Modelling the continuous innovation capability enablers in Indonesia's manufacturing industry

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Received 11 April 2020
Revised 26 August 2020
13 October 2020
Accepted 24 October 2020

Abstract

Purpose – The purpose of this paper is to identify and screen continuous innovation capability enablers (CICEs) in Indonesia's manufacturing sectors, develop a relationship among these enablers and determine their driving power and dependence power in the sector.

Design/methodology/approach – The initial CICEs identification process is based on a literature review, while a fuzzy Delphi method (FDM) was used for the screening process of CICEs. Total interpretive structural modelling (TISM) was used to develop contextual relationships among various CICEs. The results of the TISM are used as an input for the matrix of cross-impact multiplications applied to classification (MICMAC) to classify the driving power and dependence powers of the CICEs.

Findings – This paper selected 16 CICEs classified in seven dimensions. TISM results and MICMAC analysis show that leadership, as well as climate and culture, are enablers with the highest driving power and lowest dependence powers; followed by information technology. The results of this study indicate that efforts to continuously develop innovation capabilities in the Indonesian manufacturing industries are strongly influenced by their leadership capability, climate and culture, also information technology-related capability.

Practical implications – The framework assessed in this study provides business managers and policymakers to obtain a bigger picture in developing policies with evidence-based strategy and priority in regard to continuous innovation capability.

Originality/value – The results will be useful for business managers and policymakers to understand the relationship between CICEs and identify key CICEs in Indonesia's manufacturing sectors, which were previously non-existent.

Keywords Innovation, Manufacturing, Fuzzy, Expert systems, Modelling, Innovation enablers, Continuous innovation capability, Indonesia

Paper type Research paper

1. Introduction

The manufacturing sectors can be analysed from different perspectives depending on what information is being sought. This is because manufacturing sectors in the Asia Pacific are diverse and consist of many sectors, covering a wide range of perspectives from energy efficiency (Foumani and Smith-Miles, 2019) to automation (Foumani *et al.*, 2020). The perspective of this study specifically is concentrated on Continuous Innovation (CI) as it has been widely proven as one of the key factors for a company's competitiveness and success in

The authors would like to thank University of Surabaya (UBAYA) for permits and support this research funding.

Journal of Modelling in Management

1746-5664
DOI 10.1108/JM2-04-2020-0103

the ever-changing and dynamic business and industries environment (Steiber and Alänge, 2013; Javahernia and Sunmola, 2017; Stålberg, 2018; Lianto *et al.*, 2018). Rothaermel and Hess (2010) stated that CI is the engine driving highly successful companies such as Apple, Google, Honda, Hewlett-Packard, Microsoft, General Electric, P&G, Sony and Tata Group. Hyland and Boer (2006) defines CI as the fundamental task for an organization that exists in dynamic and unstable environments and it requires constant surveillance of regulatory policies, technologies and the capability to quickly accomplish changes while being and staying successful in the market place at the same time, all the time. CI is also referred to as the ability to continuously innovate and renew an organization to develop new products and business models (Steiber and Alänge, 2013).

Given the importance of continuous innovation, many companies, including the ones in Indonesia's manufacturing industry, strive to manage their innovation activities effectively and sustainably as a means of preparation to enter the very dynamic business environment in the Fourth Industrial Revolution. Hence, companies need to have a model or methodology to monitor their continuous innovation capability (CIC) to ensure innovation activities in the company are performed continuously in a timely and sustainable manner (Steiber and Alänge, 2013). The models are needed to identify ways to stay innovative sustainably, in the long term.

Previously, CIC has been studied from various setting and various enablers, called their continuous innovation capability enablers (CICEs), have been identified (Joshi *et al.*, 2010; Steiber and Alänge, 2013; Steiber, 2014; Ab Rahman *et al.*, 2015; Chen, 2016). However, the effort to formulate contextual relationships between CICEs and to determine the driving power and dependence power of each enabler is still limited, particularly for Indonesia's manufacturing industry. Thorough understanding of prominent CICEs, their relationship patterns, as well as driving power and dependence power is much needed because they will provide insights to academic experts, industry practitioners and the government on which crucial enablers needed the most to develop sustainable CI capability. Dewangan and Godse (2014) mentioned that a holistic understanding of the system of innovation capability and performance must be able to show cause and effect relationship between measured factors or elements.

The purpose of this paper is to fill the gap in determining contextual CICEs in the manufacturing industry in Indonesia, to investigate the contextual relationships between selected CICEs and to determine their driving power and dependence power. The paper will provide insights to industry managers and practitioners on how to effectively manage the innovation process and to obtain a proper macro picture analyzing the relationship between CICEs – as to assist them in selecting strategic CICEs to focus on.

The paper is structured as follows: firstly, the selection of previous research on CI, CIC and CICEs will be made available, the review focuses more on factors relevant to the manufacturing industry and particularly for the Indonesian context. Secondly, the method for this study will be presented: selection process for CICEs was performed by using the fuzzy Delphi method (FDM) approach, with a panel of industry practitioners and academic experts, followed by drawing a contextual relationship between CICEs using total interpretive structural modelling (TISM) model involving a panel of experts from Indonesian manufacturing associations and by determining driving power and dependence power of CICEs using the matrix of cross-impact multiplications applied to classification (MICMAC). Fourth, the research result and its subsequent implications will be discussed.

2. Literature review

Nowadays, with a very competitive business environment, innovation has become one of the most important sources of competitive advantage for many companies (Chutivongse and Gerdsri, 2018). However, in a very dynamic business environment, innovation performance is not sufficient. Javahernia and Sunmola (2017) implied that CI capability, that is the ability to continuously innovate, is needed by the manufacturing industry today so the industry can have high competitiveness and continue to survive; by continuously producing new products, new processes, new service systems and new business models that are always relevant to the needs. Xue in Chen (2016) explained three characteristics of CI, i.e. persistence, sustainable economic growth and sustainable development of enterprises. Based on those characteristics, CI is a process performed consistently in the long term, to achieve sustainable economic performance and development in a company. This concept is supported by Xiang and Wu (2012), they promoted the *enterprise sustainable innovation* concept – a long term process in which a company constantly introduces and implements new innovation projects and subsequently benefiting sustainably from the process.

CI is also defined as the ability of a company to renew the organization, to develop new products, new processes and new business models (Steiber and Alänge, 2013). Boer and Gertsen (2003) mentioned three essential elements of CI: continuous improvement, learning, dan innovation. Consistent and effective interaction between continuous improvement, learning, dan innovation will contribute significantly to sustainable innovation in an organization. Nisula and Kianto (2013) proposed a concept of organizational renewal capability, of which a company with constant renewal willingness and the process will have the advantage to properly develop, change, modify and organize resources, knowledge, assets and routines to boost its competitiveness.

In practice, CI is determined strongly by CIC – a set of fundamental elements and comprehensive characteristics in an organization required to facilitate and support innovation activities. This set consists of different capabilities, acting as assets and special resources within an organization in doing innovation activities. Determining factors for CICEs or so-called continuous innovation capability enablers, are complex and diverse (Boly *et al.*, 2014; Saunila, 2017; Saunila and Ukko, 2012). Steiber and Alänge (2013) mentioned seven determining factors for CIC, i.e. culture, individuals, leaders, organization, P&I system, learning and external interaction. The following year, Steiber (2014) proposed the Six Management Principles of Continuous Innovation, consisting of dynamic capabilities, a continuously changing organization, a people-centric approach, an ambidextrous organization, an open organization that networks with its surroundings, dan a systems approach. Colarelli O'Connor in Björkdahl and Börjesson (2012) stated that in a systemic approach for innovation activities in an organization, these factors are important: organizational structure, leadership, organizational culture, development of people skills, organizational governance and decision-making mechanism.

A number of CICEs relevant to the manufacturing industry are presented and explained in the following.

2.1 Digital technology

The role of digital technology, usually identified as a form of modern technology such as cloud, wearables, mobile, social media and business analytics, has been acknowledged in improving a company's innovation potential (Lokuge *et al.*, 2019). Ferreira *et al.* (2019) mentioned that digital technology will open a big opportunity for a company to develop its innovation capability, particularly in this digital era. It will also allow companies to collaborate with other necessary parties but at a low capital intensity (Tan *et al.*, 2016). Past research on manufacturing industries in various countries shows that digital technology influences the development of innovation capability (Oldham and Da Silva, 2015; Ravichandran, 2018).

2.2 Information technology

Research and observation on manufacturing industries in various countries show that information technology (IT) capability influence the development of an innovation capability (Dong and Netten, 2017; Joshi *et al.*, 2010; Benitez *et al.*, 2017; Chen *et al.*, 2015). Good IT capability will dispense data or information up/down to or from employees so a company can adapt fast to changes in the environment (Chae *et al.*, 2018). Ben Moussa and El Arbi (2020) also concluded that investment in improving IT capability such as the implementation of the human resources information system, could improve individual innovation capability, particularly to enhance human resource creativity and the ability to find new approaches and solutions.

2.3 Production technology

Several studies found that the innovation capability of a company is determined by its ability to develop production technological capabilities (Afuah, 2002; Reichert *et al.*, 2011). Production technology capability will support the development process and production of new products. A number of research on manufacturing industries in various countries also indicated production or manufacturing technology capability as the core indicators to evaluate continuous innovation capability (Chen, 2016). It also should be noted that one of the primary aspects of technology innovation capability is manufacturing capability, determined by the advanced manufacturing technology level of an organization (Wang *et al.*, 2008). Production technology capability will also influence the innovation process strategy of a company to yield high-quality, flexible and efficient products – readily delivered to consumers in a precise and timely manner (Prajogo, 2016).

2.4 Internal research and development

Internal research and development have been recognized as an effective management strategy to facilitate firms' innovation (Zhang and Tang, 2017). Internal research and development (R&D) capability will improve a company's ability to renew their technological knowledge, nurturing the company's ability to redesign products for ease of use, increasing the range of customized options, radical changes in product definition and open up to the new market (Kocoglu *et al.*, 2012). A number of research on manufacturing industries clearly highlight the finding that R&D capabilities are one of the key factors for innovation capability development, particularly for large-scale industries (Boly *et al.*, 2014; Dong and Netten, 2017; Gkypali *et al.*, 2017; Gu *et al.*, 2016; Hsu *et al.*, 2017; Rasiah *et al.*, 2016).

2.5 Adaptive capability

The adaptive capability has been understood as abilities related to problem-solving and speedy responses to customers, responses to market customer opportunities, response to opportunities and speedy response in pursuing these opportunities (Wei and Lau, 2010). Employee's adaptive capability will increase their creativity in developing diverse products and processes in response to new opportunities. Several studies on CI capabilities in the manufacturing industries in various countries showed that adaptive capability influences the development of continuous innovation capability (Boly *et al.*, 2014; Rangus and Slavec, 2017). Wiwoho *et al.* (2020) found that adaptive capability was positively related to product innovation. Another study by Ali *et al.* (2017) also highlighted a strong and significant relationship between adaptive capability and organizational innovation. They found that all dimensions of adaptive capability helped to develop and to improve the performance of organizational innovation.

2.6 Skill and education

Employee's skill and education level are widely observed as one of the determining aspects for a company to develop its innovation capability (Kianto *et al.*, 2017; Liu *et al.*, 2017; Ben Moussa and El Arbi, 2020). Employees with higher skill and education levels tend to have a higher commitment, and thus can give more contributions to innovation performance. Mir-Babayev (2015) found that those employees would support a company in patent development to improve product innovation performance. These observations were also supported by various researchers, confirming that skill, education and talent influence the development of an innovation capability (Ceci and Iubatti, 2012; Steiber, 2014; Zeng *et al.*, 2017).

2.7 Motivation and participation

Employees' motivation to be part of an innovation process is affected by multiple factors. The ability of an employee to make decisions and feel empowered is a significant factor in their motivation to participate in innovation processes (Palin and Kaartemo, 2016). The motivation resulted from support from the company's management will affect their participation level in the company's innovation activities (Fernandez and Pitts, 2011). In another study, it was found that encouragement and support from the company's side are key factors for employees to feel bound to innovate. Allen *et al.* (2015) mentioned that a proper human resource management approach contributed to increasing trust and consequently boost employee's motivation and participation in innovation processes. One fundamental principle found in companies with continuous innovation capabilities is that they are people-centric (Steiber, 2014). This finding is also supported by Banerjee (2014).

2.8 Integrated strategy

Several past studies discovered that the strategy dimension plays an important role in maximizing the capability of a company's innovation (Rohrbeck and Gemünden, 2011). A number of factors related to the dimension include strategic enablers (Sun *et al.*, 2012), integrated strategy (Boly *et al.*, 2014) and strategic competence (Nisula and Kianto, 2013; Mir *et al.*, 2016). Aramburu and Sáenz's (2011) studies revealed that innovation strategy and the network had a significant influence on innovation capability. An innovation strategy facilitates an organization's ability to identify external opportunities and match those opportunities with internal capabilities so as to explore new markets and deliver innovative products (Wang and Ahmed, 2004).

2.9 Dynamic capabilities

Dynamic capabilities refer to how a firm uses resources to respond to or initiate market changes (Michailova and Zhan, 2015). Dynamic capabilities are also considered as strategic dimensions, describing the ability of a company to integrate, develop and reconfigure internal and external competencies to face rapid changes. There are three dynamic capability skills, namely, sensing and shaping opportunities/threats, seizing opportunities and maintaining competitiveness (Teece, 2007). Dynamic capabilities will play a role in a company's activities to harmonize and integrate various resources, to reconfigure resources and to create new knowledge routines, in which company leaders build up new resources and knowledge in developing innovation capabilities (Eisenhardt and Martin, 2000).

2.10 Leadership

The role of leadership in supporting innovation by creating a conducive environment has been established in the literature (Lawson and Samson, 2001; Saunila *et al.*, 2014).

Chang *et al.* (2015) stated that leadership is the key to facilitating innovation activities and tends to affect the success of companies in emerging countries. On the other hand, Xie *et al.* (2011) revealed that the style of leadership greatly influences the innovation atmosphere in a company and can facilitate trust and individuals' identification. Several studies on manufacturing industries in various countries showed that leadership capability greatly influences the development of an innovation capability (Delgado-Verde *et al.*, 2011; Xie *et al.*, 2018; Sun *et al.*, 2012; Nisula and Kianto, 2013; Steiber and Alänge, 2013; Chang *et al.*, 2015; Carreiro and Oliveira, 2019).

2.11 Culture and climate

Numerous studies have recognized organizational culture and climate as a driving force for innovation capability. Past research also showed that climate and culture determine the innovation performance of a company (Shahzad *et al.*, 2017). A strong organizational culture tends to significantly stimulate the creativity and innovation behaviour of employees by creating formal rules and regulations with an open climate for employees to develop ideas and creativity (Naranjo-Valencia *et al.*, 2016). Research on manufacturing industries in various countries indicated that the organization's culture and climate have a positive influence on innovation capability development (Sarros *et al.*, 2008; Delgado-Verde *et al.*, 2011; Steiber and Alänge, 2013; Boly *et al.*, 2014).

2.12 Organizational agility

Organizational agility, defined as a company's ability to respond swiftly and innovatively to unexpected changes, has been widely recognized as an important capability to develop innovation in a company (Lu and Ramamurthy, 2011). Cai *et al.* (2017) stated that organizational agility will drive a company to be more sensitive to valuable market information and subsequently, act and make decisions for product innovation. Past research in manufacturing industries in various countries indicated that organizational agility has a positive influence on innovation capability development (Ravichandran, 2018; Rohrbeck and Gemünden, 2011; Wu *et al.*, 2016).

2.13 Project management skill

Project management skill has been highlighted as one of the most important enablers of innovation capability (Guertler and Sick, 2020). The role of project management in supporting innovation activities and projects in a company has become increasingly significant. Kavanagh and Naughton (2009) found that the ability to develop and maintain innovation capability was determined by a company's ability to advance and preserve project management skills at world-class levels. Hernandez and Cormican (2016) proposed the need for a project management approach in social innovation-oriented projects. Ju *et al.* (2019) also mentioned that agile project management contributed to increasing a company's innovation capability. Research on innovation capabilities in various countries indicated that project management skills have a positive influence on innovation capability development (Boly *et al.*, 2014; Mir *et al.*, 2016; Zeng *et al.*, 2017).

2.14 Structure and system

One of the six management principles proposed by Steiber (2014) is a continuously changing organization. This principle states that organizations need to continue to change and adapt to changing dynamic business and industrial environments. Conversely, Steiber and Alänge (2013) expressed that the organization structure and performance of an incentive system in an internal infrastructure is very important for the development of continuous innovation capabilities. Past research on innovation capabilities in various countries revealed that the organization's structure and system have a positive influence on its development (Chen *et al.*, 2015; Palacios-Marqués *et al.*, 2016; Rangus and Slavec, 2017; Zeng *et al.*, 2017).

2.15 Knowledge management capacity

In a rapidly changing market, the knowledge dimension plays a central role in determining opportunities for innovation and company excellence (Dong and Netten, 2017; Dong *et al.*, 2016). Knowledge is a key component in achieving long-term continuous innovation and has been widely accepted in modern management (Chapman and Magnusson, 2006). A study by Yusr *et al.* (2014) showed that the ability of the manufacturing industry to administer their knowledge management optimally will increase their innovation capability. Chapman and Hyland (2004) revealed that the capabilities of continuous innovation are closely associated with the knowledge management system and processes. A number of other studies on innovation capabilities in the manufacturing industry highlighted similar findings (Boly *et al.*, 2014; Liu *et al.*, 2017; Pérez-Luño *et al.*, 2011; Santoro *et al.*, 2018; Wang and Hu, 2017).

2.16 Knowledge assets

Knowledge assets are identified as one of the key organizational factors to support innovation development in a company (Delgado-Verde *et al.*, 2011). The number and the quality of knowledge assets and their optimum utilization will contribute positively to innovation activities (Rupietta and Backes-Gellner, 2019). Management of knowledge assets, in the form of intellectual property rights, will also affect a company's innovation productivity (Allarakhia and Walsh, 2011). Past research on innovation capabilities in various countries revealed that knowledge assets have a positive influence on its development (Joshi *et al.*, 2010; Delgado-Verde *et al.*, 2011; Rupietta and Backes-Gellner, 2019)

2.17 Organizational learning

Learning has been emphasized as one of the most important enablers of innovation capability (Bessant *et al.*, 2012). Xie *et al.* (2011) stated that continuous innovation capability could be formed through continuous learning and renewal process to achieve a self-sustaining and self-reinforcing state. The learning process will bridge the working process and innovation process (Iddris, 2016). It is recommended that lifelong learning, management support and risk tolerance should be encouraged to improve creativity. A high level of creativity is important in enhancing the capacity to integrate internal and external knowledge for greater levels of organizational learning. Further research should be carried out to find how customers' and suppliers' information can be used to enriched organizational learning (Gachanja *et al.*, 2020). It has been recorded that organizational learning capability influenced the development of innovation capability (Boly *et al.*, 2014; Chen, 2016; Nisula and Kianto, 2013).

2.18 Inter-firm collaboration

Numerous empirical studies have confirmed that innovation is influenced by social interactions and social networks (Gonzalez-Brambila *et al.*, 2013; Guan and Liu, 2016). In this digital and enhanced connectivity era, companies have the advantage and opportunity to develop collaborative innovation networks and to work on innovations collectively. This circumstance drove the emergence of a new innovation strategy called Open Innovation (OI).

With OI, the innovation performance of a company is no longer dependent on internal knowledge and technology but also needs to be completed with external knowledge obtained from the company's ability to form linkages with external parties. Numerous studies on the innovation capabilities of the manufacturing industries in various countries showed that several factors related to inter-firm collaboration have a significant effect on the development of innovation capabilities: cooperative networks (Gu *et al.*, 2016), collaboration innovation activities (Wang and Hu, 2017), open innovation (Santoro *et al.*, 2018), connectivity (Nisula and Kianto, 2013), external interaction (Steiber and Alänge, 2013), social capital (Pérez-Luño *et al.*, 2011), informal social interaction (Liu *et al.*, 2017), collaboration (Walsh *et al.*, 2016) and customer input (Gu *et al.*, 2016).

2.19 Intra-firm collaboration

Innovation is a collective and social activity. Bittner and Heidemeier (2013) found that employees' innovation activities will increase when being supported by a collaborative environment within a company. If a collaborative culture between employees and departments in a company are nurtured well, they will be more comfortable and supportive in sharing and discussing to develop new ideas. Zhang and Tang (2017) stated that extensive intra-firm collaboration may promote the flow of diversified knowledge and bring forth novel knowledge combination to facilitate the faster formation of innovation capability. Past studies on the innovation capabilities of the manufacturing industries in various countries mentioned several factors of intra-firm collaboration necessary to drive innovation capability: internal collaboration (Zhang and Tang, 2017), intra-organizational control (Liu *et al.*, 2017), intra-organizational social capital (Maurer *et al.*, 2011), online social networks (Palacios-Marqués *et al.*, 2016) and integration between functions (Zeng *et al.*, 2017).

2.20 Internal financing capabilities

Research on the impact of internal financing capabilities on innovation activities in a company has been widely published. Abdu and Jibir (2018) found that the financing capability of a company is a crucial factor affecting innovation capability. A study on companies in 9 African countries revealed that limitation in the financing capability of a company negatively affected innovation capability (Lorenz, 2014). Based on input from manufacturing industry practitioners in Indonesia, this research will follow the hypothesis constructed by Efthyvoulou and Vahter (2013), that the effect of financial constraints on innovation activities or capability of a company might differ according to the company's characteristics and sectors.

2.21 Access to external financing

Studies on a company's ability to have access to external financing and its effect on the degree of innovation have been conducted in the past (Abdu and Jibir, 2018; Efthyvoulou and Vahter, 2013; Kou *et al.*, 2020; Nylund *et al.*, 2019). The capability of access to external financing such as the capability to obtain concessional loans will aid the company in performing innovation activities. If the reverse were to occur, innovation activities are hindered (Nylund *et al.*, 2019).

3. Methodology and model development

The research process consists of the following four stages, as shown in Figure 1.

3.1 Identification of initial continuous innovation capability enablers

The process of identifying the initial CICEs was performed in two stages. In the first stage, initial CICEs were identified using a literature review approach, which was then confirmed by manufacturing industry practitioners using the focus group discussion (FGD) approach. This FGD was conducted to ensure that CICEs identified from the results of the literature review were contextually relevant to current conditions experienced by manufacturing industries in Indonesia. The initial CICEs were further grouped into seven dimensions, consisting of six dimensions of continuous innovation development strategies based on conformity (Lianto *et al.*, 2018), namely, technology, people, strategy, organization, knowledge management, collaboration; and one dimension from the industry practitioners' input, i.e. the financial dimension.

3.2 Screening of continuous innovation capability enablers

The screening process for initial CICEs was carried out using FDM; which is an analytical method based on the Delphi and fuzzy theory. FDM is a collaborative decision-making method, which involves experts and has been used extensively in various fields (Cho and Lee, 2013; Hsu *et al.*, 2017; Tahriri *et al.*, 2014). In the screening process for the CICEs, the Fuzzy Delphi method (Hsu *et al.*, 2010) is used to show the consensus of the experts using the geometric mean approach. The FDM steps are as follows:

3.2.1 Collection of experts' opinions. This step was conducted using a questionnaire, consisting of two parts. The first contains questions related to the experts' general data and profiles. The second contains questions on the level of importance of 18 initial CICEs; the importance weights are calculated using linguistic terms (one to seven-point scale) and a fuzzy scale (Table 1).

The panel of experts comprising industry experts and academic experts (scholars). The selection of experts was carried out based on their knowledge and skills (Hsu *et al.*, 2017) as shown in Table 2. Practitioners in this study also came from reputable manufacturing industries with a long history and were included in the Forbes Indonesia Best Award in

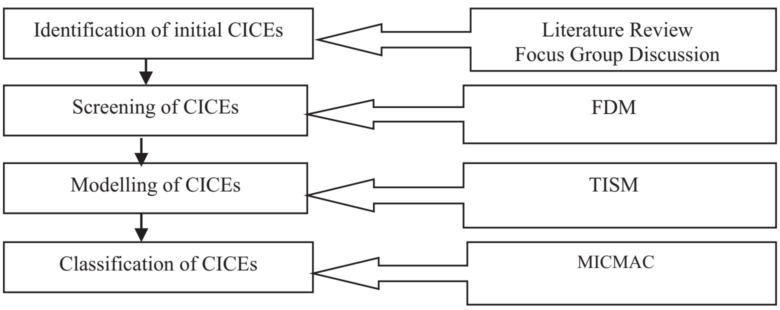

Figure 1.
Stages of the research process

Linguistic variable	Fuzzy scale
Absolutely unimportant	(0.0,0.0,0.1)
Unimportant	(0.0,0.1,0.3)
Slightly unimportant	(0.1,0.3,0.5)
Neutral	(0.3,0.5,0.7
Slightly important	(0.5,0.7,0.9)
Important	(0.7,0.9,1.0)
Important	(0.9,1.0,1,0)

Table 1.
Linguistic variables for the importance weight of criteria

2017 and 2018. The experts were expected to provide various inputs related to companies' abilities to survive and grow amid the crisis and industrial challenges in Indonesia.

A total of 26 experts (13 academic experts and industrial experts each) fit the above criteria. The experts' willingness was confirmed through phone calls, and then questionnaires containing initial CICEs were sent via email, in the form of a Google Survey Form. However, only 17 experts filled out and returned valid questionnaires, leading to a survey response rate of 65%. This number (17 experts) met the requirements where the size of the homogeneous experts ranged from 10 to 15 (Manakandan *et al.*, 2017).

3.2.2 Calculation of triangular fuzzy number and defuzzification. This process began by changing all the linguistic terms (one-seven points) to a fuzzy scale. For example, the linguistic term seven was changed to three fuzzy scales: 0.9; 1.0; 1.0, with the calculation of the triangular number performed using the following formula:

$$\mathrm{a_j} = \underset{i}{\mathrm{Min}}\{\mathrm{a_{ij}}\}, \ldots\ldots\ldots\ldots \tag{1}$$

$$\mathrm{b_j} = -\sum_{n^{i-1i}}^{1_n} \mathrm{b_{ij}}, \ \ldots\ldots\ldots\ldots \tag{2}$$

$$\mathrm{c_j} = \mathrm{Max}\{\mathrm{c_j}\} \ldots\ldots\ldots\ldots\ldots\ldots \tag{3}$$

Where n = number of experts and m = number of factors/elements

Defuzzification was then calculated using the following formula:

$$\mathrm{S_{j\,=}} \frac{\mathrm{a_j} + \mathrm{b_j} + \mathrm{c_j}}{3} \qquad \mathrm{j} = 1, 2, \ldots, \mathrm{m} \tag{4}$$

Acceptance or rejection of a factor was carried out using the following principles:

if $S_j \geq a, j$ is accepted

if $S_j < a$, j is rejected; where α = 0,75

3.3 Modelling of continuous innovation capability enablers

A relationship was developed among the CICEs, using the TISM method, which has been widely used in the development of several fields (Dubey *et al.*, 2015; Jena *et al.*, 2017; Rajesh, 2017; Shibin *et al.*, 2017). The TISM method applied in this study consists of the following seven stages (Rajesh, 2017), as shown in Table 3.

Table 2.
Qualifications of academic experts and industry practitioners

No	Qualification	Academic expert	Industrial experts
1	Knowledge	They are experts in industrial engineering, manufacturing systems, strategy and management of innovation, technological innovation and organizational innovation	The practitioners work in fields related to production, product development, business development, R&D, technology development
2	Skill	Possesses at least a PhD with a good track record in research	The practitioners have worked as middle/upper managers for at least five years

3.4 Classification of continuous innovation capability enablers

The classification of CICEs was carried out using MICMAC. This analysis works on the principle of the multiplication properties of the matrices (Diabat and Govindan, 2011). The basis of this classification is "driving power" and "dependence power" which are calculated in the final reachability matrix (FRM) of the previous stage.

4. Research result

The results are presented in the order of research stages, i.e. identification of CICEs in Indonesia's manufacturing industries, modelling of the contextual relationship between the CICEs and the classification of driving power and dependence power of CICEs.

4.1 Continuous innovation capability enablers

The identification of CICEs resulted in 21 initial CICEs, which were then grouped into seven dimensions. A total of 18 CICEs were obtained from the literature review and 3 from the industry practitioners' input. The results of CICEs grouping based on seven dimensions and operational definitions are shown in Table 4:

After going through the four stages of FDM's screening with a threshold value of $\alpha \geq 0.75$ (accepted) and $\alpha < 0.75$ (rejected), the results are as shown in Table 5:

The table above shows that 16 of the initial 21 CICEs items are accepted, while five are rejected. The five rejected CICEs are digital capabilities (0.74), skills and education (0.73), organizational agility (0.74), knowledge assets (0.64) and access to external financing (0.72). The 16-accepted CICEs were then entered into modelling process using TISM.

4.2 Modelling and classification of continuous innovation capability enablers

The process of modelling and classifying the CICEs is performed out through the following stages:

4.2.1 Selection of experts. In addition to determining the CICEs through the aforementioned screening process, another step in the TISM method is the selection of an expert team. The opinions of the members are input to develop a pattern of contextual relationships between CICEs. The respondents (experts) involved in this stage are a member of the management of manufacturing industry associations, institutions and government agencies. Aside from being manufacturing company practitioners, they also represent the general view of existing industrial problems and conditions. The experts from industry and government agencies are people with an adequate understanding of the condition of the manufacturing sector in Indonesia. They came from five manufacturing sectors prioritized in the Making Indonesia 4.0 Programme, namely, automotive, chemical, electronics, textiles and clothing and the

Stage 1	Identify and determine the main elements and expert team
Stage 2	Develop a SSIM to describe the pattern of contextual relationships between the main elements. The development was carried out by a team of experts
Stage 3	Develop a DRM by transforming the SSIM data into a binary matrix
Stage 4	Develop FRM by checking the transitive relations between elements
Stage 5	Determine the bulkhead level of each element/factor based on the FRM
Stage 6	Develop a relationship pattern diagram between the elements/factors based on the level of significance of the relationship and the bulkhead level
Stage 7	Validate the total interpretive structural model

Table 3. Stage of TISM method

Table 4.
Initial CICEs

Dimension	Factor	Operational definition	Criteria	Source
Technology	Digital technology's capabilities	Describe the potential capabilities of digital technology that a company has, its utilization and its impact on innovation activities	Digital business intensity; Digital technology utilization and Digital technology's impact	Oldham and Da Silva (2015), Ravichandran (2018) and Benitez *et al.* (2017)
	IT capabilities	Describe the technical and human IT resources of a company, their utility and the impact of using IT in supporting innovation activities	IT infrastructure; IT utilization and IT capability impact	Dong and Netten (2017), Joshi *et al.* (2010) and Benitez *et al.* (2017)
	Production technology capabilities	Describe the orientation of the company's production technology and its impact on innovation activities	Tech. orientation; cost; flexibility; quality and delivery	Chen (2016) and Nassimbeni (2001)
	R&D capabilities	Describe the company's internal capabilities in conducting R&D as measured by the intensity, activities and results of R&D	R&D intensity; R&D activities and R&D results	Dong and Netten (2017), Gkypali *et al.* (2017); Gu *et al.* (2016) and Hsu *et al.* (2017)
People	Adaptive capabilities	Describe the company's HR adaptability capabilities	Creative self-efficacy; relational competencies and innovative behaviour	Boly *et al.* (2014), Rangus and Slavec (2017) and Cámara *et al.* (2016)
	Skill and education	Describe the company's HR capabilities from the level of education, skills and development	Education level; human skill level and training and development	Ceci and Iubatti (2012); Steiber and Alänge (2013) and Zeng *et al.* (2017)
	Motivation and participation	Describe the company's HR capabilities as measured by the level of motivation, participation and contribution to innovation activities	Employees' motivation; employees' participation and employees' contribution	Input from industrial practitioners

(*continued*)

Table 4.

Dimension	Factor	Operational definition	Criteria	Source
Strategy	Strategic capabilities	Describe the company's strategic capabilities, evaluated from the readiness of the innovation strategy, the relationship of the company's strategy and the impact of the innovation strategy	Innovation strategy readiness; integrated strategy and strategy's capability impact	Sun *et al.* (2012), Boly *et al.* (2014); Nisula and Kianto (2013) and Mir *et al.* (2016)
	Dynamic capabilities	Describe the ability to integrate, develop and reconfigure internal and external competencies in dealing with change	Sensing and shaping opportunities; seizing opportunities and maintaining competitiveness	Teece (2007); Ferreira *et al.* (2018) and Ellonen *et al.* (2009)
Organization	Leadership	Describe the capabilities and commitment of company leaders and management to innovation activities	Empowerment; transformational and leadership impact	Steiber and Alänge (2013); Nisula and Kianto (2013), Chang *et al.* (2015); Carreiro and Oliveira (2019) and Xie *et al.* (2018)
	Culture and climate	Describe the culture and climate of the company in supporting innovation and change activities	Climate for innovation; support for change and employees' empowerment	Steiber and Alänge (2013); Mir *et al.*, 2016); Boly *et al.* (2014) and Shahzad *et al.* (2017)
	Organizational agility	Describe the agility and resilience of the organization in anticipating and facing unexpected changes	Strategic flexibility; operational flexibility and speed of response	Ravichandran (2018); Wu, Chen and Jiao (2016) and Denning (2013)
	Project management skill	Describes the capabilities of the company in managing an innovation project from the idea stage to its diffusion, project information systems and management performance	PM method; PM information system and PM performance	Boly *et al.* (2014), Zeng *et al.* (2017) and Mir *et al.* (2016)

(*continued*)

Table 4.

Dimension	Factor	Operational definition	Criteria	Source
	Structure and system	Describe the capability of the structure and the corporate governance system for supporting innovation activities	Organizational structure; system and procedure and system integration	Palacios-Marqués *et al.* (2016); Steiber and Alänge (2013) and Rangus and Slavec (2017)
Knowledge management	Knowledge management	Describe the company's capabilities in managing knowledge to support innovation activities	Knowledge recognition; Knowledge transformation and Knowledge application	Liu *et al.* (2017), Boly *et al.* (2014); Chen (2016), Santoro *et al.* (2018) and Wang and Hu (2017)
	Knowledge assets	Describe the amount and quality of company knowledge assets, the utilization and the contribution to innovation activities	Knowledge stock; knowledge assets utilization and knowledge assets outcomes	Delgado-Verde *et al.* (2011), Joshi *et al.* (2010); Lin (2007) and Rupietta and Backes-Gellner (2019)
	Organizational learning	Describe organizational learning capabilities, commitment and learning activities and the outputs of learning processes which support innovation activities	Commitment to learning; learning activities and absorptive capability	Boly *et al.* (2014), Chen (2016); Steiber and Alänge (2013) and Nisula and Kianto (2013)
Collaboration	Inter-firm collaboration	Describe the company's capability to build connectivity and collaborations with various external parties in support of innovation activities	Diversity of collaboration; strength of collaboration and collaboration impact	Wang and Hu (2017), Santoro *et al.* (2018); Liu *et al.* (2017) and Walsh *et al.* (2016)
	Intra-firm collaboration	Describe the company's collaboration capability and internal cooperation in support of innovation activities	Structure of collaboration; strength of collaboration and collaboration impact	Zhang and Tang (2017); Palacios-Marqués *et al.* (2016); Zeng *et al.* (2017) and Rupietta and Backes-Gellner (2019)
Financial				

(continued)

Dimension	Factor	Operational definition	Criteria	Source
	Internal financial capabilities	Describe the company's internal financial capability in support of innovation activities, financial risk management and the rate of return on investment in innovation activities	Availability of finance; financial risk management and return on innovation	Input from industry practitioners
	Ability to access external finance	Describe the company's capabilities in accessing external funding sources to support innovation	Financing policy; the amount of innovative financing and capital costs of external funds	Input from industry practitioners

Table 4.

food industry. Based on the above criteria, nine expert respondents were involved in this study and their profile is shown in Table 6.

4.2.2 Development of structural self-interaction matrix. Structural self-interaction matrix (SSIM) illustrates the pattern of contextual relationships between CICEs, of which the process of building a connection pattern between them is performed by a team of experts. In this study, the process of experts' opinion collection was conducted in two stages. In the initial stage, a questionnaire interview form was sent by email to all respondents with a preference given to the management of industrial associations. It was filled and submitted to all members of the associations for further discussion at the industry associations' management meetings. In the second stage, in-depth interviews were conducted with nine expert respondents separately. During the interview process, the experts were asked to provide an assessment of the level of connectedness between the CICEs. The relationship level values are presented in the form of linguistic variables as follows:

The convergence process of the nine experts' opinions is done for each pattern of the relationship from factor *i* to *j* using the principle of a majority decision (Kamble *et al.*, 2018), and presented in Table 7. For example, the values on the relationship of F1 to F15 by nine experts are V; V; V; X; O; V; X; V. Five experts gave a pattern of relation V, two experts gave X and only one expert gave O. It means that the pattern of relations of F1 to F15 is V or factor 1; which influences the 15th factor. Assuming the two relationship patterns possess the same amount, then discussions with several experts are needed to choose one of the two. The SSIM convergence of all the experts is also displayed in Table 8.

4.2.3 Development of direct reachability matrix. The direct reachability matrix (DRM) development is performed by transforming the SSIM data into a binary matrix (zero or one). The value in the reachability matrix depends on the type of relationship in SSIM (Valmohammadi and Dashti, 2016) and is summarized as follows:

Dimension	Factor	Min	Max	Score Average	De-fuzzy	Hasil
Technology	Digital capabilities-	0.3	1	0.91	0.74	*Rejected*
	IT capabilities (F1)	0.7	1	0.96	0.89	Accepted
	Production technology capabilities (F2)	0.5	1	0.95	0.82	Accepted
	Internal R&D capabilities (F3)	0.3	1	0.94	0.75	Accepted
People	Adaptive capabilities (F4)	0.7	1	0.98	0.89	Accepted
	Skill and education-	0.3	1	0.9	0.73	*Rejected*
	Motivation and participation (F5)	0.7	1	0.98	0.89	Accepted
Strategy	Integrated strategic capabilities (F6)	0.5	1	0.91	0.8	Accepted
	Dynamic capabilities (F7)	0.5	1	0.95	0.82	Accepted
Organization	Leadership (F8)	0.5	10	0.94	0.81	Accepted
	Culture and climate (F9)	0.5	1	0.92	0.81	Accepted
	Organizational agility-	0.3	1	0.91	0.74	*Rejected*
	Project management skill (F10)	0.5	1	0.94	0.81	Accepted
	Structure and system (F11)	0.5	1	0.92	0.81	Accepted
Knowledge management	Knowledge management capacity (F12)	0.5	1	0.91	0.8	Accepted
	Knowledge assets-	0.1	1	0.83	0.64	*Rejected*
	Organizational learning (F13)	0.3	1	0.96	0.75	Accepted
Collaboration	Inter-firm collaboration (F14)	0.5	1	0.93	0.81	Accepted
	Intra-firm collaboration (F15)	0.5	1	0.94	0.81	Accepted
Financial	Internal financing capabilities (F16)	0.3	1	0.94	0.75	Accepted
	Access to external financing-	0.1	1	0.83	0.72	*Rejected*

Table 5.
CICEs after FDM screening

Expert	Pftosition	Industry
P1	President of the Indonesian Automotive Institute	Automotive
P2	Chairperson of the Indonesian Association of Basic Inorganic Chemicals	Chemical
P3	Secretary of the Indonesian Association of Basic Inorganic Chemicals	Chemical
P4	Director for the Electronic and ICT Industry, Ministry of Industry	Electronics
P5	Chairperson of the Indonesian Electronics and Electrical Equipment Industry Association	Electronics
P6	Chairperson of the Indonesian Textile Association	Textiles and clothing
P7	Chairperson of the Indonesia-East Java Textile Association	Textiles and clothing
P8	Chairperson of the development committee of the Indonesian Food and Beverage Entrepreneurs Association	Food and beverage
P9	Chairperson of the Indonesian Food and Beverage Entrepreneurs Association – East Java region	Food and beverage

Note: ICT = Information and Communication Technology

Table 6.
List of TISM experts

Verbal rating scale	Relationship
Sub element *i* contributes to sub-element *j*	V
Sub element *j* contributes to sub-element *i*	A
Sub element *i* contributes to sub-elements *j*	X
Sub element *i* does not contribute to sub-elements *j*	O

Table 7.
Value of the level of relationship between factors

		J															
	Factor	F16	F15	F14	F13	F12	F11	F10	F9	F8	F7	F6	F5	F4	F3	F2	F1
i	F1	A	V	V	V	V	V	V	A	A	V	V	A	V	O	O	
	F2	X	O	O	O	O	O	O	O	A	V	O	O	O	X		
	F3	A	A	A	A	A	A	A	A	A	X	A	A	A			
	F4	A	X	V	V	A	A	O	A	A	X	A	A				
	F5	A	V	V	V	V	A	O	A	A	V	O					
	F6	X	X	X	A	X	V	O	A	A	V						
	F7	O	A	A	A	A	A	O	A	A							
	F8	V	V	V	V	V	V	V	X								
	F9	O	V	V	V	V	V	O									
	F10	O	A	O	A	X	A										
	F11	V	V	V	V	V											
	F12	O	A	A	X												
	F13	O	A	A													
	F14	O	X														
	F15	O															
	D16																

Table 8.
Self-structural interaction matrix

- If the relationship between the variables in one row and the other variables in the column is “V”, then in the initial reachability matrix, the row entry becomes “one” while the column entry between these two variables becomes “zero”; (V if eij = one and eji = zero).

- If the relationship between variables in one row and other variables in the column is "A", then in the initial reachability matrix, the row entry becomes "zero" while the column entry between these two variables becomes "one"; (A if eij = zero and eji = one).
- If the relationship between variables in one row and other variables in the column is "X", then in the initial reachability matrix, the row entry becomes "one" while the column entry between these two variables becomes "one"; (X if eij = one and eji = one).
- If the relationship between variables in one row and other variables in the column is "O", then in the initial reachability matrix, the row entry becomes "zero" while the column entry between these two variables becomes "zero"; (O if eij = zero and eji = zero).

The DRM results are shown in Table 9:

4.2.4 Final reachability matrix. Development of the FRM is conducted by checking the transitive relations (transitivity checks) between the CICEs. Transitivity checking aims to form a closed matrix. It is carried out on cells with a value of zero, irrespective of whether the value meets the transitivity rules or not.

Transitivity in contextual relationships is a basic assumption made in TISM. According to this concept, if the variable X is related to Y and Y is related to Z, then X must be related to Z (Venkatesh *et al.*, 2015; Yadav and Barve, 2016).

The transitivity check rules used in this study are as follows (Sushil, 2017):

- If i–j/i = j and j–k/j = k then i–k
- If j–i/i = j and k–j/j = k then k–i
- If i = j and j = k then i = k

For example, cell (1,2) = 0 because (1,4) = 1 and (4,2) = 1 then (1,2) needs to be = 1The results of FRM development can be seen in Figure 2 and Tables 10–14

		J															
	Factor	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16
i	F1	1	0	0	1	0	1	1	0	0	1	1	1	1	1	1	0
	F2	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1
	F3	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
	F4	0	0	1	1	0	0	1	0	0	0	0	0	1	1	1	1
	F5	1	0	1	1	1	0	1	0	0	0	0	1	1	1	1	1
	F6	0	0	1	1	0	1	1	0	0	0	1	1	0	1	1	1
	F7	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0
	F8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	F9	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	0
	F10	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0
	F11	0	0	1	1	1	0	1	0	0	1	1	1	1	1	1	1
	F12	0	0	1	1	0	1	1	0	0	1	0	1	1	1	1	0
	F13	0	0	1	0	0	1	1	0	0	1	0	1	1	1	1	0
	F14	0	0	1	0	0	1	1	0	0	0	0	0	0	1	1	0
	F15	0	0	1	1	0	1	1	0	0	1	0	0	0	1	1	0
	F16	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1

Table 9. Direct reachability matrix

Factor		J																Driving Power	Rank
		F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16		
	F1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1	13	III
	F2	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	5	VIII
	F3	0	1	1	1	0	0	1	0	0	0	0	0	1	1	1	0	7	VII
	F4	0	1	1	1	0	1	1	0	0	1	1	1	1	1	1	0	11	V
	F5	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	13	III
	F6	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	14	II
i	F7	0	1	1	1	0	1	1	0	0	1	1	1	1	1	1	0	11	V
	F8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	I
	F9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	16	I
	F10	0	1	1	1	0	1	1	0	0	1	1	1	1	1	1	0	11	VI
	F11	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	14	II
	F12	0	1	1	1	0	1	1	0	0	1	1	1	1	1	1	1	12	IV
	F13	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	13	III
	F14	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	13	III
	F15	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	13	III
	F16	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	14	II
Dependence power		7	15	16	16	10	14	16	2	2	14	14	14	15	15	15	10		
Rank		VI	II	I	I	V	III	I	VII	VII	III	IV	III	II	II	II	V		

: Transitivity cells

Figure 2.
Final reachability matrix

Factor	Reachability set	Antecedent set	Intersection set	Level
F1	1,3,4,5,6,7,10,11,12,13,14,15,16	1, 5,6,8,9,11,16	1,5,6,11,16	
F2	2,3,4,7,16	2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	2,3,4,7,16	1
F3	2,3,4,7,13,14,15	1,2,3,4,5, 6,7,8,9,10,11,12,13,14,15,16	2,3,4,7,13,14,15	1
F4	2,3,4,6,7,10,11,12,13,14,15	1,2,3,4,5, 6,7,8,9,10,11,12,13,14,15,16	2,3,4,6,7,10,11,12,13,14,15	1
F5	1,2,3,4,5,6,7,10,11,12,13,14,15	1,5, 6,8,9,11,13,14,15,16	1,5,6,11,13,14,15	
F6	1,2,3,4,5,6,7,10,11,12,13,14,15,16	1,4,5, 6,7,8,9,10,11,12,13,14,15,16	1,4,5,6,7,10,11,12,13,14,15,16	
F7	2,3,4, 6,7,10,11,12,13,14,15	1,2,3,4,5, 6,7,8,9,10,11,12,13,14,15,16	2,3,4,6,7,10,11,12,13,14,15	1
F8	1,2,3,4,5, 6,7,8,9,10,11,12,13,14,15,16	8,9	8,9	
F9	1,2,3,4,5, 6,7,8,9,10,11,12,13,14,15	8,9	8,9	
F10	2,3,4,6,7,10,11,12,13,14,15	1,4,5, 6,7,8,9,10,11,12,13,14,15	4,6,7,10,11,12,13,14,15	
F11	1,2,3,4,5, 6,7,10,11,12,13,14,15,16	1,4,5, 6,7,9,10,11,12,13,14,15,16	1,4,5,6,7,10,11,12,13,14,15,16	
F12	2,3,4,6,7,10,11,12,13,14,15,16	1,4,5, 6,7,8,9,10,11,12,13,14,15,16	4,6,7,10,11,12,13,14,15,16	
F13	2,3,4,5, 6,7,10,11,12,13,14,15,16	1,3,4,5, 6,7,8,9,10,11,12,13,14,15,16	3,4,5,6,7,10,11,12,13,14,15,16	
F14	2,3,4,5, 6,7,10,11,12,13,14,15,16	1,3,4,5, 6,7,8,9,10,11,12,13,14,15,16	3,4,5,6,7,10,11,12,13,14,15,16	
F15	2,3,4,5, 6,7,10,11,12,13,14,15,16	1,3,4,5, 6,7,8,9,10,11,12,13,14,15,16	3,4,5,6,7,10,11,12,13,14,15,16	
F16	1,2,3,4,5,6,7,10,11,12,13,14,15,16	1,5,6,8,9,11,12,13,14,15,16	1,5,6,11,12,13,`4,15,16	

Table 10.
Level partition of factors (iteration 1)

Factor	Reachability set	Antecedent set	Intersection set	Level
F1	1,5,6,10,11,12,13,14,15,16	1, 5,6,8,9,11,16	1,5,6,11,16	
F5	1,5,6,10,11,12,13,14,15	1,5, 6,8,9,11,13,14,15,16	1,5,6,11,13,14,15	
F6	1,5,6,10,11,12,13,14,15,16	1,5, 6,8,9,10,11,12,13,14,15,16	1,5,6,10,11,12,13,14,15,16	2
F8	1,5, 6,8,9,10,11,12,13,14,15,16	8,9	8,9	
F9	1,5, 6,8,9,10,11,12,13,14,15	8,9	8,9	
F10	6,10,12,13,14,15	1,5, 6,8,9,10,11,12,13,14,15	6,10,12,13,14,15	2
F11	1,5, 6,10,11,12,13,14,15,16	1,5, 6,9,11,12,13,14,15,16	1,5,6,11,12,13,14,15,16	
F12	6,10,11,12,13,14,15,16	1,5, 6,8,9,10,11,12,13,14,15,16	6,10,11,12,13,14,15	2
F13	5, 6,10,11,12,13,14,15,16	1,5, 6,8,9,10,11,12,13,14,15,16	5,6,10,11,12,13,14,15,16	2
F14	5, 6,10,11,12,13,14,15,16	1,5, 6,8,9,10,11,12,13,14,15,16	5,6,10,11,12,13,14,15,16	2
F15	5, 6,10,11,12,13,14,15,16	1,5, 6,8,9,10,11,12,13,14,15,16	5,6,10,11,12,13,14,15,16	2
F16	1,5,6,10,11,12,13,14,15,16	1,5,6,8,9,11,12,13,14,15,16	1,5,6,11,12,13,14,15,16	

Table 11.
Level partition of factors (iteration 2)

4.2.5 Determining level partition of factors. Next, a level partition was conducted for the FRM which had fulfilled the transitivity rules. The process of determining the level factor bulkhead of each CICEs is tabulated with the following format filling:

4.2.6 Development of relationship pattern diagram between continuous innovation capability enablers. The level partition of factors describes the initial structural model of TISM from the CICEs, followed by the validation process by the experts. The level of connection between the two factors was also evaluated using a Likert scale of one-five. Level one (1) means that the experts strongly disagree about the relationship between elements, while five (5) shows the opposite. When the average score obtained is three (60%), the relationship between elements is accepted and when it is <60%, the connection is eliminated (Rajesh, 2017). Validated TISM models for the relationship pattern diagram between the CICEs are shown in Figure 3.

4.2.7 Development of matrix of cross-impact multiplications applied to classification. MICMAC is used to classify the system variables studied. The basis of this classification is the driving power and dependence power, which are calculated in the FRM at the TISM stage. Based on the driving power and dependence power, the enablers in this study are classified and described into four groups, as follows:

(1) *Autonomous factor* (Quadrant I: weak driver – weak dependent variables): these enablers do not have much influence or dependency or only having a micro-effect on the system. In this study, there are no CICEs included in Quadrant I, which shows that the identification and screening process of the CICEs conducted by the first panel of experts using the FDM method was accurate. This was validated by the second panel of experts using the TISM method.

Table 12. Level partition of factors (iteration 3)

Factor	Reachability set	Antecedent set	Intersection set	Level
F1	1,5,11,16	1, 5,8,9,11,16	1,5,11,16	3
F5	1,5,11	1,5, 8,9,11,16	1,5,11	3
F8	1,5, 8,9,11,16	8,9	8,9	
F9	1,5, 8,9,11,16	8,9	8,9	
F11	1,5, 11,16	1,5, 9,11,16	1,5,11,16	3
F16	1,5,11,16	1,5,8,9,11,16	1,5,11,16	3

Table 13. Level partition of factors (iteration 4)

Factor	Reachability set	Antecedent set	Intersection set	Level
F8	8,9	8,9	8,9	4
F9	8,9	8,9	8,9	4

Table 14. Relationship means between CICEs (strong)

Factors – i	Relationship	Factor – j	Mean
IT capabilities	**V**	Adaptive capabilities	4.33
IT capabilities	**A**	Leadership	4.33
IT capabilities	**X**	Structure and system	4.22
IT capabilities	**V**	Inter-firm collaboration	4.22
Internal R&D	**A**	Leadership	4.22

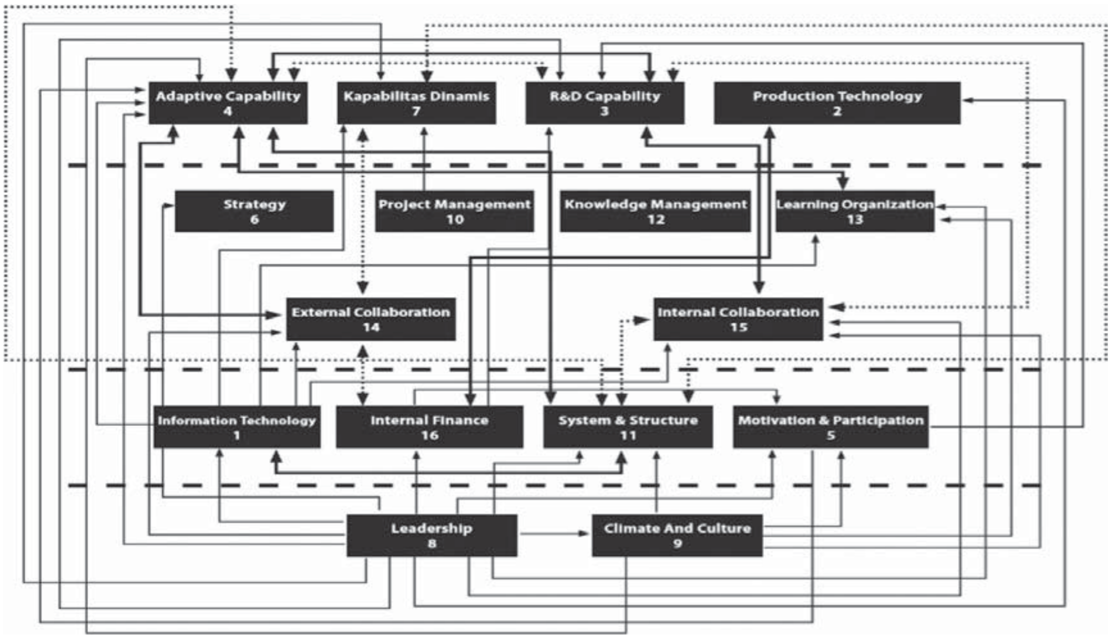

Figure 3.
Validated TISM model

(2) *Factor Dependent* (Quadrant II: weak driver – strongly dependent variables): these enablers have little effect with high dependency. The MICMAC analysis shows that production technology (F2) and internal R&D capabilities (F3) are dependent enablers. The CICEs are categorized as dependent factors because they are driven by independent factors. Figure 4 shows that internal R&D (F3) is strongly influenced by leadership (F8), climate and culture (F9), as well as information technology (F1); while production technology (F2) is largely determined by the leadership factor (F8). In addition, R&D capability is also influenced by some CICEs' environment categories such as human resources (HR) motivation and participation (F5), project management (F10) and internal finance (F16). Some of the CICEs relationships affecting R&D are the adaptive capabilities of HR (F4) and the internal collaboration (F15), while production influences internal finance (F16).

(3) *Factor Linkage* (Quadrant III: strong driver – strongly dependent variables): these enablers have a high degree of influence as well as dependence and every action or change affects their superiors. There are a significant number of CICEs included in Quadrant III of this study, i.e.: adaptive capability (F4), HR motivation and participation (F5), strategy capability (F6), dynamic capability (F7), project management capability (F10), system and structure (F11), knowledge management (F12), learning organization (F13), external collaboration (F14), internal collaboration (F15) and internal finance capability (F16). The CICEs contained in Quadrant III need to be carefully studied and deactivated because their interactions tend to affect the system.

(4) *Factor Independent* (Quadrant IV: strong driver – weak dependent variables): independent enablers are the most important due to their high-level driving power and low-level dependence power. The CICEs in this quadrant have a strong influence on the system and largely determine a company's continuous innovation capability. Three types of CICEs in this study belong to Quadrant IV, namely, leadership (F8), climate and culture (F9) and information technology (F1).

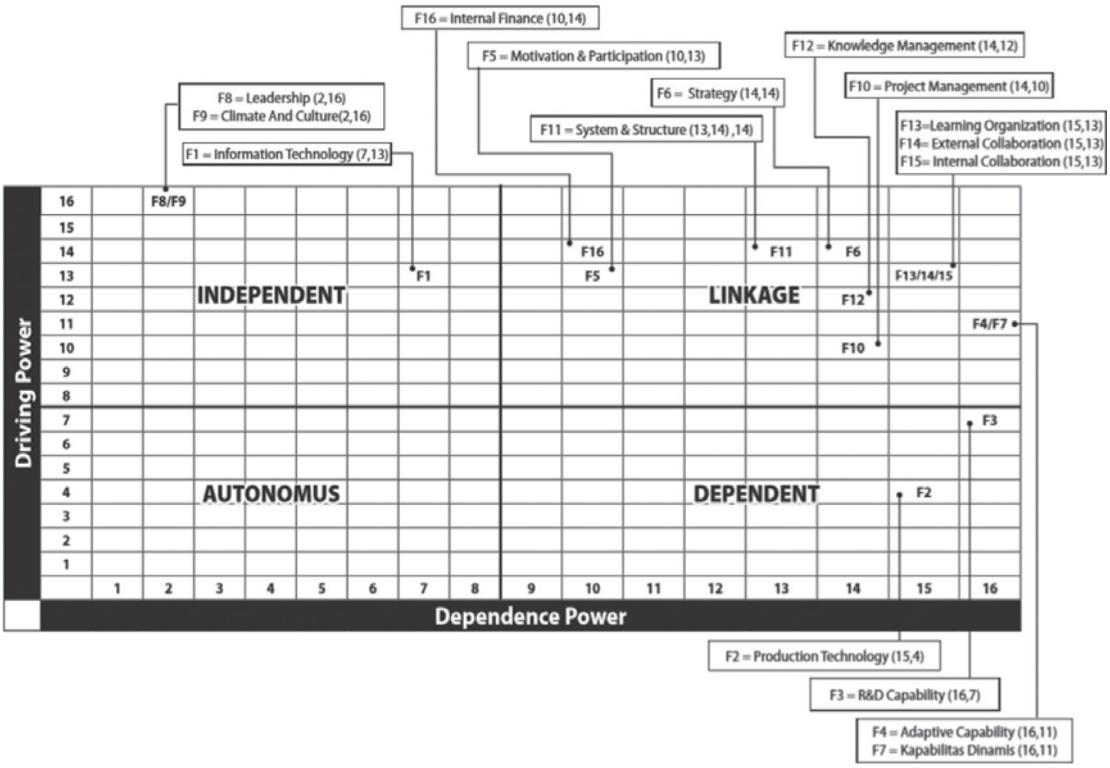

Figure 4.
Diagram of driving power and dependence power of CICEs

Leadership (F8), as well as climate and culture (F9), are factors with the greatest driving power and lowest dependence power (16.2) followed by information technology (F1) (13.7). The results of this study indicate that efforts to continuously develop innovation capabilities of Indonesia's manufacturing industry are strongly influenced by leadership capability (F8), climate and culture (F9) and information technology's capability (F1).

5. Findings and discussions

The objective of this paper is to identify and screen CICEs in Indonesia's manufacturing sectors, to develop a relationship among these enablers and to determine their driving power and dependence power in the sector.

Initial CICEs' identification process was conducted using a literature review and focus group discussion with industry practitioners. The identification process resulted in 21 initial CICEs; which were then grouped into seven dimensions. In total, 18 CICEs were obtained from the literature study and three CICEs were from the industry practitioners' input. After passing through the four stages of fuzzy Delphi screening (Hsu *et al.*, 2010) with a threshold value of $\alpha \geq 0.75$ (accepted) and $\alpha < 0.75$ (rejected), a total of 16 factors were accepted, while five were rejected. The rejected factors were digital technology, skills and education, organizational agility, knowledge assets and access to external finance. The following points discuss rejected CICEs in this study:

- Interview results show that most of the experts agreed that knowledge assets capability, contained in humans and technology, are not meaningful to the company – with the lowest fuzzy value of 0.64. Companies are more concerned with the ability to use assets for innovation efforts, which led to a de-fuzzy value of 0.74 for digital platform technology (close to the threshold value). These assessment results confirm the opinion of several experts that manufacturing industries in Indonesia are not ready to move towards digital factories. A lengthy preparation is, thus, needed before the manufacturing processes can use knowledge assets effectively, especially in terms of the data's completeness, the availability of hardware and software for simulation, as well as the ability of the workers (Sunardi and Saputra, 2016). Research on digital transformation in developing countries conducted by Gonzalez *et al.* (2017) concluded that generally, industries have very little confidence or trust in digital transactions. The results of initial discussions with the manufacturing industry practitioners indicate that companies need an IT capability more than a digital technology capability.

- On the other hand, skills and education levels have a de-fuzzy value of 0.73, prompting most of the experts to provide a neutral judgement or consider them as something rather important. Today, the level of education and skills is used administratively as a benchmark and in general, is focused on the number of diplomas and certificates. However, in practice, motivation and the ability to adapt are more important than the level of education and skills. In the current era, companies embracing Industry 4.0 need people who are willing to keep improving on themselves by continuously learning from various internal and external sources using technological advancements (Briganti and Samson, 2019).
- The organizational agility factor is rejected with a de-fuzzy value of 0.74. Several experts claim that agility is more determined by the human aspect rather than by the organization. It has been observed by Sindhwani and Malhotra (2017), who stated that manufacturing agility is determined by human aspects such as flexible workforce, manpower utilization and top management support.
- There are two CICEs from industry practitioners' input that are related to financial dimensions. Although it is rarely mentioned as a determinant, several studies have shown that finance influences innovation capability. Abdu and Jibir (2018) mentioned that the financial capabilities of a company affect its innovation activities. Studies conducted on nine African companies also shows that corporate financial limitations have a significant and negative effect on innovation (Lorenz, 2014). A study investigating the determinants of innovation in companies in Indonesia found that finance determines the development of innovation in small and medium-sized companies, while its development in large-scale companies is determined by other factors such as their institutional quality (Mahendra *et al.*, 2015). Guariglia and Liu (2014) show that based on the results of investigations into 120,000 companies in China from 2000 to 2017, Chinese private and foreign investment companies' innovation activities are determined by the availability of internal corporate cash flows, while the influence of financial aspects on state-owned companies tends to be lower.

The rest of CICEs were then entered modelling process using TISM. There are 5 contextual relationships between CICEs having a strong relationship, i.e.:

Leadership capability strongly affects (A) IT capability with a relationship mean of 4.33. Investment in IT infrastructure to stay up to date, stable, reliable, also to provide improvement in IT people skill and IT utilization in a company is determined by strategic decisions from upper management. In this study, discussion with manufacturing industry practitioners concluded that decision-related to IT investment is a very strategic decision and create a wide effect, including on innovation activities. Leadership capability also strongly influences R&D capability, with a relationship mean of 4.22. The intensity of R&D activities as measured from sufficient investment and the number of employees involved is determined by company leaders and their commitment. A leader capable of building an effective team of R&D and its communication mechanisms will significantly improve R&D capability (Paulsen *et al.*, 2009). Concrete support from company leaders also drives R&D employees to be firm in initiating ideas for product innovation.

On the other hand, IT capability strongly affects and contributes to (V) human resources adaptive capability with a relationship mean of 4.33. Good IT capability will help in disseminating information upward/downward, so the company and its employees can adapt swiftly to changes (Chae *et al.*, 2018). IT capability also has reciprocal interaction (X) with an organizational system and structure (relationship mean of 4.22). High IT capability will support the system and organizational structure integration and vice versa. The implementation of e-business technology, for example, is proven to affect a company's planning and operational performance, system integration with suppliers and consumers, the company's flexibility level and production systems – to support innovation activities (Devaraj *et al.*, 2007). Good organizational structure and system will contribute to IT utilization for innovation activities in the form of improvement on the quality and quantity of information sharing in the whole company (Prajogo and Olhager, 2012). IT capability also has a strong effect (V) on inter-firm collaboration capability (relationship mean of 4.22). With a good support level of IT capability, a company could collaborate effectively with external parties to support innovation activities. A company's IT capability will influence information sharing and information quality needed in supply chain collaboration, particularly with suppliers and consumers (Afshan *et al.*, 2018). The availability of reliable IT infrastructure will better facilitate communications to build external connectivity and collaboration – for example, to get product information from consumers, when exchanging knowledge with research and academic institutions and in information sharing with associations and government bodies (Olesen and Myers, 1999).

Further analysis on CICEs with TISM and MICMAC reveals that leadership (F8) and climate and culture (F9), are factors with the highest driving power and the lowest dependence powers (16.2); followed by information technology (F1) (13.7). Analysis of the contextual relationship between CICEs shows that leadership is the most dominant factor. The results of this study are in line with previous studies, they show that leadership greatly influences the performance of corporate innovation and is a key determinant for an organization to successfully adopt an innovation (Ding *et al.*, 2018; Xie *et al.*, 2018; Carreiro and Oliveira, 2019). Meanwhile, Xie *et al.* (2011) stated that the leadership style considerably affects the innovation atmosphere in a company and can facilitate trust and individuals' identification. Chang *et al.* (2015) also mentioned that leadership is the key to facilitating innovation activities and tends to affect the success of companies in emerging countries. This opinion applies to manufacturing companies in Indonesia, where leaders play a critical role in various activities and in the innovation process because they are more powerful and autocratic.

Culture and climate in a company gives several strong effects on other CICEs. Previous studies also show that climate and culture determine the innovation performance of a company (Shahzad *et al.*, 2017). A strong organizational culture tends to significantly stimulate the creativity and innovation behaviour of employees by creating formal rules and regulations with an open climate for employees to develop ideas and creativity (Naranjo-Valencia *et al.*, 2016). Multiple effects of IT capability on other CICEs were also observed. A number of past studies on innovation capabilities in manufacturing industries in several countries highlight that IT capabilities are CICEs with a positive effect on continuous innovation capabilities (Dong and Netten, 2017; Joshi *et al.*,2010; Benitez *et al.*, 2017; Chen *et al.*, 2015).

6. Conclusion, implications, limitations and scope for future work

6.1 Conclusion

This paper identified 21 initial CICEs, grouped into seven dimensions; of which 18 CICEs were obtained from the literature study and three CICEs from industry practitioners' input. After passing through the four stages of fuzzy Delphi screening with a threshold value of $\alpha \geq 0.75$ (accepted) and $\alpha < 0.75$ (rejected), a total of 16 factors were accepted, while five were rejected. The rejected CICEs were digital technology, skills and education, organizational agility, knowledge assets and access to external finance.

Analysis of the contextual relationship between 16 selected CICEs resulted in 5 strong contextual relationships, as follows: leadership capability on IT, leadership capability on R&D capability, IT capability on human resources adaptive capability, IT capability on structure and system capability and IT capability on inter-firm collaboration capability.

TISM results and MICMAC analysis show that leadership and climate and culture are enablers with the highest driving power and the lowest dependence powers, followed by information technology. The results of this study indicate that efforts to continuously develop innovation capabilities in Indonesia's manufacturing industries are strongly influenced by leadership capability, climate and culture and information technology capability. It has been observed that long-term innovation capability is asserted when there is strong industry leadership, encouraging climate and culture of innovation and sufficient support of prevailing information technology.

6.2 Implication

The practical implication from this study is to give insights and assurance to manufacturing industry management and leaders that critical factors in developing sustainable innovation capabilities are leadership, culture and climate and IT capability. With this information, priority on the company's improvement should start from improving leadership capability, building a conducive working climate and culture, as developing reliable IT capability. Without considering these 3 capabilities, a high amount of investment and effort to enhance innovation capability will not be performed as expected. This study will also contribute to advance the holistic knowledge of innovation through a comprehensive understanding of prominent CICEs, their relationship patterns, as well as driving power and dependence power in Indonesia's manufacturing industry.

6.3 Limitations and scope for future work

This study has several limitations as follows. The identification process of initial CICEs using the literature review approach, which covers similar industries in other countries, may not necessarily be in accordance with the conditions found in the manufacturing industries in Indonesia; although they have been verified by manufacturing industry practitioners through a focus group discussion. For future research, a content analysis approach should be performed in addition to literature review; by studying various documents, notes, books and reports from various government and non-government institutions related to the manufacturing industries in Indonesia.

The process to converge expert opinions in developing contextual relationships between CICEs in this study was conducted using the majority decision approach; and this approach has limitations because experts do not have the opportunity to present their arguments when providing an assessment of the level of connectedness between CICEs. Further research should use a focus group discussion approach for this convergence process. If convergence is not reached during the focus group discussion, only then the majority decision approach can take place.

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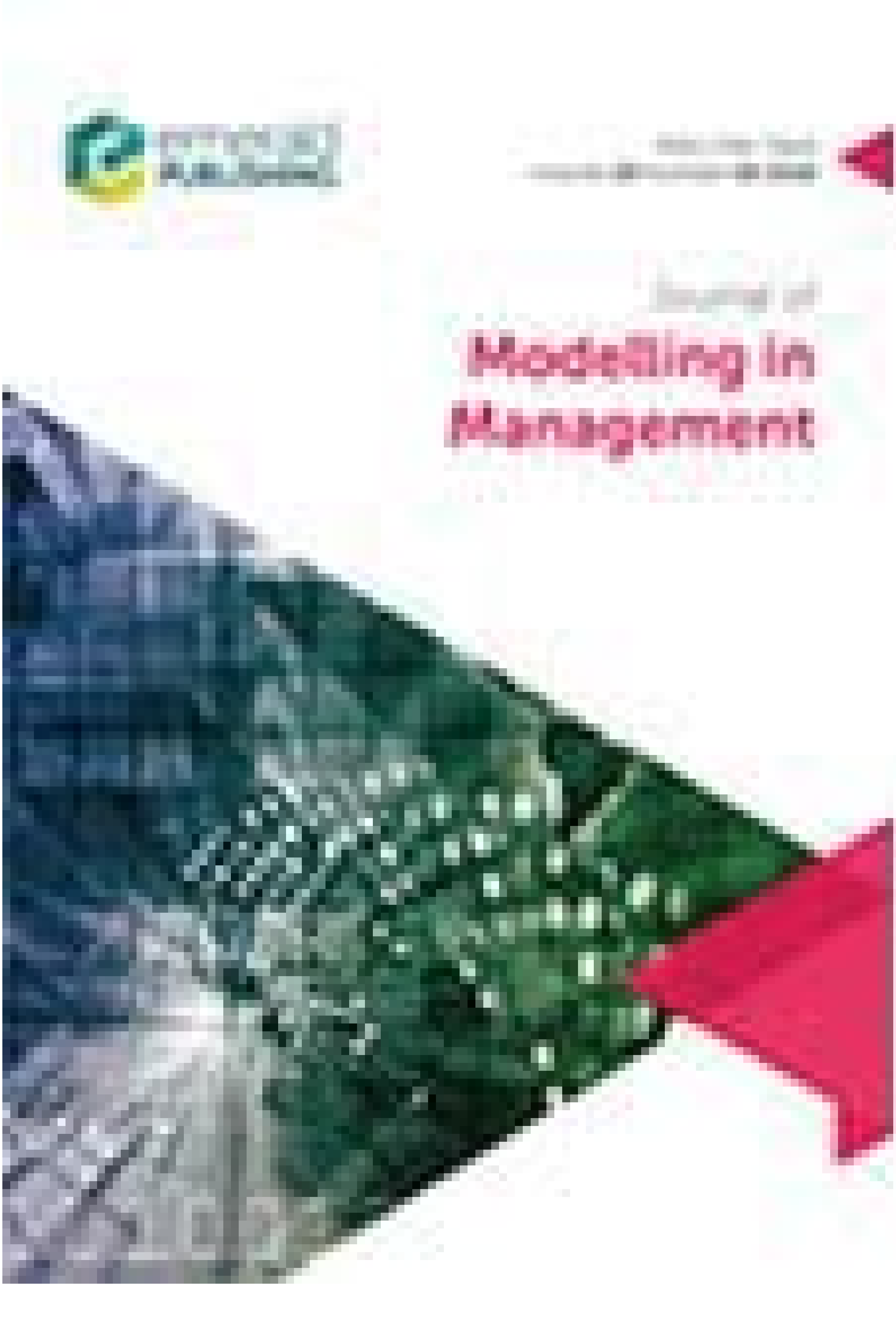
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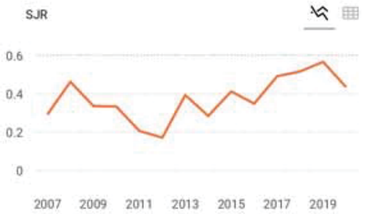

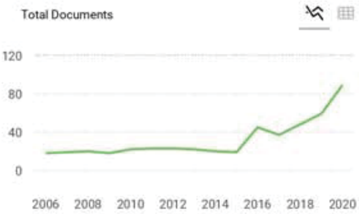

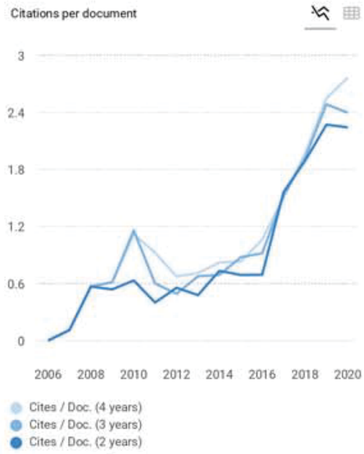

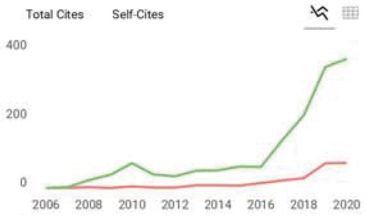

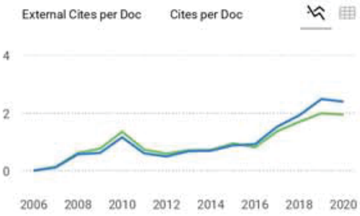

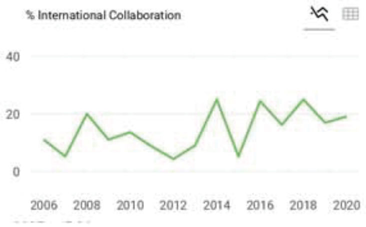

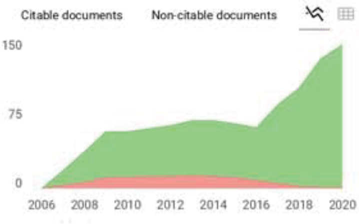

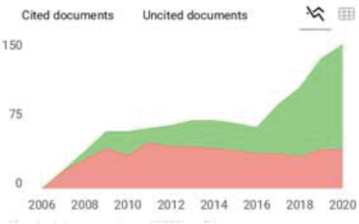

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