et al., 2020). The aspect is potential for firms to generate a business models' portfolio to enhance the communication and information within value chain (Agyekumhene et al., 2018). However, establishing a platform strategy is complex due to innovation actions are changing on the growth of digital technologies and how business is created in number, place, organizing, and the stakeholder involvement. Maintaining digital infrastructures, ensuring information belief among partners, promoting inter-dependencies networked data, managing data and digital platform interoperability are important to link with SPSS. Digital industrial conjunction and associations to innovated business models, approachable crowdsourcing, trustworthiness and security beyond sheer markets and real-time monitoring of service platforms is argued to help firms gain a hidden insight into the SPSS.

Nevertheless, the institutional compression, which comes from a set of institutions including firms and competitors, trade unions public utilities, educational institutions, and government agencies; are indicated as a causing aspect that influence the SPSS. The aspect shows significant impacts to the organization capacity and performance, and intelligent interaction. On one hand, institutional compressions could help to shape SPSS as reproducing actions and maintaining legitimacy in an ordinary reaction between firms and high uncertainty due to information technology functionality and interorganizational networking (Kropp and Totzek, 2020). The aspects endure vagueness and risk-averse as institutional arrangements tend to stand mediate between firms and the ambiguity uncertainty threat. Institutions are the powerful influencers that generate the relationships between the firms and its customers because they have legitimized power to reward and punish certain types of products/services. Indeed, institutions have powerful influences on customers' purchase and usage behaviors by complicating or reducing the product/service choices and continue to engage in certain types of consumption patterns. Yet, some institutions may seek to have some advantages over their product/service, and use them to gain political favors. Authoritarian governance can take over those digital technology platforms to control the of information flow. For instance, the social media generalize such influence information that make help one specific firm to get the market advantages over another. This rises difficulty to creating create an effective SPSS model that can benefit both the stakeholders among the network.

5.2. Managerial implication

The banking SPSS development is an inevitable and objective trend in the era of modern economy and international economic integration. This brings great benefits for customers, banks and for the economy, thanks to their convenience, speed, accuracy and security. In particular, SPSS has been developed with many amenities such as providing account digital information; securities trading, making payment platform, which requires commercial banks to cooperate with financial technology service providers to research and develop services. Once the information technology are favorable conditions, the innovation on SPSS for the development of virtual banking services is new ways to effectively solve problems, thus, opening new avenues of opportunity. This study identified the five most important SPSS criteria for the banking industry practices including the forcible compression, cyber-physical systems, industrial big data, cloud service allocation and sharing, and transparency improvement.

Forcible compressions refer as government financial restrictions regulations, laws and other market restrictions that the economy must follow. The criterion encompasses the bank regulation boundary to all financial service providers and obliging financial innovation as well as protection the new comers as promoting innovation, enabling cross-border payments, avoiding potential monopolization of e-money provision, and making monetary transmission policy more effective. Further, the governments can offer support policy goals by ensuring legal and regulatory agendas that guarantee safe and sound fintech solutions, reduce legal complication and managerial obstacles, recommending digital-ready adoption; deliver synchronized government protocols. Since the government depends on the political culture distinctions, the bank and fintech service providers should facilitate innovation follow the local conditions and diversify the SPSS. But the forcible compressions also damage banks and harm their liquidity stability because of insufficient policy agenda, credit transaction information insecurity. Banks should react by improving their product/service and increasing interest to stakeholder to maintain SPSS, which assists profitability. A regulatory balance must be obtained concealing all activities that potentially have systemic risk. The industry needs to be flexible to respond to rules and policies changing by coordinating the prudential policy and competition regulation. Since the SPSS addresses the conduction of cleaner product/service and sustainable consumption. Understanding SPSS create the opportunity to see strategic of new market trends and developments.

Cyber-physical systems are able to control or manage the different chronological and spatial scales on various behavioral modalities, and incorporate with each other through physical and software components are deeply entangled. In the systems the integration playing an important role across both security measures and markets requiring firms to have features remote oversight and management solutions. The criteria provides such SPSS tools such as sale devices point, mobile banking, and ATM services, yet, the failure in both physical and cyber security creates vulnerable on various types of internet-of-things risks such as unidentified intelligent devices, misconfigurations, and undetected wireless networks makes financial services become sensitive to stealing and cyberattacks. Cyberattacks on are more widespread and diverse in the industry, ranging from simple attacks to complicated endeavors such as credit cards and bank accounts assessment. Banks necessity plug the gaps between unconnected platforms by integrating with both physical and information technology follow the same cybersecurity protocols and be evaluated in the same method. Apply artificial intelligent and deep learning resolutions, ensure physical hardware components are cyber secure, and protecting all data and information in a robust and inclusive firewall can enhance the financing operations security.

Industrial big data refers to a large and complex collection of data so that traditional data processing tools and applications cannot afford it. Compiling a large amount of information from different sources makes big data a very powerful tool for business decision making, recognizing behavior and trends much faster and better than the traditional way. Currently, most banking, financial services and insurance organizations are making efforts to adopt a new approach towards data mining for innovative SPSS. As customer volume increases data such as personal information, customer's transaction history and credit records, customer feedback, and other confidential information, it significantly affects the level and ability of financial firms to provide services. With the help of big data, banks can track customer behavior and identify the necessary data sources to collect for solution and use it to analyze the spending habits of customers, segment customer and profile appraisal, develop cross-sell other services (introduce investments opportunities to customers with spare money or cautious investors), improve service quality, marketing towards personalization, control risks, detect and prevent frauds and illegal violations, and control and evaluation and improve employee's work efficiency. However, the current banking market is still simple, when the needs of customers are not much and especially do not have access to smart and modern technologies. Several banks' management remains to be seen that decisions can be made based on experience without relying on the results of big data analysis. There is a need to change the thinking in the banking management team about the importance of data and modern data processing methods. The bank collects information from a variety of sources about a centralized processing monitoring system, but maintaining data quality in terms of accuracy, timeliness, and other factors becomes increasingly difficult. Currently, there is a fact about the human resources in the banking industry that bank officers do not understand information technology well, and people in information technology do not understand banking operations. To address this, a bank needs to set up a collect, screening, clean, reconcile and data classification process into a centralized focal point; then redistribute the data to relevant departments to analyze and provide useful information. Preparation of the team of data science specialists is an indispensable condition. With the countless applications of Big Data and its popularity in modern banks, if banks in Taiwan want to improve their competitiveness and profit, engaging the big data is necessary.

Cloud service allocation and sharing help create a flexible infrastructure and optimize information technology operations. The development of cloud computing allows banks to focus more on a customer-centric model, digitize transactions and assets, and create multi-channel relationships with stakeholders. The technology enables the storage, backup and recovery of the huge data produced by the banking system. Moreover, many other services such as software provisioning, transferring, updating and restoring data are also very easy. Updating payments, exchange of insurance data is quite easy via cloud computing. Cloud computing has an advantage in regulation. Banks with numerous of branches have many benefits such as reduce management and system operating costs, shorten the time to build and purchase physical technology infrastructure, ensure the availability and flexibility for the system, thus, increase revenue. Still, there are also challenges when implementing cloud service allocation and sharing model. There are still barriers to mobile phone application in Taiwan, that is, awareness about this technology is not enough and psychology of being afraid to switch because as bank are too familiar with the old model. Although, the centralization of data in the cloud is a way to increase security, the confidentiality and information safety is still a major concern of users because if the cloud is attacked, all data will be occupied; therefore, the chance for information is stollen is possible. Therefore, a bank needs to understand what types of data are allowed to be posted. The bank should build a basic model for assessing the value pros/cons brought by Cloud, then plan for changing resources assessment, new price brackets and other business assumptions. For each business problem on cloud platform, banks need to clearly recognize and script changes in management issues. They need to change the employee's role, and prepare employees to fit into the new organizational culture and mindset. The transfer of bank data to Cloud to take advantage of data analysis tools, machine learning and artificial intelligence help speed up the launch of new SPSS. Additionally, firms that provide such services such as Big-techs: Google, Amazon, Microsoft, and Alibaba are creating broader communication ecosystems with a wide range of corporate clients, including very large firms and the public sector. Choose a Public Cloud service provider with experience working with the bank, as they can offer more flexible pricing and the Cloud platform allows to move to other Cloud providers when needed.

Transparency improvement is very important because it helps banks easily access financial market, reduce capital mobilization costs, thereby expanding market share, increasing competitiveness. In Taiwan, strengthening banking information transparency is essential due to declining information disclosure, low quality of disclosure, and pressure from capital mobilization. Applying SPSS offers new transparent approaches for banks to improve the customer relationships. Even though the business nature of the financial SPSS has been improved through drastically reducing procedures, applying and online services; enhancing sustainability and transparency for banks using digital technology such as data analysis tools, artificial intelligence, machine learning, internet-of-things platforms are still a priority mission. Particularly, Real time liquidness and administration systems can efficiently determine the interbank risk. As such risk is easier to chase and calculate when more banks participate and willing to provide their information. the cloud banking may help banks to connect more closely together through sharing data, using data analysis to quickly solve customer problems, improve customer experience. These creativity and cohesion could help the bank retain talented personnel, increase organizational consistency, and create a creative and transparent working environment. Yet, this can be difficult to perceived transparency, even in the digital age due to lack of control, and less sensitive data. Practical problems such as tracking original information, confliction in determining variety, and managing update synchronization creates the risk in integrity the data records. The uncertainty in information accuracy is depressing firms to release their data and suspicion on whether their data is being leaked or abused, or at least have a permanent inspection when it happens. Thus, there should be a regulatory policy to modify the transparency procedures and comfort anxiety over the potential data cracks.

6. Conclusion

Sustainability is a desired target of social development that intensely enhanced the needs of fulfilling the SPSS. Yet, the speedy elaboration of advanced smart technologies such as artificial intelligence, internet-of-things, and cyber-physical system, there is a lack in identifying the SPSS model based on the service-oriented context that guides firms to create more value. It is critical to define and convey the digital competencies from a managerial perspective, knowledge, methods and tools are required. This study adopts the DOI as a theoretical foundation to develop the SPSS model in banking industry. To overcome the uncertainty, this study proposes the hybrid method of FDM and FDEMATEL is proposed to construct a valid SPSS hierarchical model and identified the causal interrelationships among the attributes.

An attribute set includes 41 criteria based on eight aspects is proposed in the initial hierarchical model. There are 22 criteria and seven aspects remain as the valid SPSS hierarchical model. The result shows the causal-interrelationship among the aspects. The institutional compression, digital platform operation, and e-knowledge management are indicated as the causing aspects that having influence to the SPSS model. In detail, the digital platform operation and e-knowledge management is strongly impact on intelligent interaction, and organization capacity and performance, as well as having the interaction with other aspects among the network, while the institutional compression has strong effects to the organization capacity and performance. For practices, the forcible compression, cyber-physical systems, industrial big data, cloud service allocation and sharing, and transparency improvement are the most importance criteria playing a decisive role in a successful SPSS.

This study contributes both theoretical insights and practical implications for financial institutes that want to achieve sustainable goals. The theoretical structure of SPSS hierarchical model with seven aspects and 22 criteria are determines enriching the existing literature, and that identify appropriate strategies to achieve operational performance. (1) The e-knowledge management obtainability motivates firm to initiate new capabilities of effectively networking, and avoid competitors' pressures; (2) the SPSS based on the integration of intelligent platform supports efficiency improvements of service delivery or changing in engineering management; (3) institutional compressions helps to form SPSS reproducing actions and maintaining legitimacy in high uncertainty. Meanwhile, practical implications are also provided for banking industry practice in Taiwan. The banking SPSS should develop in an innovation trend of modern economy and international integration in terms of encouraging the miscellany of digital technology accomplishment for sustainable targets. This brings great benefits for customers, banks and for the economy, through the convenience, speed, accuracy and security.

Yet, some limitation still remains in this study. First, this study adopted the DOI to build the theoretical structures on the smart technologies on SPSS innovation, the discussion may not fully address the comprehensive SPSS scenarios. Future study may evaluate another niche of SPSS such as resource utilization, consumers' behaviors, or the impacts of SPSS on the social, economy, environmental performance (triple bottom line) of the sustainability is encouraged. Second, only the banking industry in Taiwan is evaluated in this study, applying the proposed SPSS hierarchical model to another industry or comparison between the geographical areas is proposed for future study to ensure the model generalibility. Third, the result may be influence from the objective expert's judgment the since the committee only consisted of 30 members who is familiar to the field, increasing the number of respondents is recommended to avoid this problem.

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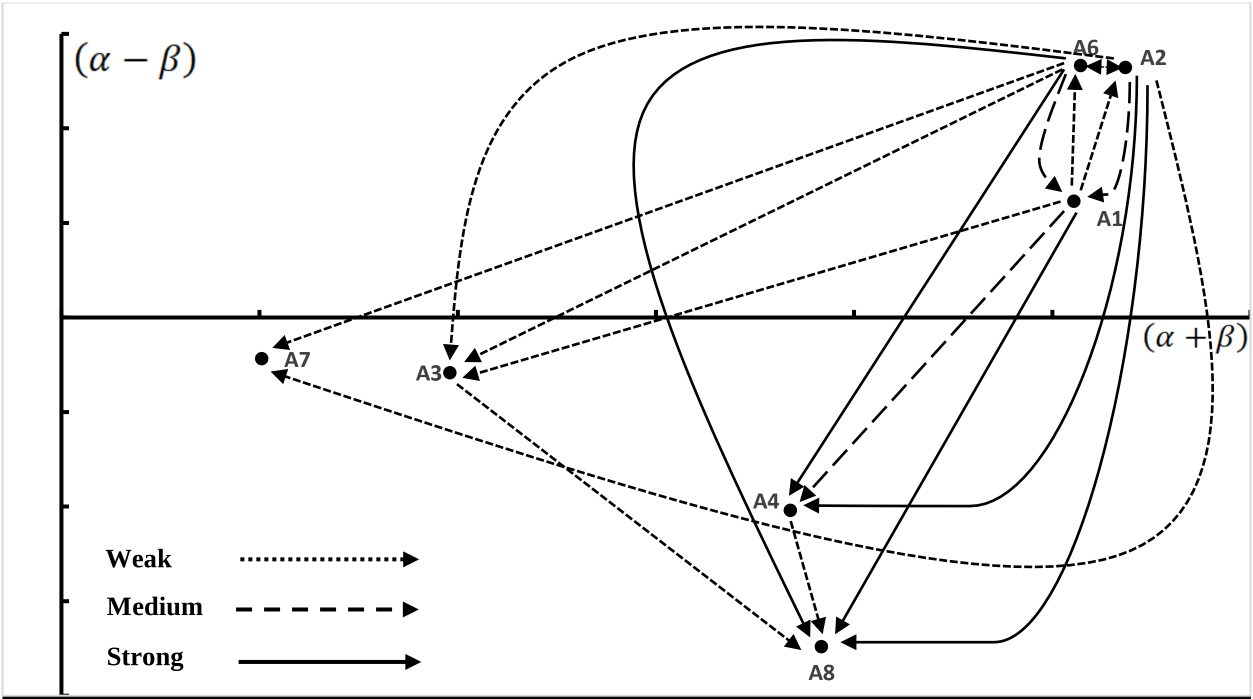

Figure 1. Causal interrelationship diagram for aspects

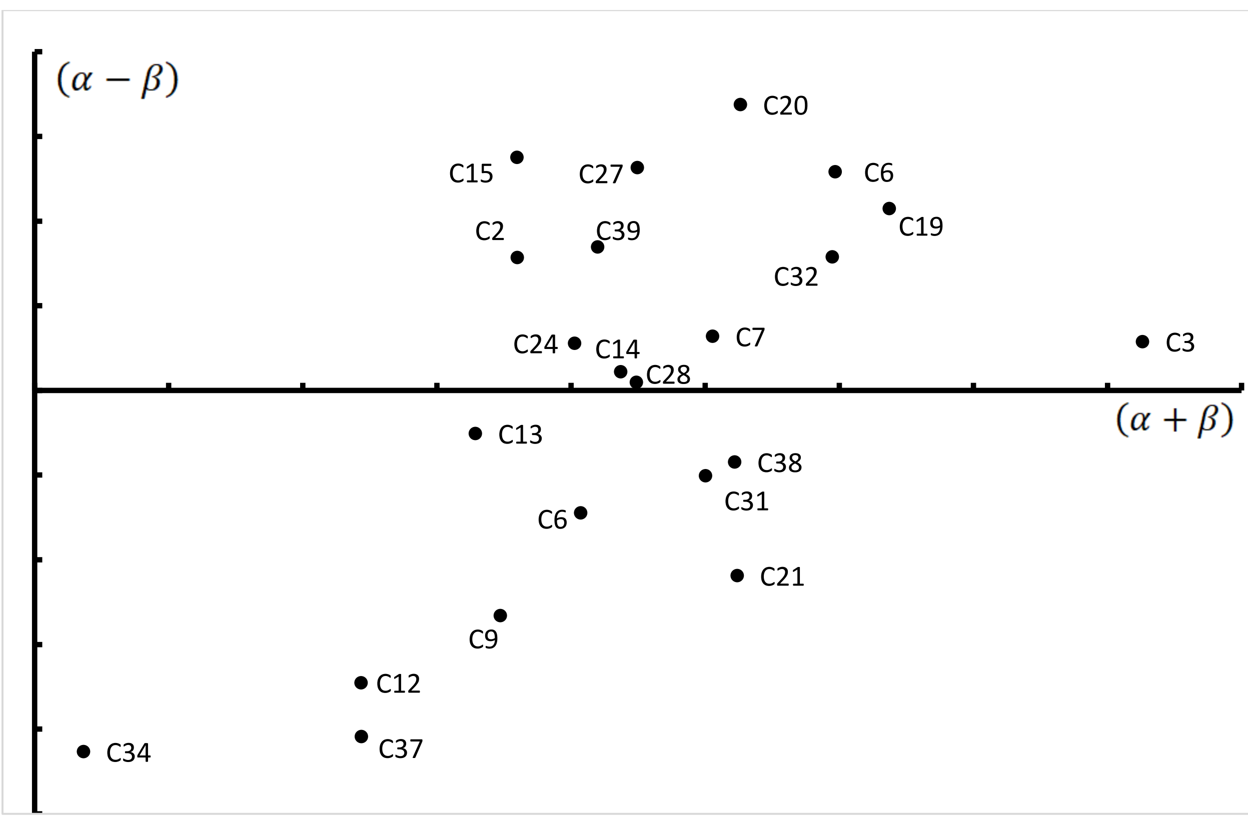

Figure 2. Causal diagram for criteria

Table 1. Proposed SPSS hierarchical model

	Aspects	Criteria		References
A1	Institutional compression	C1	Derivative pressure	Kropp & Totzek, 2020; Heugens and Lander, 2009; Ho et al., 2020.
		C2	Normative pressure	
		C3	Forcible pressure	
A2	Digital platform operation	C4	Smart connected products gathering	Agyekumhene et al., 2018; Frishammar et al., 2019; Pagoropoulos et al., 2017; Alippi and Ozawa, 2019; Li et al., 2020
		C5	Data-interacting	
		C6	Cyber-physical systems	
		C7	Big data processing and cloud-computing	
		C8	Data-value delivering	
A3	Security structure	C9	Data security	Yang et al., 2020; Pirola et al., 2020; Min, 2019; Li et al., 2020
		C10	Application security	
		C11	Smart contracts	
		C12	Information storage	
A4	The intelligent interaction	C13	Effective information interaction,	Valencia et al., 2015; Pirola et al., 2020; Siegel et al., 2018; Badi and Murtagh, 2019
		C14	Real-time monitoring management.	
		C15	Adequate decision support.	
A5	Servitization system innovation	C16	Intelligent clauses.	Annarelli et al., 2020; Min, 2019; Li et al., 2020; Pirola et al., 2020
		C17	Flexible production.	
		C18	Safety reservation	
A6	E-knowledge management	C19	Industrial big data	Kang et al., 2021; Mourtzis et al., 2017; Annarelli et al., 2020; Li et al., 2020; Lafuente et al., 2019; Wang et al., 2020; Roblek et al., 2020
		C20	Cloud service allocation and sharing	
		C21	Internet-of-things provision	
		C22	SPSS lifecycle knowledge management	
		C23	Data share management abilities	
		C24	Smart equipment configuration	
		C25	Operational data collection	
		C26	Shareholder-generated data	
A7	Coordination and integration	C27	Firms interactions	Cenamor et al., 2017; Pagoropoulos et al., 2017; Lafuente et al., 2017 Kohtamäki et al., 2019; Cenamor et al., 2017; Agyekumhene et al., 2018; De van der Laan and Aurisicchio, 2020
		C28	Digital platforms for trust in credit provision	
		C29	Monitoring and accountability	
		C30	Trust and control dynamic information in credit cooperation	
		C31	Cooperative information improvement	
		C32	Transparency improvement	
A8	Organization capacity and performance	C33	Service infrastructure	Reim et al., 2015; Annarelli et al., 2020; Annarelli et al., 2020; Pirola et al., 2020; Chowdhury et al., 2018; Zheng et al., 2018; Zheng et al., 2019
		C34	Dedicated human resources	
		C35	Service quality evaluation procedures	
		C36	SPSS decisions assessment tools	
		C37	Digital-oriented capabilities	
		C38	Trading power	
		C39	Production capability and performance	
		C40	Marketability for ease of debt repayment	
		C41	Training assessment	

Table 2. FDM linguistic terms transformation table.

Linguistic terms (performance/importance)	Corresponding triangular fuzzy numbers
Extreme	(0.75, 1.0, 1.0)
Demonstrated	(0.5, 0.75, 1.0)
Strong	(0.25, 0.5, 0.75)
Moderate	(0, 0.25, 0.5)
Equal	(0, 0, 0.25)

Table 3. FDEMATEL triangular fuzzy number linguistic scale

Scale	Linguistic variable	Corresponding triangular fuzzy number (TFNs)
VL	Very low influence	(0.0, 0.1, 0.3)
L	Low influence	(0.1, 0.3, 0.5)
M	Moderate influence	(0.3, 0.5, 0.7)
H	High influence	(0.5, 0.7, 0.9)
VH	Very high influence	(0.7, 0.9, 1.0)

Table 4. FDM evaluation result

Criteria		l_b	u_b	D_b	Decision
C1	Derivative pressure	0.000	0.500	0.250	Unaccepted
C2	Normative pressure	0.009	0.866	0.435	Accepted
C3	Forcible pressure	0.012	0.863	0.435	Accepted
C4	Smart connected products gathering	0.000	0.500	0.250	Unaccepted
C5	Data-interacting	0.000	0.500	0.250	Unaccepted
C6	Cyber-physical systems	(0.413)	0.913	0.353	Accepted
C7	Big data processing and cloud-computing	(0.375)	0.875	0.344	Accepted
C8	Data-value delivering	0.000	0.500	0.250	Unaccepted
C9	Data security	(0.358)	0.858	0.339	Accepted
C10	Application security	0.000	0.500	0.250	Unaccepted
C11	Smart contracts	0.001	0.874	0.437	Accepted
C12	Information storage	(0.361)	0.861	0.340	Accepted
C13	Effective information interaction,	0.014	0.861	0.434	Accepted
C14	Real-time monitoring management.	(0.051)	0.926	0.450	Accepted
C15	Adequate decision support.	(0.033)	0.908	0.446	Accepted
C16	Intelligent clauses.	0.000	0.500	0.250	Unaccepted
C17	Flexible production.	0.000	0.500	0.250	Unaccepted
C18	Safety reservation	0.000	0.500	0.250	Unaccepted
C19	Industrial big data	0.040	0.835	0.428	Accepted
C20	Cloud service allocation and sharing	(0.369)	0.869	0.342	Accepted
C21	Internet-of-things provision	(0.387)	0.887	0.347	Accepted
C22	SPSS lifecycle knowledge management	0.000	0.500	0.250	Unaccepted
C23	Data share management abilities	0.000	0.500	0.250	Unaccepted
C24	Smart equipment configuration	0.002	0.873	0.437	Accepted
C25	Operational data collection	0.000	0.500	0.250	Unaccepted
C26	Shareholder-generated data	0.000	0.500	0.250	Unaccepted
C27	Firms interactions	(0.360)	0.860	0.340	Accepted
C28	Digital platforms for trust in credit provision	(0.364)	0.864	0.341	Accepted

C29	Monitoring and accountability	(0.291)	0.791	0.323	Unaccepted
C30	Trust and control dynamic information in credit cooperation	0.000	0.500	0.250	Unaccepted
C31	Cooperative information improvement	0.037	0.838	0.428	Accepted
C32	Transparency improvement	(0.048)	0.923	0.450	Accepted
C33	Service infrastructure	0.000	0.500	0.250	Unaccepted
C34	Dedicated human resources	(0.418)	0.918	0.355	Accepted
C35	Service quality evaluation procedures	0.000	0.500	0.250	Unaccepted
C36	SPSS decisions assessment tools	0.000	0.500	0.250	Unaccepted
C37	Digital-oriented capabilities	0.038	0.837	0.428	Accepted
C38	Trading power	0.012	0.863	0.434	Accepted
C39	Production capability and performance	(0.366)	0.866	0.342	Accepted
C40	Marketability for ease of debt repayment	0.000	0.500	0.250	Unaccepted
C41	Training assessment	0.000	0.500	0.250	Unaccepted
		Threshold		0.329	

Table 5. Valid SPSS hierarchical model

Aspects		Criteria	
A1	Institutional compression	C2	Normative pressure
		C3	Forcible pressure
A2	Digital platform operation	C6	Cyber-Physical Systems
		C7	Big data processing and cloud-computing
A3	Security structure	C9	Data security
		C11	Smart contracts
		C12	Information storage
A4	Intelligent interaction	C13	Effective information interaction
		C14	Real-time monitoring management
		C15	Adequate decision support
A6	E-knowledge management	C19	Industrial big data
		C20	Cloud service allocation and sharing
		C21	Internet-of-Things provision
		C24	Smart equipment configuration
A7	Coordination and integration	C27	Firms interactions
		C28	Digital platforms for trust in credit provision
		C31	Cooperative information improvement
		C32	Transparency improvement
A8	Organization capacity and performance	C34	Dedicated human resources
		C37	Digital-oriented capabilities
		C38	Trading power
		C39	Production capability and performance

Table 6. Synthetic crisp values notation for aspects

	A1	A2	A3	A4	A6	A7	A8
A1	0.762	0.524	0.440	0.470	0.401	0.388	0.687
A2	0.554	0.764	0.509	0.537	0.468	0.393	0.588
A3	0.378	0.403	0.768	0.354	0.335	0.364	0.646
A4	0.437	0.377	0.326	0.768	0.416	0.357	0.572
A6	0.510	0.505	0.417	0.530	0.753	0.488	0.596
A7	0.336	0.350	0.343	0.451	0.468	0.752	0.461
A8	0.462	0.419	0.516	0.492	0.474	0.485	0.250

Table 7. Interrelationship matrix and causal interrelationship among aspects.

	A1	A2	A3	A4	A6	A7	A8	α	β	$(\alpha+\beta)$	$(\alpha-\beta)$
A1	1.443	1.336	1.307	1.423	1.291	1.251	1.534	9.585	8.970	18.555	0.615
A2	1.439	1.456	1.378	1.499	1.362	1.302	1.569	10.003	8.681	18.685	1.322
A3	1.172	1.145	1.248	1.219	1.117	1.096	1.347	8.344	8.636	16.980	(0.291)
A4	1.200	1.146	1.125	1.350	1.151	1.102	1.336	8.410	9.429	17.839	(1.020)
A6	1.419	1.376	1.342	1.490	1.437	1.325	1.562	9.952	8.619	18.571	1.332
A7	1.133	1.104	1.096	1.223	1.135	1.185	1.268	8.143	8.362	16.505	(0.218)
A8	1.164	1.119	1.140	1.226	1.127	1.100	1.213	8.088	9.829	17.917	(1.740)

Table 8. Causal interrelationship among criteria.

	α	β	$(\alpha+\beta)$	$(\alpha-\beta)$
C2	14.607	14.292	28.899	0.314
C3	15.673	15.557	31.231	0.116
C6	15.301	14.784	30.085	0.517
C7	14.878	14.750	29.628	0.128
C9	14.152	14.684	28.836	(0.532)
C11	14.424	14.713	29.136	(0.289)
C12	13.813	14.503	28.317	(0.690)
C13	14.321	14.423	28.744	(0.102)
C14	14.665	14.620	29.285	0.044
C15	14.725	14.174	28.898	0.551
C19	15.358	14.928	30.286	0.430
C20	15.203	14.528	29.731	0.675
C21	14.641	15.078	29.720	(0.437)
C24	14.612	14.501	29.113	0.112
C27	14.937	14.410	29.347	0.527
C28	14.682	14.662	29.344	0.020
C31	14.700	14.901	29.601	(0.201)
C32	15.195	14.879	30.074	0.316
C34	13.215	14.068	27.282	(0.853)
C37	13.751	14.568	28.319	(0.817)
C38	14.771	14.939	29.710	(0.169)
C39	14.769	14.430	29.199	0.339