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Problem Analysis on Public-Private Partnership for Small and Medium Enterprises: A Case Study in Cambodia

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One potential enabling factor in emerging economies toward their transition to the circular economy is promoting public-private partnership (3Ps). Such collaboration will bring about such a systemic transition wherein not only large business entities, but also small and medium enterprises (SMEs) could develop innovative business models following the circular economy principles. However, policymakers need to understand the complex challenges faced by SMEs to create an appropriate supportive policy framework. Interrelationships among barriers in promoting SMEs must be elucidated. This work thus presents the spherical fuzzy extension of the analytic hierarchy process (FAHP) integrated with the decision-making trial and evaluation laboratory (DEMATEL) as a tool for problem analysis to analyze these barriers systematically. A case study in Cambodia to identify the barriers to promoting SMEs through 3Ps is presented. Implications from this study could provide prioritization of the interventions to address these barriers. Thus, such analysis can be used for the development of policy recommendations to promote not only SMEs but also in implementing circular economy through a 3Ps scheme.

1. Introduction

The concept of circular economy is widely introduced in the ASEAN region, given its unique features of resource efficiency, competitiveness, and innovation (Anbumozhi, 2016). Moreover, its potential transition in emerging economies is explored from the enabling policy framework to the market trends. For example, the Royal Government of Cambodia, through the support of the United Nations Industrial Development Organization (UNIDO), put forward the strategy for Agro-Value Chain Development, Industrial Diversification, and Innovation and Special Economic Zones Development, under which the circular economy model is used as the key driver (UNIDO, 2020). The early adopters of this circular economic concept, among other players, are the small and medium enterprises (SMEs) which see the present emerging economics and disruptive technology as the opportunity to increase their productivity and competitiveness. The alignment of this new business model could only be possible if the foundation of public-private partnerships (3Ps) is strongly built. Thus far, several 3Ps development projects have been implementing in Cambodia and covering various sectors such as power supply, airports, roads, rail, seaports, water, and waste management, as emphasized in the Asian Development Bank (ADB) report (ADB, 2012). However, none of these projects focuses on the application of 3Ps under the framework of circular economy to promote the growth of SMEs. In addition, establishing an enabling environment for 3Ps is a challenge because the barriers to the circular economy will also be relevant in the context of SMEs (Holzer et al., 2021). Thus, this study introduces a novel problem analysis via spherical fuzzy extension of analytic hierarchy process (FAHP) and decision-making trial and evaluation laboratory (DEMATEL) to understand the complexity of the problem attributed to these barriers. The problematic situation of interest has not been addressed systematically yet via this proposed method of analysis. To date, the integrated method of spherical FAHP and DEMATEL has not been applied for the structural analysis of the problem that incorporates the perception of the experts or stakeholders. The state-of-the-art of method is briefly discussed in the following section. Then, the study aims to demonstrate the said method through an illustrative case study in Cambodia.

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2. Methodology

The methodology is developed toward a problematique analysis described in Promentilla et al. (2016). A problematique is a complex problematic situation analyzed by a set of interrelated problems to describe it. Problematique analysis thus provides a mapping of a particular complexity that arises from the human's perception and interpretation of the problematic situation. The analysis is done by decomposing the problem into aggravating factors and elucidating the importance of these factors and their causal relationships. The proposed method puts emphasis on the description of interrelationships of these factors or problem symptoms and causes as identified by the stakeholders or experts. Such an approach could aid us in elucidating the structure that underlies the problematic situation and thus increases the potential of finding effective solutions (Warfield and Perino, 1999).

2.1 Fuzzy AHP

Analytic Hierarchy Process (AHP) and its variant or extension are one of the widely used multicriteria decision analysis (MCDA) tools to compute priority weights from the value judgment of the decision-makers. Since its original conception in the 1970s for conflict resolution (Alexander and Saaty, 1977), this decision-aiding tool has been applied in numerous problem domains of interest. One of the main tenets of AHP is the measurement of intangible priorities from a pairwise comparison matrix. One most recent emerging extension of AHP is the incorporation of the spherical fuzzy set to handle uncertainty attributed to the ambiguity in eliciting judgments from respondents (Gündoğdu and Kahraman, 2019). The spherical fuzzy set provides the mathematics to deal with the ambiguity or fuzziness of the value judgment in three dimensions, namely the degree of membership (μ), nonmembership (v), and hesitancy (π). To simply note, the spherical fuzzy set is one of the recent extensions of the ordinary fuzzy sets to capture the vagueness and impreciseness in human thoughts. Spherical fuzzy set theory focuses on the better definition of vagueness, imprecision, and indeterminacy to create a system more analogous to human thinking style when linguistic assessment is involved in the decision-making process. For example, some decision problems present qualitative aspects that are difficult to assess precisely by numerical values but can be expressed in linguistic terms as fuzzy sets. In contrast to a classical or crisp set where an element either belongs to (μ=1) or not (μ=0), the degree of membership (μ) of an element in a fuzzy set is a value between zero and one to capture the ambiguity. However, the degree of nonmembership (v) of the said element is not always equal to one minus the degree of membership because of hesitation due to the imprecision and indeterminacy of the assessment. The degree of hesitancy (π) thus expresses the lack of knowledge of whether an element belongs to the fuzzy set or not. The idea behind the spherical fuzzy sets is to generalize the extension of fuzzy sets by defining the membership function on a spherical surface and independently assigns the parameters of the membership function with a larger domain. Details on the theory of spherical fuzzy set is described in Gündoğdu and Kahraman (2019) and the references therein. By using a spherical fuzzy set, the linguistic term for the pairwise comparison is defined as shown in Table 1.

Table 1: 7-point spherical fuzzy linguistic scale for AHP pairwise comparison

Linguistic term	Spherical fuzzy number [μ, v, π]	Score index
Very highly more important (VHI)	[0.70, 0.30, 0.20]	5
Highly more important (HMI)	[0.65, 0.35, 0.35]	3
Slightly more important (SMI)	[0.60, 0.40, 0.40]	2
Equally important (EI)	[0.50, 0.40, 0.40]	1
Slightly less important (SLI)	[0.40, 0.60, 0.40]	1/2
Highly less important (HLI)	[0.35, 0.65, 0.35]	1/3
Very highly less important (VLI)	[0.30, 0.70, 0.20]	1/5

The following steps are described on how to derive the priority weights of the barriers from the spherical fuzzy set extension of AHP:

Step 1: Populate the pairwise comparison matrix with the linguistic judgment (see Table 2) and transform it to spherical fuzzy pairwise comparative judgment matrix A (e.g., see Eq(1)). The relative priorities of these *n* barriers are estimated by eliciting the value judgment of respondents using pairwise comparison questions. For example, the relative importance of barrier *i* as compared to barrier *j* is denoted as a_{ij}. The entries in the primary diagonal are EI (equally important) by default as barrier *i* is comparing to itself in terms of relative importance. Score indices (SI) in Eq(2) can be computed from the spherical fuzzy set φ = S(μ_φ, v_φ, ξ_φ) which can be used as entries in the classical AHP matrix to determine the level of consistency of judgments from the respondents (Gündoğdu and Kahraman, 2019).

$$A = \begin{bmatrix} EI & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & EI \end{bmatrix} \tag{1}$$

$$SI = \sqrt{100*\left[\left(\mu_{\varphi} - \pi_{\varphi}\right)^{2} - \left(\nu_{\varphi} - \pi_{\varphi}\right)^{2}\right]} \quad \text{for linguistic term: VHI, HMI, SMI, EI} \tag{2a}$$

$$\frac{1}{SI} = \frac{1}{\sqrt{100*\left[\left(\mu_{\varphi} - \pi_{\varphi}\right)^{2} - \left(\nu_{\varphi} - \pi_{\varphi}\right)^{2}\right]}} \quad \text{for linguistic term: VLI, HLI, SLI, EI} \tag{2b}$$

Step 2: Compute the spherical fuzzy weights of each barrier *i* using the spherical weighted arithmetic mean operator to aggregate the row entries in the pairwise comparison matrix as shown in Eq(3).

$$\bar{W}_i\left(\varphi_1, \varphi_2, ..., \varphi_n\right) = \tilde{S}\left(\sqrt{1 - \prod_{j=1}^{n}\left(1 - \mu_{\varphi_i}^2\right)^{1/n}}, \prod_{j=1}^{n}\left(\nu_{\varphi_i}\right)^{1/n}, \sqrt{\prod_{j=1}^{n}\left(1 - \mu_{\varphi_i}^2\right)^{1/n} - \prod_{j=1}^{n}\left(1 - \mu_{\varphi_i}^2 - \pi_{\varphi_i}^2\right)^{1/n}}\right) \forall i \tag{3}$$

Step 3: Defuzzify the spherical fuzzy weights using Eq(4) and normalize using Eq(5).

$$\tilde{w}_i^s = \sqrt{100\left[\left(3\mu_{\bar{W}_i} - \frac{\pi_{\bar{W}_i}}{2}\right)^2 - \left(\frac{\nu_{\bar{W}_i}}{2} - \pi_{\bar{W}_i}\right)^2\right]} \tag{4}$$

$$\bar{w}_i = \frac{\tilde{w}_i^S}{\max(\tilde{w}_1^S, \tilde{w}_2^S, ...\tilde{w}_n^S)} \tag{5}$$

2.2 DEMATEL

DEMATEL technique is widely used to solve complex and interrelated problems through structural analysis (Fontela and Gabus, 1972). The DEMATEL framework, for example, was applied to determine the causality among drivers of circular economy (Gue et al., 2019), financial efficiency of 3Ps projects (Wang et al., 2015), among others. For the sake of brevity, the steps for implementing DEMATEL are described elsewhere (Gue et al., 2019). To derive the metrics needed for causal mapping, the initial direct-influence matrix (Z) is first populated to describe the influence among n barriers by asking the experts or stakeholders whether barrier i has a direct influence on barrier j. The individual rating is based on the respondent's pairwise comparison of the barriers according to the 5-point intensity scale wherein zero means "no influence" and 4 denotes "very high influence". Scaling factor is then computed from the maximum of the row sums or column sums of matrix Z. The initial matrix is then normalized by this scaling factor to transform Z to matrix X prior to the computation of the total relation matrix T. Matrix T captures both the direct and indirect influences through the sum of the powers of the said matrix ($T = X + X^2 + \ldots + X^{\infty}$). The row sum ($r$) in T represents the total influences of barrier i to j, which is an indication of the barrier i's strength as a driver or causer. On the other hand, the column sum (c) represents the degree of how barrier j has been influenced by the other barriers. Prominence and network relation index can then be derived from these row sum (r) and column sum (c) computations.

Prominence is the degree of the linkage of barrier in the network of problems as the barrier is both aggravated by other barriers and aggravative to the other barriers. The prominence index ($r + c$) is computed from the sum of the row sum and column sum attributed to the barrier. On the other hand, the network relation index ($r - c$) is the net influence as calculated by the difference of the row sum and column sum attributed to the barrier. If the difference is positive, then the barrier belongs to the causal cluster, which has a net influence that aggravates many other barriers. Otherwise, the barrier belongs to the effect cluster, which is influenced by many other barriers. Accordingly, this index allows problem analysis by structuring the cause-and-effect relations among barriers or sub-problems.

2.3 Problematique causal map

The problematique causal map (pCM) visualizes not only the causal dependencies or influences among the barriers but also the degree of their perceived importance to address the problematic situation. The horizontal axis of pCM represents the prominence index of the barriers, while the vertical axis shows the network relation index of barriers. A threshold (Θ) is defined to filter out the minor influences in the total relation matrix and thus simplify the depiction of the causal relationship among barriers. A digraph (or directed graph) can be plotted in pCM, which describes the barriers as nodes and any significant or major influences between barriers as arcs or arrows. The size of the node (analogous to bubble chart) in the digraph depicts the relative priorities derived from FAHP.

3. Results and Discussion

Common barriers for the growth of SMEs in Cambodia through 3Ps were identified through the literature review and consultation with experts and stakeholders in both public and private sectors. For example, the National Employment Agency (NEA) has conducted the employer survey in 2017 and found that the private sectors, especially SMEs, faced recruitment difficulties due to a low number of applicants with the required skills of technicians and professionals (NEA, 2018). The lack of technical staff and skilled workers to support not only the business operation but also in expansion was emphasized in the said survey. Another report from German International Cooperation (GIZ) identified other barriers such as affordable technology, electricity, and logistic cost, complicated tax & customs procedure, access to finance and systematic support, and unfair competition (GIZ, 2020). Moreover, a report by the Asian Development Bank (ADB) also discussed the constraints, i.e., electricity, licenses and permits, access to finance, and unfair competition, to name a few, faced by SMEs (ADB, 2012). Table 2 summarizes the common barriers validated by the experts through interview and focus group discussion including the sample results from the problematique analysis.

Table 2: Definition of barriers and summary of results

Label	Barriers	Rank[e]	Causal/Effect[f]
B1	Lack of technical staffs and skilled workers for the business operation[a,d]	2	Effect
B2	Lack of up to date & affordable technology to produce quality product[b,d]	4	Effect
B3	High electricity & logistic costs as barrier to expand business[b,c,d]	3	Effect
B4	Complicated tax & customs procedure, licenses/ permits, other legal issues as barrier to set-up and operate business[b,c,d]	5	Causal
B5	Lack of systematic support to access the financial support & loan to expand business[b,c,d]	6	Effect
B6	Lack of systematic support to expand business market overseas[b,d]	7	Effect
B7	Unfair competition due to the lack of business network[b,c,d]	1	Causal

Source: [a] (NEA, 2018), [b] (GIZ, 2020) [c] (ADB, 2012), [d] Experts' validation, [e] FAHP, [f] DEMATEL

Table 3 describes a sample pairwise comparison matrix with the computed spherical fuzzy weights and the normalized weights. For example, the respondent perceived that barrier B2 is slightly more important (SMI) than B1 in terms of resolving the problematic situation. This automatically assumes that B2 is slightly less important (SLI) than B1, i.e., the inverse of the judgment in AHP pairwise comparison matrix. Using the spherical fuzzy set defined in Table 1, and Eq(3), the spherical fuzzy weights ($\tilde{w}_i^S$) were computed. These fuzzy weights were then defuzzified and normalized using Eq(4) and Eq(5) to compute the single-value priority weights ($\overline{w}_i$). With a computed weight of 1.0, B7 is interpreted as most important according to this respondent. The last column in Table 3 also shows the relative priorities of the other barriers with respect to the most important barrier B7.

Table 3: Pairwise comparison of barriers in terms of their importance to address the SMEs challenges

	B1	B2	B3	B4	B5	B6	B7	$\tilde{w}_i^S$[μ, ν, π]	$\overline{w}_i$
B1	EI	SMI	EI	SMI	HMI	HMI	EI	[0.58, 0.39, 0.39]	0.94
B2	SLI	EI	EI	EI	EI	SMI	SLI	[0.49, 0.45, 0.40]	0.77
B3	EI	EI	EI	EI	SMI	SMI	HLI	[0.52, 0.43, 0.40]	0.82
B4	SLI	EI	EI	EI	EI	EI	HLI	[0.47, 0.45, 0.39]	0.73
B5	HLI	EI	SLI	EI	EI	EI	SLI	[0.46, 0.48, 0.39]	0.71
B6	HLI	SLI	SLI	EI	EI	EI	VLI	[0.43, 0.52, 0.38]	0.67
B7	EI	SMI	HMI	HMI	SMI	VHI	EI	[0.61, 0.37, 0.36]	1.00

Table 4 describes an example of an initial direct-influence matrix which was populated by averaging the ratings from the respondents. The entries in the principal diagonal have a value of zero since the barrier has no direct influence on itself by default. The term "influence" here refers to the degree on how the problem, such as barrier *i* (see the row in Table 4) aggravates the other problem, barrier *j* (see the column in Table 4). The average influence ratings of the respondents were normalized and transformed to yield the total relation matrix (see Figure 1a), which accounts for both direct and indirect relations. Such indirect relations also yield a self-loop to the barrier itself, as indicated by a non-zero value in the primary diagonal of the total relation matrix (Figure 1a). The self-loop means that barrier *i* can aggravate the other barriers directly or indirectly but at the same time be aggravated by these barriers, and thus creating a vicious cycle.

Table 4: Initial direct-influence matrix for this case study

	B1	B2	B3	B4	B5	B6	B7
B1	0.00	2.46	1.23	1.00	1.85	1.46	0.31
B2	2.38	0.00	1.85	0.62	2.08	2.31	0.77
B3	0.85	1.31	0.00	0.08	0.77	1.69	0.38
B4	0.92	1.62	1.38	0.00	1.69	2.46	2.31
B5	1.92	2.77	1.23	0.69	0.00	3.08	1.08
B6	1.85	1.54	0.85	2.00	2.46	0.00	1.69
B7	1.00	1.00	1.23	2.46	1.85	2.85	0.00

a) Total relation matrix and the computed prominence and net relation index

	B1	B2	B3	B4	B5	B6	B7	r+c	r-c
B1	0.20	0.38	0.24	0.20	0.34	0.37	0.16	4.03	-0.23
B2	0.38	0.26	0.30	0.21	0.39	0.45	0.21	4.64	-0.23
B3	0.19	0.23	0.10	0.10	0.20	0.28	0.11	2.97	-0.57
B4	0.31	0.38	0.29	0.19	0.39	0.50	0.32	3.96	**0.78**
B5	0.38	0.46	0.29	0.23	0.29	0.53	0.25	4.87	-0.02
B6	0.36	0.38	0.26	0.31	0.44	0.35	0.29	5.37	-0.60
B7	0.31	0.35	0.28	0.35	0.40	0.52	0.19	3.91	**0.86**

b) Problematique causal map

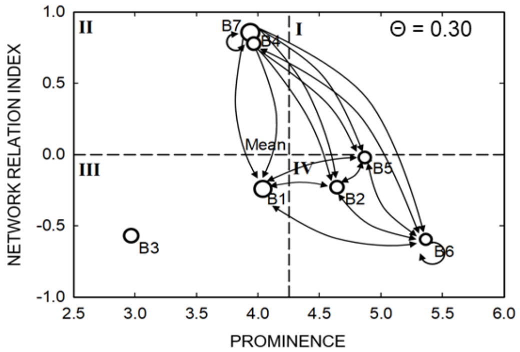

Figure 1: Interrelationship of barriers according to the respondents

Figure 1b shows a sample problematique causal map of barriers by plotting the barrier in terms of prominence (r+c column in Figure 1a) and network relation index (r-c column in Figure 1a). The map is divided into four quadrants by the network relation index = 0 (x-axis) and the average prominence index of 4.25. In quadrant-II with the positive network relation index, B7 and B4 are the key causal barriers that have relatively high influence and aggravates the other barriers (of negative network relation index) in quadrant-III and quadrant-IV. The relative size of the node also suggests the perceived importance of B7, which deserves immediate and high-priority attention to resolve the problematic situation. This underscores the importance of business network for SMEs to address the unfair competition described in B7 (Jin and Jung, 2016). On the other hand, B4 also has a relatively high influence but was not perceived as one of the most important among the barriers. This implies B4 as underrated by the respondent and deserves attention for further evaluation in the light of the network interactions. This corroborates the need of policy reforms for ease of doing business to support SMEs to address the problems described in B4 (Jitmaneeroj, 2016). In contrast, B1 seems to be overrated in terms of its relative importance, given that it is an effect barrier in quadrant-III. Note that B1 does not aggravate many other barriers and may not require immediate attention, but the respondent may perceive its importance at this moment. For a clear depiction of network relations in the map, the arcs in the digraph (see Figure 1b) are plotted by considering only the significant total influences between the two barriers, including to itself. In this example, the threshold value to filter out weak relations is set as the average of the elements (Θ = 0.30) in the total relation matrix *T* of Figure 1a. Accordingly, the yellow-shaded cells in Figure1a are only represented in the digraph since the total relation values are above 0.30. The filtering of the total relation matrix with the threshold resulted in the weakly linked barrier to be shown in the causal map as an independent node (e.g., B3 in quadrant-III), i.e., without any connections to the other barrier in the digraph. On the one hand, the significant self-loop in B6 suggests a strong feedback loop in the network. Note that B6 in quadrant-IV has the highest prominence index suggesting this barrier is highly linked even though its influence is not high. Such cyclic interaction of this barrier with the other barriers should be studied in detail. Though high-priority attention seems to be not that important to resolve the problem situation immediately, this highly linked barrier could be of critical importance and the key to break the vicious cycle in the long term.

4. Conclusions

The proposed method integrates spherical FAHP and DEMATEL to prioritize and identify the causal relationship among barriers to resolve the problem complexity in promoting SMEs in Cambodia. The problematique causal map allows us to visualize how barriers are interconnected and suggest the urgency on where interventions are needed. B7 is a critical causal barrier given its highest priority weight with a positive network relation index. B6 is the most linked barrier with the highest prominence index though it has a negative network relation index. Thus, this study underscores the key barriers which require immediate attention, such as unfair competition due to the lack of business network (B7), and the complication of tax & customs procedure, licenses/ permits, other legal issues to set up and operate the business (B4). Accordingly, it is important to set up diverse business networks in promoting fair competition for SMEs while incorporating policy reforms that promote the ease of doing business and internationalization in SMEs. Further investigation should be done to understand how the lack of systematic support to expand the business market overseas (B7) could be aggravated by other barriers and aggravative to other barriers such as B4. Such insights derived from the analysis could also lead to strategic action plans toward the establishment of a favorable ecosystem not only for SMEs but also startups for the circular economy through such 3Ps mechanism. Future work will consider the different sector's perceptions to make explicit the uncertainty in the context of group decision making.

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