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AN ISM MODELING FOR THE INNOVATION BARRIER IN PROCESSED FOOD INDUSTRY

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Abstract: In Indonesia, the processed food industry is one of the strategic sectors of economic growth because rapid and massive innovation expected to accelerate the recovery of the Indonesian economy during Covid-19 pandemic. Therefore, this study aims to identify the innovation barriers as well as to understand how they interact with each other so that the decision makers can focus on to overcome these barriers. There is a presentation of hierarchy-based and the mutual relationships among these hindrances using interpretive structural modeling. Three main barriers including economic or political uncertainty, overlapping government regulations, and low organizational commitment was identified to show a high driving power with a low dependence because they have strategic importance and require great attention from stakeholders. The results become a reference for stakeholders in formulating the innovation development strategies and several formulating policies for the maintenance of political or economic stability as well as the harmonization of regulations.

Keywords: barriers, innovation, ISM, modeling, processed food industry

***Abstrak:** Di Indonesia, industri pangan olahan merupakan salah satu sektor strategis pertumbuhan ekonomi karena inovasinya yang cepat dan masif diharapkan dapat mempercepat pemulihan perekonomian Indonesia di masa pandemi Covid-19. Tujuan dari penelitian ini adalah untuk mengidentifikasi kendala-kendala inovasi di industri pangan olahan Indonesia sekaligus memahami bagaimana kendala-kendala tersebut berinteraksi satu sama lain sehingga dapat membantu para pengambil keputusan untuk fokus mengatasi kendala tersebut dalam rangka pengembangan inovasi. Penelitian ini menggunakan teknik analisis pemodelan struktural interpretatif (ISM) dengan menyajikan model berbasis hierarki dan hubungan timbal balik diantara kendala-kendala inovasi yang berhasil diidentifikasi. Tiga kendala utama yaitu ketidakpastian ekonomi atau politik, tumpang tindih peraturan pemerintah, dan rendahnya komitmen organisasi terkait inovasi berhasil diidentifikasi, yang menunjukkan daya dorong besar dengan tingkat ketergantungan rendah sehingga ketiganya dapat dikatakan memiliki kepentingan strategis dan memerlukan perhatian besar dari para pemangku kepentingan. Hasil penelitian menjadi acuan bagi para pemangku kepentingan di perusahaan dalam merumuskan strategi pengembangan inovasi dan beberapa perumusan kebijakan yang ditujukan untuk menjaga stabilitas politik atau ekonomi serta harmonisasi regulasi.*

***Kata kunci:** kendala, inovasi, ISM, pemodelan, industri pangan olahan*

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INTRODUCTION

The processed food industry plays an important role in the Indonesian economy because it contributes to Gross Domestic Product. According to BPS (2021), the growth rate of this strategic sector reached a positive number of 1.58% in 2020 while the country's development is -2.07% during covid-19. In the first quarter of 2021, the processed food industry consistently increases by 2.45% while the economic improvement is -0.74%. Furthermore, from 2013 to 2018, this strategic sector performance is above 8-9% surpassing the economic growth rate, and contributes >30% to the Non-Oil and Gas as well as the National GDP. In 2019, this industry development decreased by 7.95% but was still higher than that of economic growth by 5.02%. Therefore, this shows the strategic position of the processed food industry for this country's economy in the past, present, and future.

Moreover, the processed food industry positively affects the national economy including foreign exchange earnings from investment and exports, large employment absorption, and an increase in added value to contribute to Gross Domestic Product achieved through massive innovation. The innovation in this strategic sector ensures an increase in national competitiveness (Kemenperin, 2018). Innovation is an important parameter for companies to ensure the achievement of competitive advantage over competitors, growth, and also long-term sustainability (Bellini et al. 2017; Pantano et al. 2017; Pantano et al. 2018; Souto, 2021). The study of Mu *et al*. (2017) showed that most industries have realized the importance of investing in innovation development to survive and achieve a competitive advantage.

The processed food industry is facing enormous demands for innovation because it is a strategic sector in fulfilling the needs of the community during the pandemic. According to Heinonen and Strandvik (2020), innovation develops quickly, dynamically, and widely because of the crisis. This is related to the concept of "CoviNovation" introduced by Amoah (2021) where industry innovation is rooted in or increased by crises including Covid-19.

Several industries collapse during this pandemic and some continue to innovate to become more resilient in the future (Fretty, 2020). This ongoing crisis coupled with technological breakthroughs helps to create a fertile and hostile environment for business actors by transforming their value chain and innovate (Amoah, 2021). Pandemic also causes changes in the community's consumption patterns, consequently the processed food industry innovate actively and massively by considering health protocols and maintaining food hygiene as well as good taste (Kemenperin, 2021). These transformations are closely related to the marketing system, logistics, and production processes because they create new normality for competitiveness. However, there is a continuation of these innovations in the post-pandemic era where people have received the vaccine because new consumption patterns are formed due to community development.

Therefore, this study shows the importance of innovation in the processed food industry before, during, and after the pandemic in Indonesia. It also focuses on how this innovation develops quickly, massively, and effectively by stakeholders. The innovation process is well performed by understanding the factors that facilitate and hinder its development (Garrigos, 2020; Sucha et al. 2021; Duran et al. 2021). According to Tiina and Leena (2015), the components promoting or facilitating this innovation are more common than the inhibiting one which also become the focus of this study. Innovation barrier is a boundary that prevents or hinder innovation activities between internal firm and external market environments, which are dynamic since their existence and relevance vary (D'Este et al., 2012; Barker, 2017).

This study aims to identify the main innovation barriers in the Indonesian processed food industry and also understand how they interact with one another so that it can help decision makers to focus on overcoming these barriers in the context of developing innovation. However, these innovation barriers are compiled in an Interpretative Structural Modeling. The results showed the rank of each sub-element of innovation barriers that was identified as well as the pattern of relationships among them.

METHODS

This study is quantitative in nature by utilizing Interpretative Structural Modeling (ISM). According to Eriyatno (2012), ISM is a group learning process aimed at photographing the complex nature of a system through designed patterns using graphics and sentences. The study of Saxena (1992) showed that ISM is related to the interpretation of a complete object or system representation using the graphical theory systematically and iteratively manner. Meanwhile, the process of ISM emphasized the importance of geometric shapes over algebra. The structural modeling described the format and structure compared to quantitative measurement results because it is a descriptive and holistic method. Therefore, users tend to improve a better understanding of the system behavior as a whole.

Interpretative Structural Modeling helps to identify the relationship and analyze the effect of one variable on another. This ISM is called interpretive because there is a group assessment in making decisions on how the sub-elements are interrelated. According to Kannan *et al*. (2009), the contextual relationships among the variables always depend on the users' knowledge and familiarity, operations, as well as the industry. Therefore, people's choices affect the final result because ISM does not give any weighting associated with the sub-elements. Figure 1 shows the complete ISM development flow.

This study identifies the sub-elements of barrier elements in the innovation development based on literature, questionnaires, expert, and business practitioner opinions from several processed food industries. Data were collected from April to December 2019 using in-depth interviews and Focus Group Discussions, by involving experts in the Jakarta, Bogor, Tangerang and Bekasi areas. Therefore, 10 barriers were identified and analyzed in terms of the structure level in the processed food industry in Indonesia. The contextual relationship between K^i is that it causes K^j to be ij = 1,2,3, …. meaning that i,j < 10. Table 1 below shows the 10 sub-elements.

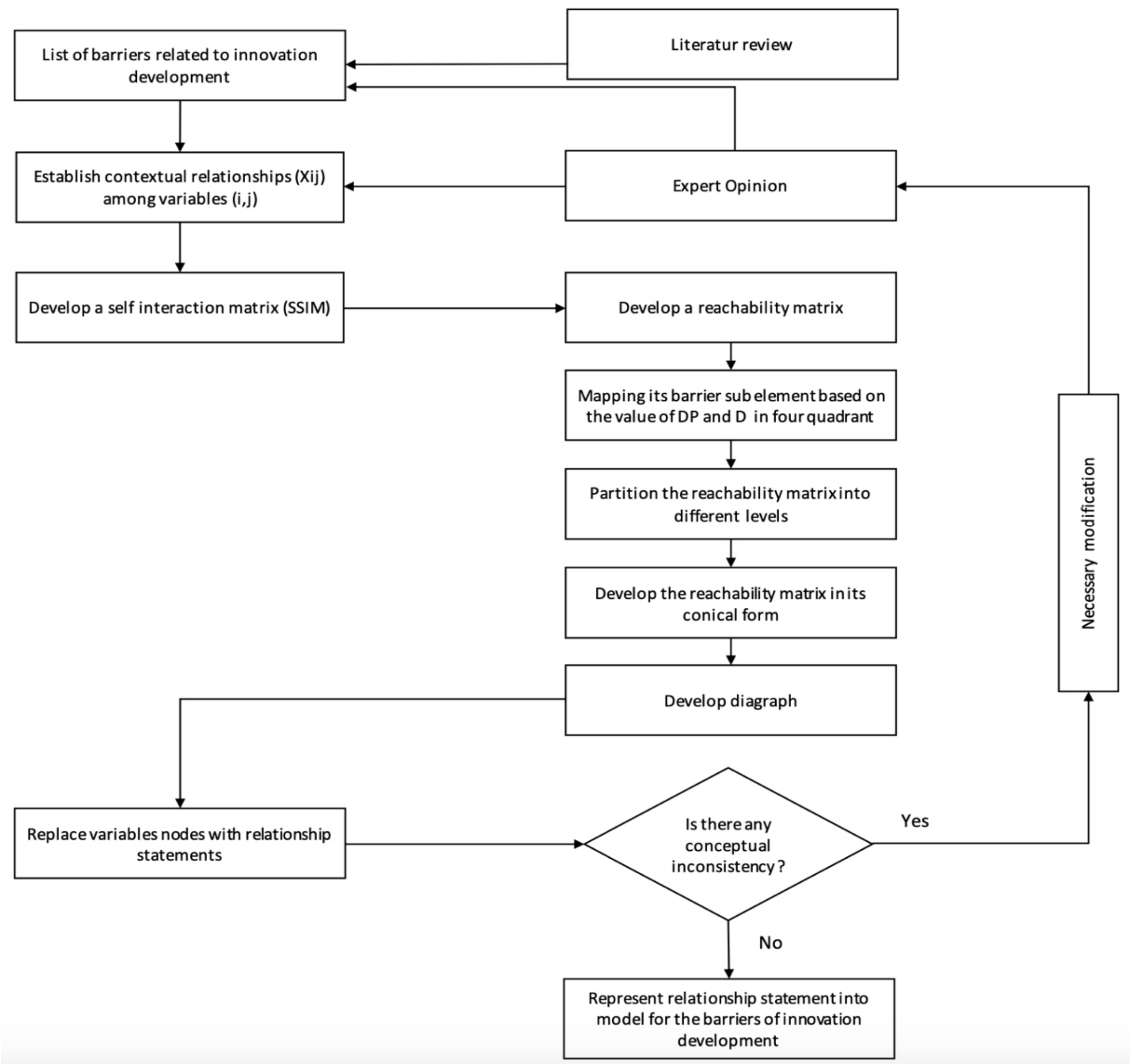

Figure 1. An ISM Model Flowchart of Innovation Development Barriers in Indonesia Processed Food Industry (modified from Kannan et al. 2009)

RESULT

The expert opinion in the FGD forum on the ten barriers was performed by assigning values of V, A, X, and O to the contextual relationship of K^i and K^j. However, four symbols are used to denote the connection between i and j and they include:

V: Barrier i causes barrier j;
A: Barrier j causes barrier i;
X: Barrier i and j causes each other; and
O: Barrier i and j are unrelated.

Table 2 and 3 show the initial structural self-interaction matrix (SSIM) and reachability matrix for the barriers in developing innovation. However, the SSIM is converted into reachability matrix by changing the cell information into binary digits (i.e. ones or zeros). According to Mathiyazhagan et al. (2012), this transformation is performed with the following rules:

- If the entry in the cell (i, j) in the SSIM is V, then the cell (i, j) entry becomes 1 and the cell (j, i) entry becomes 0 in the initial reachability matrix.
- If the entry in the cell (i, j) in the SSIM is A, then the cell (i, j) entry becomes 0 and the cell (j, i) entry becomes 1 in the initial reachability matrix.
- If the entry in the cell (i, j) in the SSIM is X, then the entries in both cells (i, j) and (j, i) become 1 in the initial reachability matrix.
- If the entry in the cell (i, j) in the SSIM is O, then the entries in both cells (i, j) and (j, i) become 0 in the initial reachability matrix.

Table 1. 10 Sub-elements of barriers

Code	Sub-Element	Description
K1	Differences in perceptions regarding the characteristics of innovation	Characteristics of innovation where it is not visible in the short term
K2	Incompetent employees	Lack of highly competent employees in the industry
K3	Low employee commitment in allocating time	Employees have limited time because innovation requires a separate time allocation outside the industry routine tasks
K4	Lack of management capability in decision making	Lack of managerial capability in decision making
K5	Lack of mastery of production technology	Lack of mastery of the latest technology in the production process
K6	Limited access to raw materials	Limited access to raw materials
K7	Low organizational commitment to innovation	Lack of organizational commitment to innovation
K8	Weak market orientation	Weak company orientation to market demands
K9	Economic or political uncertainty	There are still economic or political uncertainties in the domestic sphere
K10	Overlapping government regulations	There are still overlapping government regulations that confuse industry actors

Table 2. The Initial SSIM (Structural Self-Interaction Matrix)

No	K10	K9	K8	K7	K6	K5	K4	K3	K2	K1
K1	A	A	A	A	A	A	A	A	A	
K2	A	A	V	A	V	V	A	V		
K3	A	A	X	A	V	V	A			
K4	A	A	V	A	V	V				
K5	A	A	A	A	X					
K6	A	A	A	A						
K7	A	A	V							
K8	A	A								
K9	X									
K10										

Table 3. The initial reachability matrix

No	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
K1	1	0	0	0	0	0	0	0	0	0
K2	1	1	1	0	1	1	0	1	0	0
K3	1	0	1	0	1	1	0	1	0	0
K4	1	1	1	1	1	1	0	1	0	0
K5	1	0	0	0	1	1	0	0	0	0
K6	1	0	0	0	1	1	0	0	0	0
K7	1	1	1	1	1	1	1	1	0	0
K8	1	0	1	0	1	1	0	1	0	0
K9	1	1	1	1	1	1	1	1	1	1
K10	1	1	1	1	1	1	1	1	1	1

Furthermore, a transitivity test is performed to close the initial reachability matrix of the barriers. A correction is carried out on 8 out of 100 cells and this means that the consistency of expert opinion is 92%. Table 4 and 5 shows the results of the final reachability matrix and the SSIM after the transitivity test. Table 4 shows that the Driver Power (DP) and Dependence (D) barriers are performed with the values of each sub-element to be from K1 - K10. Figure 2 show the mapping results.

Four sub-elements including K9, K10, K7, and K4 are independent quadrant, K2 is exactly at the intersection between the independent and linkage quadrants, while K1, K3, K5, K6, and K8 are at the intersection between the linkage and dependent quadrants. In this mapping, there are no sub elements that are in the autonomous quadrant that are generally not related to the system. Meanwhile, the dependent contains dependent variables, while the independent quadrant comprises of independent variables. According to Eriyatno (2012), sub-elements in the linkage quadrant need special attention because all their actions affect others.

Table 4. The final reachability matrix

No	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	DP
K1	1	0	1	0	1	1	0	1	0	0	5
K2	1	1	1	0	1	1	0	1	0	0	6
K3	1	0	1	0	1	1	0	1	0	0	5
K4	1	1	1	1	1	1	0	1	0	0	7
K5	1	0	1	0	1	1	0	1	0	0	5
K6	1	0	1	0	1	1	0	1	0	0	5
K7	1	1	1	1	1	1	1	1	0	0	8
K8	1	0	1	0	1	1	0	1	0	0	5
K9	1	1	1	1	1	1	1	1	1	1	10
K10	1	1	1	1	1	1	1	1	1	1	10
D	10	5	10	4	10	10	3	10	2	2	

Table 5 The Final SSIM (Structural Self-Interaction Matrix)

No	K10	K9	K8	K7	K6	K5	K4	K3	K2	K1
K1	A	A	X	A	X	X	A	X	A	
K2	A	A	V	A	V	V	A	V		
K3	A	A	X	A	X	X	A			
K4	A	A	V	A	V	V				
K5	A	A	X	A	X					
K6	A	A	X	A						
K7	A	A	V							
K8	A	A								
K9	X									
K10										

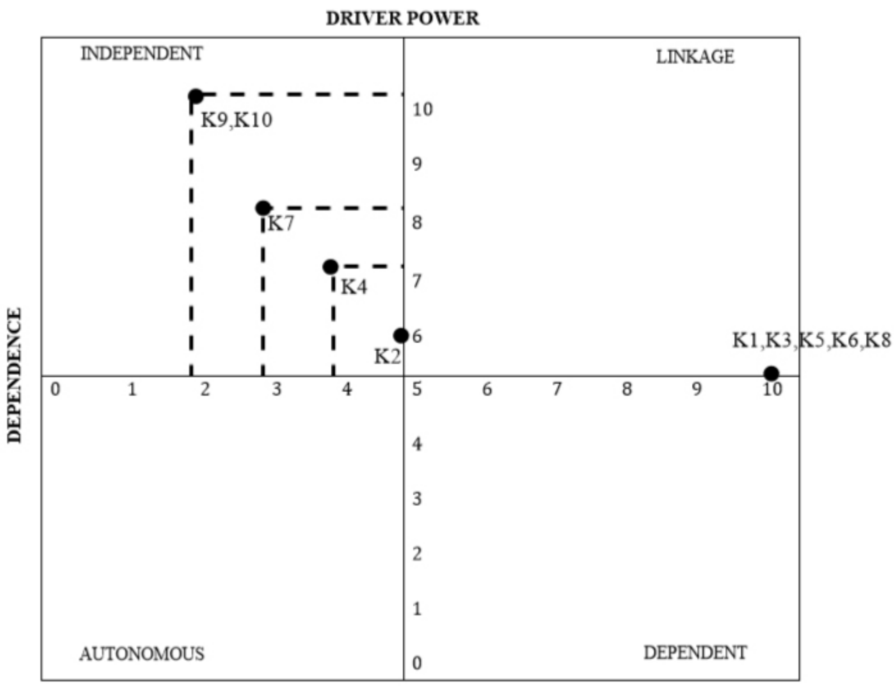

Figure 2. Barrier element mapping based on DP (Driver Power) and D (Dependence)

Economic or political uncertainty (K9) and overlapping government regulations (K10) are in the independent quadrant because they have the largest DP and the smallest D. Subsequently, K9 and K10 are external, while the remaining eight barriers are internal. The low organizational commitment to innovation (K7), lack of management capability in decision making (K4), and incompetent employees (K2) are in the independent quadrant. K7 comprises of the largest DP and the smallest D compared to the other seven internal sub-elements. Meanwhile, incompetent employees (K2), differences in the characteristics of innovation (K1), low employee commitment (K3), lack of mastery of production technology (K5), limited access to raw materials (K6), and weak market orientation (K8) are in the quadrant that intersects with the system linkage. According to Eriyatno (2012), these six sub-elements need to be studied carefully because their relationship is unstable. This means that every effort made to address these barriers promote innovation development in the processed food industry, however the inability to overcome them causes failure.

The partition process that helps to determine the hierarchy level of these sub-elements becomes the next step to be performed after mapping Driver Power (DP) and Dependence (D). This partitioning process is intended to classify the barriers into different levels of an ISM structure. Table 6 shows the iteration stages of the partitioning process.

The process of partitioning the ten barriers involves five iteration stages where in the first, K1, K3, K5, K6, and K8 are obtained at level 1 and the second places K2 at level 2. Furthermore, the third and fourth sequentially place K4 at level 3 and K7 at level 4, and the fifth shows K9 and K10 at the highest level.

Mapping through the canonical matrix is performed to ensure the pattern of the relationships between sub-elements at the hierarchy level in this ISM structure. The result provided as 1 indicates that K^i causes K^j, while the 0 shows the opposite. Generally, this canonical matrix is characterized by 0 and 1 in the triangle above and below the diagonal line respectively. Table 7 shows the canonical matrix on the barrier elements.

Table 6 The Partition Process

Barrier (Ki)	R (Ki)	A (Ki)	Intersection	Level	Description
1	1,3,5,6,8	1,2,3,4,5,6,7,8,9,10	1,3,5,6,8	I	Iteration I
2	1,2,3,5,6,8	2,4,7,9,10	2		
3	1,3,5,6,8	1,2,3,4,5,6,7,8,9,10	1,3,5,6,8	I	
4	1,2,3,4,5,6,8	4,7,9,10	4		
5	1,3,5,6,8	1,2,3,4,5,6,7,8,9,10	1,3,5,6,8	I	
6	1,3,5,6,8	1,2,3,4,5,6,7,8,9,10	1,3,5,6,8	I	
7	1,2,3,4,5,6,7,8	7,9,10	7		
8	1,3,5,6,8	1,2,3,4,5,6,7,8	1,3,5,6,8	I	
9	1,2,3,4,5,6,7,8,9,10	9,10	9,10		
10	1,2,3,4,5,6,7,8,9,10	9,10	9,10		
2	2	2,4,7,9,10	2	II	Iteration II
4	2,4	4,7,9,10	4		
7	2,4,7	7,9,10	7		
9	2,4,7,9,10	9,10	9,10		
10	2,4,7,9,10	9,10	9,10		
4	4	4,7,9,10	4	III	Iteration III
7	4,7	7,9,10	7		
9	4,7,9,10	9,10	9,10		
10	4,7,9,10	9,10	9,10		
7	7	7,9,10	7	IV	Iteration IV
9	7,9,10	9,10	9,10		
10	7,9,10	9,10	9,10		
9	9,10	9,10	9,10	V	Iteration V
10	9,10	9,10	9,10	V	

Table 7 The canonical matrix of barrier elements

	K1	K3	K5	K6	K8	K2	K4	K7	K9	K10
K1	1	1	1	1	1	0	0	0	0	0
K3	1	1	1	1	1	0	0	0	0	0
K5	1	1	1	1	1	0	0	0	0	0
K6	1	1	1	1	1	0	0	0	0	0
K8	1	1	1	1	1	0	0	0	0	0
K2	1	1	1	1	1	1	0	0	0	0
K4	1	1	1	1	1	1	1	0	0	0
K7	1	1	1	1	1	1	1	1	0	0
K9	1	1	1	1	1	1	1	1	1	1
K10	1	1	1	1	1	1	1	1	1	1
D	10	10	10	10	10	5	4	3	2	2

Table 7 shows that K1, K3, K5, K6, and K8 rows have the same set of numbers 1 and 0 from left to right because this data indicates that they are at the same hierarchy level. This is supported by the partitioning process results that these five sub-elements are at level 1 because the number 1 shows them to be reciprocally related to one another. Furthermore, K9 and K10 rows have 1 and 0 from left to right because this data shows that they are at the same hierarchy level. This is supported by the partitioning process results that these two sub-elements are at level 5 because 1 indicates that they are reciprocally related to one another. Meanwhile, K2, K4, and K7 rows have different sets of numbers 1 and 0 and this means that all three are at different levels, strengthened by the partitioning process. Figure 3 shows a hierarchy diagram of the barriers and the relationships patterns that exist between them.

Economic or political uncertainty (K9) and overlapping government regulations (K10) are at the highest level. This means that K9 and K10 are the main sub-elements that lead to others because they are more external. However, the low organizational commitment to innovation (K7) is the highest compared to the remaining seven internal barriers. Therefore, K7 is also the main sub-element besides K9 and K10.

Meanwhile, economic and political stability help to provide business certainty, while its instability causes business actors not to take appropriate steps in running the industry. Economic stakeholders always find it difficult to plan especially in the long term related to investment. According to Soliwoda (2020), the macroeconomic situation and its implications for fiscal or monetary policy are one of the key challenges for innovation development in Poland's financial sector. Furthermore, coordination and synergy between ministries and agencies are important for the industry because conflicting or overlapping regulations cause additional costs for business actors. DeMaria and Zezza (2020) showed that the implementation of energy policies including prices and availability significantly affect innovations in the food processing industry in Europe. Additionally, it is necessary to have the infrastructure, policies, and support networks from the government for creativity to occur. However, progressive government R&D policies help business actors to achieve and maintain the competitiveness of their industry in the global market. Training, R&D initiatives, copyright laws, and access to capital positively affect the innovative perception of stakeholders. According to Ramesh (2020), government policies and initiatives influences innovation and entrepreneurship. Government is playing an important role in providing access to valuable resources and network connection among individuals, groups, organizations and institutions (Scillitoe, 2020). The economic or political uncertainty (K9) and overlapping government regulations (K10) cause low organizational e to innovation (K7) because innovation is a form of long-term investment that requires support for macro-environment stability and clear regulations.

According to Marthis and Jackson (2000), commitment is employee's confidence to accept goals and aspirations to remain with the organization. Also, this phenomenon shows the level of workers' relationship with the industry and their involvement in it (Nobarieidishe et al. 2014). The study of Irefin and Mechanic (2014) described it as an employee's attachment to certain aspects of work situations in an organization. Also, organizational commitment is the confidence, engagement, and involvement level to support goals in achieving innovation. According to Nguyen *et al.* (2019), organizational commitment has a significant positive effect on employees' innovation ability, because innovation requires extra roles and behaviors. The increase in organizational commitment help to improve the worker's ability by enhancing employee engagement as involvement in realizing innovation (Trabucchi et al. 2020; Kassa and Tsigu, 2021). One of the biggest challenges for companies is not to generate ideas but to engage people toward innovation (Verganti, 2017). This commitment allows human resources in achieving goals because innovation has stages from ideas to real superiority in the form of products or others.

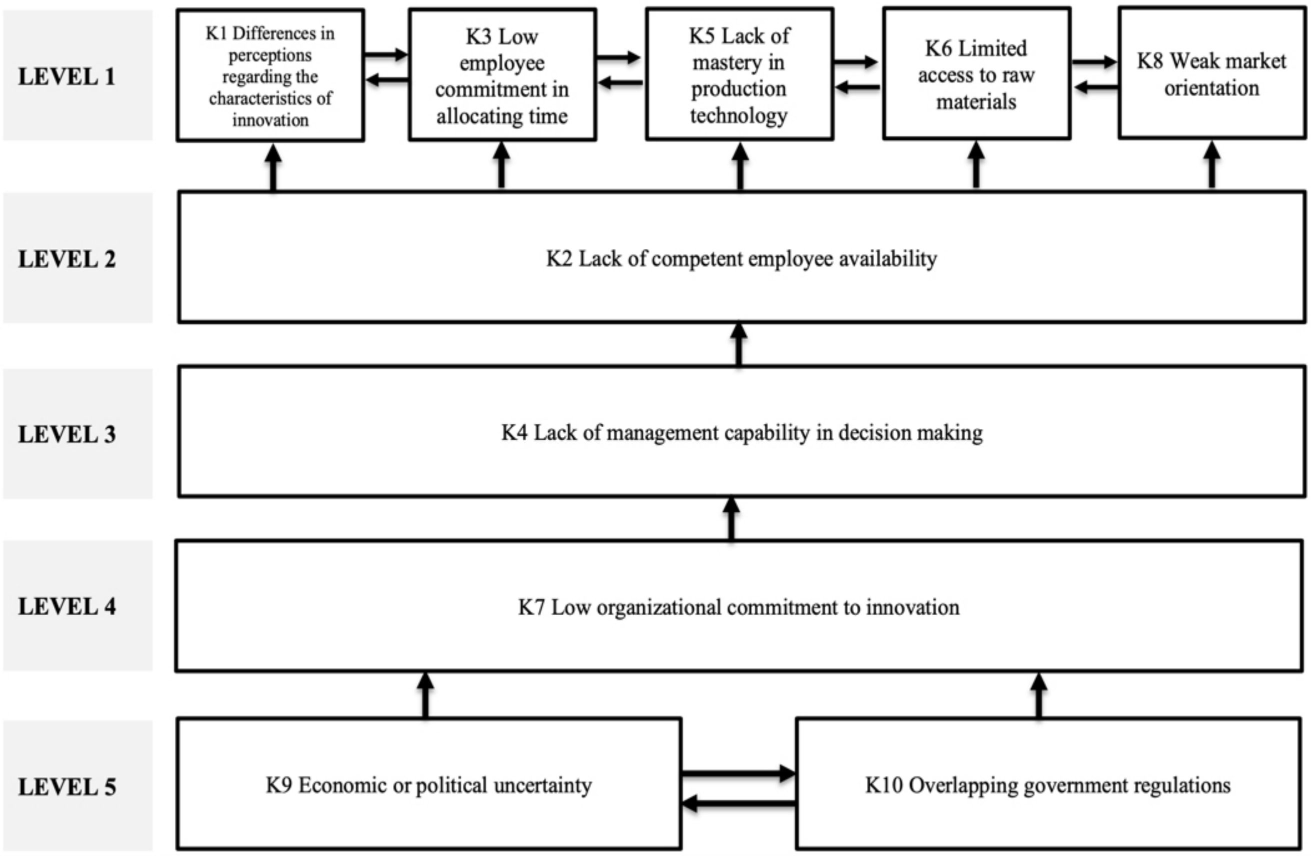

Figure 3. Hierarchy level of barrier elements

The low organizational commitment to innovation (K7) causes a lack of management capability in making decisions (K4) related to tangible and intangible investments for innovation development. Meanwhile, the high organizational commitment helps to assess creative ideas or efforts. This is in line with Sangadah et al. (2021) that stated management capability is one of the important factors in the dairy agroindustry development in rural areas. Furthermore, the lack of management capability (K4) causes incompetent employee's availability (K2) because the ability to manage an industry is characterized by decision making. This is closely related to the choice made in the recruitment, training, and development processes, career paths, as well as programs to retain the best employees. However, workers incompetency (K2) causes the low commitment in allocating time (K3), the ability to master technology related to the production process (K5), overcoming limited access to raw materials (K6), and identifying markets that affect the increase of industry orientation (K8). The five sub-elements at level 1 are in line with the study of Sangadah et al. (2021) that raw material handling activities, application of technology for production, employee training to increase competence, and product marketing strategies are related to market requirements. Moreover, employees with both hard and soft skills tend to have a high commitment because competent workers explore ideas or innovation efforts appropriately to easily see results in the short term (K1).

Managerial Implications

Several industries need to properly manage the three main sub-elements identified in this study. Meanwhile, economic or political uncertainty and overlapping government regulations are the two external barriers that are beyond the organization's control. The industry tends to innovate if it focusses on efforts to increase organizational commitment to innovation (K7) despite economic or political uncertainty (K9) or overlapping government regulations (K10). Furthermore, K9 and K10 tend not to eliminate existing innovation opportunities. According to McKinley et al. (2014) and Wenzel et al. (2020), crisis act as a catalyst of or an inhibitor to innovation.

CONCLUSION AND RECOMMENDATIONS

Conclusions

This study result identifies three main barriers including economic or political uncertainty, overlapping government regulations, and low organizational commitment to innovation. Two main barriers that have been identified in this research are external barriers, and one other main is internal barriers. These results align with previous studies that both external and internal barriers greatly affect the success of innovations carried out by companies. However, the three main barriers identified in this study are unique in relation to the development of innovations in the processed food industry in Indonesia

Meanwhile, economic or political uncertainty and overlapping government regulations are at the highest hierarchy and this enables them to lead to other sub-elements. Economic or political uncertainty and overlapping government regulations are in the independent quadrant with the largest DP and the smallest D because they are external barriers. Meanwhile, the low organizational commitment to innovation is the highest compared to the remaining seven internal sub-elements because it is at level 4. This means that the low organizational commitment to innovation is the main barrier that leads to others at levels 3, 2, and 1. The low organizational commitment related to innovation has the largest DP and the smallest D compared to the remaining seven internal sub-elements.

The results of the research above contribute to the development of theories related to innovation barriers, because the results indicate that external barriers have the largest driver power and the smallest dependence compared to other internal barriers. External barriers can lead to internal barriers in developing innovation in the processed food industry in Indonesia, a form of relationship that has not been widely disclosed from previous studies. In this case, in Indonesia, the government plays a major role in ensuring economic stability and regulating regulations properly. Therefore, stakeholders in the processed food industry need to attend to these three main barriers to increase the competitiveness of this industry in the future.

Recommendations

In Indonesia, ISM related to the barriers in developing innovation need to be developed in other industries with similar or different characteristics to enrich knowledge improvement. Also, further study needs to be performed by involving not only business actors but also suppliers, consumers, government, and universities to strengthen as well as enrich this study results.

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