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RESEARCH PAPER

Qualitative system dynamics model for composing industrial estate readiness factors

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ABSTRACT

Goal: This paper analyzes the factors composing industrial estate (IE) readiness through Qualitative System Dynamics (SD) to provide an overview of the phenomena occurring in IE in Indonesia.

Design/Methodology/Approach: SD modeling analyzes all the factors that compose the IE's readiness. The stages were problem articulation, boundary selection, and formulation of the dynamic hypothesis by designing Model Boundary Diagrams (MBD) and Causal Loop Diagrams (CLD) using Vensim software.

Results: The CLD results capture the factors composing Indonesia's IE readiness model. Those factors include supply chain readiness, market readiness, human resources readiness, regulatory readiness, institutional readiness, and selection of the right industrial estate location. In addition, several policy recommendations are proposed to help overcome the problems faced by the development of IE in Indonesia.

Limitations of the investigation: The SD model used is still qualitative (up to the CLD stage), the factors that compose IE readiness have yet to be quantified, and there is no model validation. Further study is needed to quantify the model by obtaining empirical data and developing practical measurement indicators.

Practical implications: The model is expected to be beneficial for IE decision-makers and policymakers, including the government and other stakeholders, to develop the IE by measuring the readiness of IEs from all aspects so that the IE can attract more industrial tenants and optimize the IE occupancy rate will be optimal.

Originality / Value: Describe the cause-and-effect relationship model based on the diagram for IE readiness as a recommendation for designing a readiness measurement tool for IE development in Indonesia. In addition, it can complement existing readiness documents as evaluation material for developing IEs in Indonesia at this time.

Keywords: Indonesia; Industrial Estate; Readiness; System Dynamics; Qualitative.

1 INTRODUCTION

Industrial Estates are clusters of industrial activities equipped with supporting infrastructure developed and managed within one location (UN Industrial Development Organization, 2019). There are several synonyms for industrial estates depending on the scope and type of operation, such as the industrial park, industrial zone, and industrial cluster (United Nations Environment Program - UNEP, 1997). Infrastructure and utility costs can be reduced by concentrating industrial activities on industrial estates. In addition, the existence of an industrial estate can stimulate regional development to provide economic benefits for its companies. Therefore industrial estate is an essential part of the national development strategy in many countries (Geng and Hengxin, 2009).

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Industrial estate development in Indonesia aims to stimulate industrial growth in the region, increase industrial development that is environmentally insight, and improve industrial competitiveness and investment (Wahidi, 2014; Ismail, 2016). Currently, industrial estate development in Indonesia faces land procurement and acquisition challenges, permits, management, connectivity, access to energy, and low investor interest (Faisal, 2019; Pemerintah Indonesia, 2020). However, these problems can be avoided if all aspects of planning and preparation for industrial estate development are carried out carefully.

There are 138 industrial estates in Indonesia, dominated by the Java Islands (57.97%). The total IE land area of 67,992 ha, with an average occupancy rate of IE, is still 44.81% (Table 1). It shows that the distribution of the industrial estate is not evenly distributed in Indonesia. The high occupancy rate of an IE indicates the occupancy level of industrial company tenants in the IE that has been built and the market absorption of the available IE plots (Triono and Nabilah, 2022), thus becoming one of the indicators of success in developing IE in Indonesia. In addition, it also reflects the readiness of the IE as a central location for industrial activities for the industrial companies in it. However, the occupancy rate of IE has not yet become a target achievement in the national development document. The problems faced in developing IE in Indonesia, ranging from problems at each stage to the low occupancy rate, indicate that the planning and preparation for developing IE are not yet mature.

Table 1 - Distribution of industrial estate in Indonesia (Kementerian Perindustrian RI, 2022)

No	Islands	Number of Industrial Estates	Percentage	Total Land (ha)	Occupancy
1	Java	80	57,97%	**67.992**	**44,81 %**
2	Kalimantan	11	7,97%		
3	Maluku Papua	2	1,45%		
4	Sulawesi	8	5,79%		
5	Sumatera	37	26,81%		
	Total	**138**	**100,00%**		

The readiness of industrial estates is currently limited to infrastructure and land availability, administrative requirements (permits, environmental documents, master plans) (Kementerian Perindustrian, 2021), and business feasibility (investment) (Ministry of State-Owned Enterprises, 2020).

This study addresses the gap by evaluating the readiness of IE to cover all aspects comprehensively. It develops factors that compose the IE model in the Industry 4.0 era using a system dynamics (SD) approach by displaying the Model Boundary Diagrams (MBD) and Causal Loop Diagram (CLD). In addition, this study provides an overview of the IE phenomenon in Indonesia and presents recommendations for its development.

This paper is structured as follows: Section 1 provides a general background explaining the importance of IE and the issues faced in the development of IE in Indonesia which are the focus of our study. Section 2 reviews the literature on the history of IE development, the existing readiness of IE, and factors that compose industrial estate readiness. This comprehensive review ensures that the audience is well-informed and knowledgeable about the existing research in the field. Section 3 explains the research methodology and the reasons for choosing the method. Finally, Section 4 presents a discussion of the results of the SD approach, both MBD and CLD used to compose IE readiness factors. In addition, there is also a discussion related to recommendations for the development of IE in Indonesia based on the study results.

2 LITERATURE REVIEW

2.1 History of industrial estate development

An Industrial Estate or Industrial Park, according to the National Industrial Zoning Committee (USA), is an area with industrial activities on a large land area with proper location, topography, zoning, and availability of infrastructure/utilities and ease of transportation accessibility and controlled by an institution (Wahidi, 2014). The first industrial estate was developed in England in 1876 on 1,200 hectares next to the newly launched Manchester ship canal and was the largest of the industrial estate until the 1950s. Trafford Park Estates Ltd, as the development company, provides extensive service facilities such as roads, tram lines, internal rail lines, wharf facilities, warehouses, and energy (Scott, 2001).

The United States pioneered the establishment of industrial estates in 1885. The Clearing Industrial District - Chicago was the first industrial estate to be established as private property. This establishment was followed by the development of other industrial estates operating under commercial agreements with or without assistance from the Government. These industries then developed into modern industrial estates as a new trend due to the previous industrial estates (ULI - The Urban Land Institute, 1975). Furthermore, the Central Manufacturing District was developed in 1902, and The Pershing Road District in 1910. In the 1960s, the industrial estate was developed based on research and development (Science Park / Technology Park). The concept of a business park with various activities, such as offices and industry supported by trade and recreation, was developed in the 1970s (Kwanda, 2000). In addition, the first industrial estate was developed simultaneously in the Netherlands and Germany, especially on the wharf. The development of industrial parks in several countries is closely related to the spread of electric power and many generators (Scott, 2001).

In Indonesia, the Government developed industrial estates in the early 1970s to accommodate investment both from within and abroad. Starting with the development of the Jakarta Industrial Estate Pulo Gadung (JIEP) and then followed by the Surabaya Industrial Estate Rungkut (SIER) in 1974, followed by the Cilacap Industrial Estate in 1974, Medan Industrial Estate in 1975, Makassar Industrial Estate in 1978, Cirebon in 1984 and Lampung Industrial Estate in 1986. With increasing investment, the private sector was then allowed to develop industrial estates in Indonesia (Kwanda, 2000). Until 2022, there are 138 industrial estates in Indonesia (Minisitry of Industry Republic of Indonesia, 2022).

Currently, there are 5 of the largest industrial estates in the world, such as Jubail Al Khair Industrial City (Saudi Arabia), Alberta's Industrial Heartland (Canada), Tahoe-Reno Industrial Center (USA), Yanbu Industrial City (Saudi Arabia) and KAEC Industrial Valley Grand (Saudi Arabia) (Chepkemoi, 2020). Future IEs are predicted to focus more on environmentally sustainable practices, including Eco-Industrial Park (IEP) and smart IE integrated with Industry 4.0 (Sun City IP, 2023). The number of IEPs worldwide increased from 245 in 2001 to 438 in 2020, particularly in Asia (Aggeri, 2021; Musyarofah *et al.*, 2025).

2.2 Existing readiness of industrial estate

Studies on measuring industrial estate readiness globally still need to be completed. Based on a search of related literature, the results obtained include the decision to choose an industrial estate location with consideration of access to markets, competitors, and available export markets (Schellenberg, 2006), technological readiness using Technology Readiness Level (TRL) (Pinilla *et al.*, 2019), and a sustainable energy approach from a single company to the industrial estate (Mainar-Toledo *et al.*, 2022).

Based on the stages of industrial estate development in Indonesia, the readiness of industrial estate in Indonesia currently includes the business feasibility (investment) (Ministry of State-Owned Enterprises, 2020), planning documents completeness (master plan, feasibility studies, strategic plans), fulfillment of permits (industrial estate permits, environmental permits), land availability and land acquisition (Kementerian Perindustrian, 2021). In addition, the readiness of industrial estate infrastructure includes basic facilities and public/social facilities to support industrial estate operations (Kementerian Perindustrian, 2021).

2.3 Factors that compose industrial estate readiness

Industrial estate readiness factors include location readiness, university/academic (human resource) readiness, market readiness, supply chain readiness, industrial institutional readiness, and regulatory (Government).

2.3.1 Location

Choosing the right location for the industrial estate will significantly affect industrial estate development in the future (Pratiknya, 2007; Alam, Madani and Abdi, 2021). The location of an industry is chosen by considering the transportation costs incurred based on the optimum distance from the market and raw materials to get maximum profit (Wahidi, 2014; Webber, 2020), the optimum distance from the city center, and based on land prices (Qiu, Xu and Zhang, 2015).

According to Kandiawan *et al.* (2017), determining the location of an industrial estate requires considering six essential parameters: slope, land use, soil type, distance to roads, distance to rivers, and distance to electricity networks. Cahyadi *et al.* (2018) added one parameter: land distance to public facilities. Besides that, it also according to land factors, location, regulations, management, infrastructure, external support, accessibility (Winarno and Nugroho, 2019), ease of access, the existence of development land, land contours, availability of clean water, access to transportation and waste networks (Khadiyanto, 2020).

2.3.2 Supply Chain

The main element of industrial areas is the extensive network flow of knowledge and information, which makes the operating system more flexible. The supply chain is critical in the interaction between companies that are members of the network/supply system (Musso, 2013). The integration of the supply chain and Industrial Park (IP) will improve the operational efficiency of IP and increase the industry's competitive advantage and the company's performance. Furthermore, the efficiency of the industrial material supply chain plays a crucial role in the industry because the availability of materials greatly affects the smoothness of the production process while minimizing costs, production time, and industrial productivity (Tolossa *et al.*, 2013).

High-quality suppliers can help companies in industrial areas increase their productivity. Network relationships between companies in industrial areas (complementary and competitive relationships) can improve production efficiency and competitiveness in industrial areas (Porter, 1998, 2000).

2.3.3 Market

Several studies regarding industry clusters/industrial estate show that the market development function is relevant close to the industrial estate. For example, Porter (1998, 2000) considers that industrial estate can easily help companies understand customer needs by utilizing resources so that companies can find gaps between existing products and services and customer needs. In addition, companies can select suitable suppliers and customers within the industrial estate. Therefore, industry capabilities and strong relationships with suppliers and related parties will influence the market development of the industrial estate.

Industrial estate establishment and development must benefit companies by expanding market access and increasing demand to increase sales of industrial products. In addition, investment and operational costs are incurred, from land and building costs to raw materials, energy, logistics, and labor costs, which will affect the company's profits. Therefore, industrial development, especially consumer products, concentrated close to large markets, shows an advantage in the extensive market access (Faisal, 2019).

According to Rephann (2022), the lack of market feasibility analysis of IE needs results in IE often being built in locations with less than optimal access to labor and other resources or built much more significantly than the local market requires. Analysis of IE market absorption is carried out by considering the geographic location of IE, IE facilities/infrastructure, ease of transportation access, labor availability, market conditions, and space availability. Marketing efforts can also increase the IE occupancy rate (Rephann, 2022).

2.3.4 Human Resource/Academic

Porter (1998, 2000) considers quality human resources to be one of the competitive advantages that can help increase the productivity of the estate industry. Meanwhile, Lin (2006) believes that human resources must be distinct from the need for professionals, research institutions, workforce training, quality and quantity of human resources, and innovation capabilities that affect an industrial estate.

Partnerships and information sharing between industry and academia are essential to closing the gap between industry and academia and accelerating the creation of new technology (Chida, 2009). Innovation, mastery of production technology, and human resource expertise are essential points that can provide added value, but this has yet to become a mainstay for industrial estates (Faisal, 2019). By preparing skilled human resources through vocational cooperation between the central and regional governments and education and training institutions and industry, it is hoped that this will support the readiness of industrial estates in the Indonesia (Pemerintah Indonesia, 2020).

2.3.5 Regulation

Several studies have shown the effect of the regulation (government policy) on an industrial estate in several countries, such as management policy in China (Geng and Hengxin, 2009), South Korea (Kim and Gallent, 1997), an industrial park in Ulsan, South Korea (Park *et al.*, 2008), Industrial clusters in Russia (Sosnovskikh, 2017), and the industrial Park in Tianjin, China (Geng, Zhu and

Haight, 2007). According to Geng (2009), regulations applied to the industrial estate positively impact local economic growth in China. The government provides policies in the form of facilitating loans with lower interest rates, more minor tax obligations, and discounts on land and utilities.

Korea's national policy to transform existing conventional industrial parks into eco-industrial parks with the industrial symbiosis between industries in the industrial park in Ulsan is caused by strict environmental regulations and beneficial economic impacts (Park *et al.*, 2008). However, Russia's experience, which has implemented industrial clusters for 10-15 years, shows that industrial clusters are still experiencing difficulties and need to be mature, so local governments still need to intervene in attracting investors in their development (Sosnovskikh, 2017). Implementing an integrated waste management system policy in the industrial park in Tianjin can allow China to gain additional income by selling solid waste. This can also attract investors, as the added value from the industrial estate can be adopted in other industrial estates (Geng, Zhu and Haight, 2007).

2.3.6 The industry itself/institutional

Factors composing the company's readiness include technological readiness, production facility readiness, and transformation to industry 4.0 readiness needed in the industrial 4.0 era. Technology is a crucial factor in an industrial estate, where technology supports innovation to increase competitiveness. In addition, industrial estates supported by knowledge resources and collaboration with research institutions are considered to have the opportunity to expand the production scale of the companies within them (Lin, Tung and Huang, 2006). Likewise, industry 4.0, which is considered a critical success factor in manufacturing processes, procedures, and product design principles, has been widely adopted by companies in IE, including IE in Ethiopia (Mamo, 2019) and IE in Nepal (Rajbhandari *et al.*, 2022).

In addition, environmental management is crucial in industrial activities, especially in IE, to minimize the negative impacts arising from IP development (Ghasemian *et al.*, 2012). Environmental quality assessment in IE in India has been done using Comprehensive Environmental Pollution Index (CEPI) (Rajamanickam and Nagan, 2018), Symbiotic Readiness Assessment Instrument (SRAI) has been developed for assessing the implementation of industrial symbiosis in companies in IE (Agudo *et al.*, 2022; Agudo, Bezerra and Júnior, 2023) and the proposed solution to energy efficiency problems in IE has carried out through software architecture development and methods (Farel and Bekharadi, 2014)(Farel & Bekharadi, 2014).

3 METHODS

The readiness of all aspects of industrial estate development can be considered a complex system consisting of several components and manufacturing networks with various levels of operation (Sjaifuddin, 2020). The use of SD in this study can fulfill the need to analyze all the factors composing an IE's readiness because IE is characterized by system complexity involving many decision-makers, the complexity of supplier and consumer behavior, and various other manufacturing issues. SD is a simulation method used to design models that approximate real systems when analysis techniques cannot be applied due to the complexity of the system and the problems encountered (Sokolowski and Banks, 2008; Jahangirian *et al.*, 2010; Zhou *et al.*, 2010). SD can also explain the reciprocal relationship of the influencing variables in a system described in a simple and easy-to-understand causal loop diagram (Shakib, 2020). In recent times, the SD approach has been widely applied in various fields, such as policy analysis and design (Forrester, 1994; Lyneis, 2000; Radzicki and Taylor, 2007), strategy making (Torres, Kunc and O'Brien, 2017), management and public policy (Towill, 1991), supply chain management (Barlas, 1996; Akkermans, 2001), hospital's performance (Junior *et al.*, 2019) and energy and environment (Oyarbide, Ladbrook and Baines, 2003; Sjaifuddin, 2020). The SD software used in this study is Vensim.

In this study, two stages were carried out in building SD modeling, which consisted of:

3.1 Problem articulation and boundary selection

The first and most important step in modeling is to identify the purpose of the model and the problem to be solved. Existing phenomena must be clear so that the model created can represent the actual system and aims to solve problems (Sterman, 2002). Determining phenomena/gaps can be done by searching for information based on literature reviews and interviews with experts who have mastered IE-related fields. This study identifies the phenomenon of low IE occupancy rates in Indonesia related to the readiness of IE in Indonesia. IE readiness in this study is defined as the readiness of an area to become a location for centralizing industrial activities for industrial companies. The area is equipped with the support of facilities and infrastructure provided by the area management company so that if IE is considered ready, it can attract investment into it, attract more tenants (industrial companies), and increase the efficiency and effectiveness of industrial company operations and can encourage industrial competitiveness in the area. Furthermore, the development of factors that comprehensively compose the IEs' readiness is carried out within a conceptual framework.

3.2 Formulation of the dynamic hypothesis

After identifying the problem, the next step is to develop a theory called the dynamic hypothesis. This hypothesis is dynamic because it describes dynamics that reflect issues in the form of a feedback flow system or causal. In this study, two diagrams are used to represent the causal system, namely:

a. Model Boundary Diagrams (MBD)

MBD is a diagram that classifies the model's scope to be built and contains the variables in the model (Nicholson *et al.*, 2020). Variables are grouped into exogenous variables (variables not affected by other variables inside the system/outside of the system), endogenous variables (variables influenced by other variables) (Talitha and Berliyana, 2022) and excluded (Sulistyo, Alfa and Subagyo, 2016; Nicholson *et al.*, 2020). These constructs are important to capture relevant feedback processes and provide a checklist for discussion and analysis when linking the framework to evidence to explain the overall process (Nicholson *et al.*, 2020). In this study, variables were determined based on existing conditions considered necessary.

b. Causal Loop Diagrams (CLD)

CLD is an essential tool for representing feedback from a system, so it is suitable for capturing a hypothesis about a dynamic problem, capturing individual or group mental models, and communicating important feedback on a problem (Sterman, 2002). There are two kinds of signs in CLD: positive signs (+) and negative signs (-). The positive sign indicates that the dependent variable will also increase, while the negative sign indicates that if the independent variable increases, the dependent variable will decrease. The direction of the relationship between variables is described using the letters R and B. The letter R (reinforcing loop) indicates that the variables change in the same direction to reinforce each other. In contrast, the letter B (balancing loop) indicates that the variables change in opposite directions to neutralize each other (Sjaifuddin, 2020). In this study, CLD is structured to represent causal relationships in the system by connecting the linkages between variables considered essential for the readiness of industrial estate using Vensim software as has been done in several simulation studies, including: Simonetto *et al.* (2018), Junior *et al.* (2019).

4 RESULTS AND DISCUSSION

This study uses a system dynamics approach to understand complex systems. In this context, it describes the phenomenon of industrial estates in Indonesia with low occupancy rates. This approach is suitable for understanding the phenomenon of low occupancy in industrial estates and the solutions proposed to overcome this gap. The causes of this gap include the immaturity of industrial estates and the absence of an evaluation of the readiness of industrial estates covering all aspects. The composing factors of IE and stakeholders related to IE readiness were conducted through literature studies and interviews with experts in the field of IE. As described in Table 2, 38 relevant articles were obtained from the reviewed literature.

Table 2 - Results of Literature Study Relevant Articles

Keyword	Number of articles				
	Identified	Not duplicated	Analyzed title	Analyzed abstract	Analyzed Content and relevant
“industrial estate” AND “readiness”	117	93	52	30	14
“industrial park”	129	103	61	34	10

AND “readiness”					
“industrial zone” AND “readiness”	54	42	30	16	3
“industrial estate” AND “readiness index”	34	19	12	8	8
“industrial park” AND “readiness index”	68	21	9	6	5
“industrial zone” AND “readiness index”	29	14	5	3	1
“industrial estate readiness”	14	10	6	5	4
Total	445	302	185	102	38

After a further review of the 38 selected relevant literature, as described in the process in Table 2, various factors that influence the readiness of an IE can be identified. These factors are then regrouped into a more integrative IE readiness factor and adjusted to the actors/stakeholders involved in the IE system.

The relevant stakeholders are then developed from the theory/model of relationships in the knowledge-based innovation economy represented by a circle (helix) with overlaps indicating interaction. Starting with the Triple Helix model which describes the relationship between Academics-Industry-Government (Leydesdorff, 2012), then refined by adding community and media components to the Penta Helix model (Effendi *et al.*, 2016; Soemaryani, 2016; Muhyi *et al.*, 2017; Sudiana *et al.*, 2020; Sundari *et al.*, 2021). Also known as the Quintuple Helix model, adding the natural environment of society and economy as drivers of innovation (Carayannis, Barth and Campbell, 2012). From the results of the identification of stakeholders related to the IE system, 5 (seven) stakeholders are interconnected and synergized in an IE (Multi Helix), as illustrated in Fig. 1.

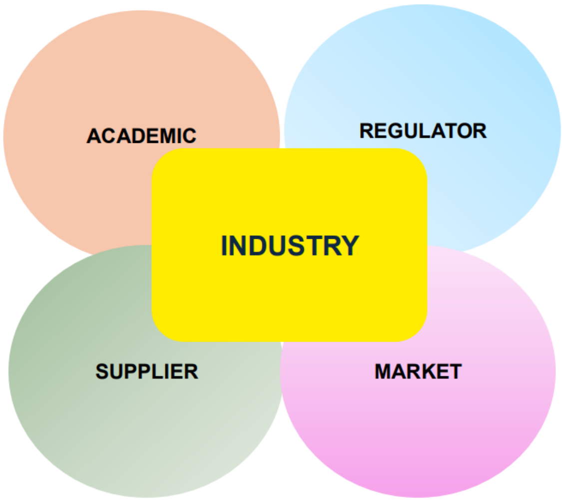


Figure 1 - Multi Helix Synergy in an Industrial Estate

Related stakeholders in the IE system and readiness factors that have been identified, then their schematic relationships/relations are illustrated in a conceptual framework as in Fig. 2.

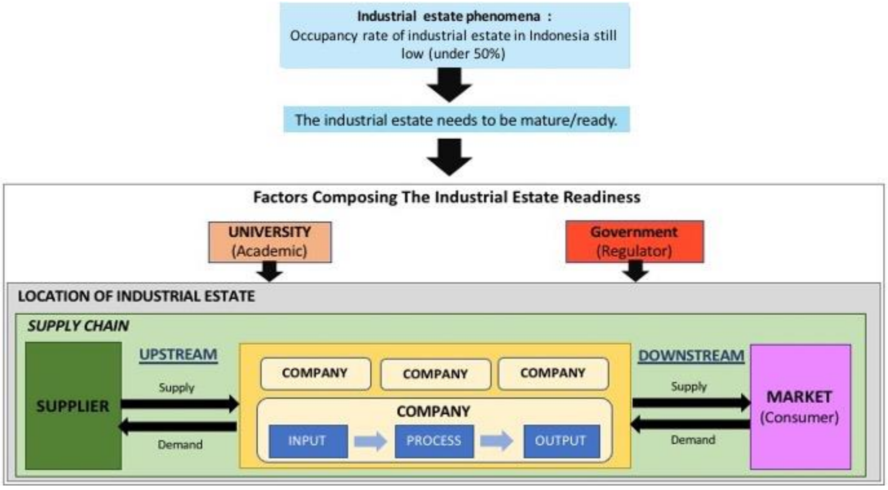
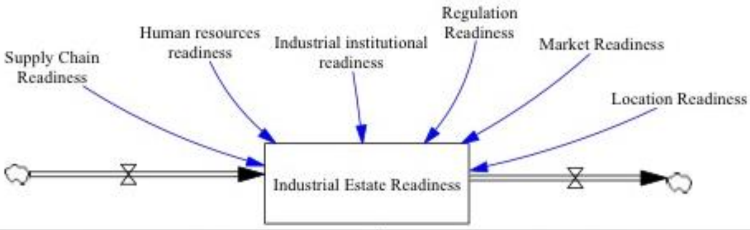


Figure 2 - Conceptual framework and factors influencing the readiness of industrial estates

Next, MBD is compiled to classify the model's scope to be built and contain the endogenous and exogenous variables in the model (Fig. 3). A good system model, with its extensive boundary analysis, several exogenous variables, and more dominant endogenous variables, does not compromise for simplification and linearization but considers all variables that affect the model. Exogenous variables can be identified using traditional scenario methodology (Torres, Kunc and O'Brien, 2017). This study defines exogenous variables as external variables to the model through literature studies. Endogenous variables are considered in the model by integrating exogenous variables (Sandra *et al.*, 2020).



Endogenous variables		Exogenous variables	
Company profit	Production Time	Infrastructure	Distance from city center
Sales	Productivity	Material Cost	Distance from raw material
Product Demand	Number of university	Energy Cost	Distance from market
Human Resources Demand	Knowledge and Information network	Labor Cost	Environmental regulation
Operating Cost	Competitive product	Investment	Financial regulation
Production Facility	Expanding market	Transportation Cost	Accessibility
Land Price	Material availability	Land Condition	
High-quality supplier	Innovative ability		
Collaboration Industry - University	Customer		

Figure 3 - Model Boundary Diagram (MBD) of Industrial Estate Readiness

Causal loop diagram analysis helps identify factors that compose industrial estate readiness and can help companies and industrial estates improve their competitiveness.

4.1 Balancing Feedback Loop BI (location)

Fig. 4 illustrates the R1 loop that choosing the right industrial estate location will affect the development of an industrial estate in the future. The optimum distance from markets, raw materials, and the city center will affect transportation costs (Pratiknya, 2007; Webber, 2020; Alam, Madani and Abdi, 2021). If transportation costs are higher, the profits earned by the industry will be reduced, thereby reducing the industry's competitiveness in the industrial estate. Industrial estate competitiveness composes industrial estate readiness and affects the development of industrial estates. Developing industrial estate will increase the price of land in the vicinity. The high price of land is also influenced by the readiness of the infrastructure provided, such as energy, electricity, water, roads, and waste management units (Winarno and Nugroho, 2019).

In addition, land prices are also influenced by the condition of the land itself, such as slope, land use, and land contour (Kandiawan, Hani'ah and Subiyanto, 2017; Cahyadi, Suprayogi and Amarrohman, 2018). Ease of access also affects the land price of an industrial estate (Khadiyanto, 2020). The high price of land will affect the magnitude of operational costs, impacting company profits.

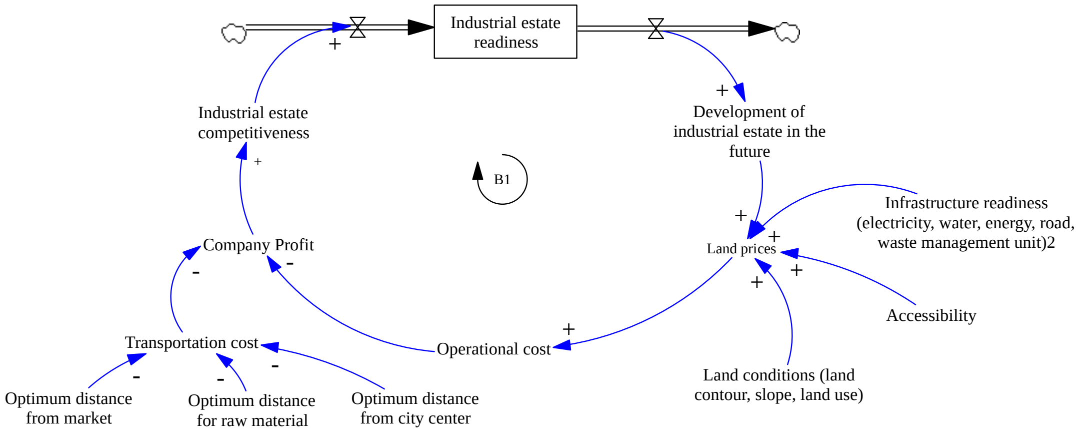


Figure 4 - Balancing Feedback Loop BI - composing location readiness

4.2 Reinforcing Feedback Loop R2 (supply chain)

The existence of an integrated supply chain in industrial estates will increase the operational efficiency of industrial estates to improve industrial performance and the competitiveness of companies in industrial estates. In addition, industrial competitiveness composes industrial estate readiness. It increases the strength of knowledge and information networks to produce high-quality suppliers capable of providing raw materials for industrial estates (Porter, 1998, 2000). The availability of the raw materials needed for industrial estates will impact the smoothness of the production process while minimizing operational costs and production time, as well as increasing industrial productivity (Tolossa *et al.*, 2013), as shown in Fig. 5.

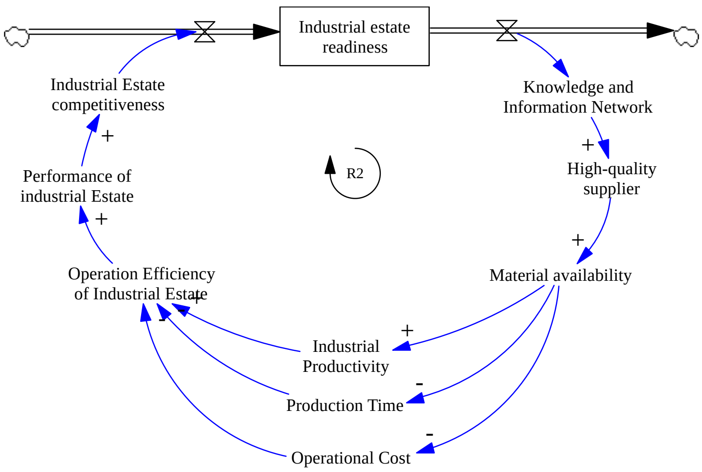


Figure 5 - Reinforcing Feedback Loop R2 - composing supply chain readiness

4.3 Reinforcing Feedback Loop R3 (market)

In the loop, as shown in Fig. 6, the market readiness function consists of endogenous variables of demand, sales, profits, and expansion of market access for business and marketing. Market expansion can increase the attractiveness of investment from domestic and foreign capital, which impacts the expansion of the industrial scale (Lin, Tung and Huang, 2006). With this expansion, producers upgrade their specialization capabilities to produce more competitive products. This increased capability can attract customers so that demand increases and impacts sales that increase significantly. This can increase the company's profit and become a reinforcing loop.

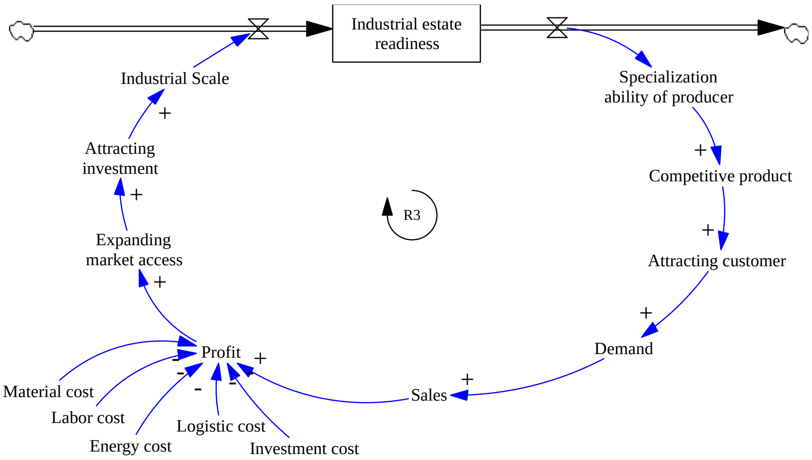


Figure 6 - Reinforcing Feedback Loop R3 - composing market readiness

In contrast, the exogenous variables are investments, logistics, energy, raw materials, and labor, which affect costs. Investment cost, as an exogenous variable, is a variable that is controllable because it can be adjusted to the company's financial capability. Labor can also be controlled because the number and quality of human resources needed in an industrial estate company can be adjusted to each region's needs and labor costs (for example, at least the equivalent of the regional minimum wage). As a result, labor will affect the number of operational costs in the industry.

However, raw materials as an exogenous variable are uncontrollable because they are the heart of the industrial business. Without raw materials, the industry will not be able to produce goods, so all industries in the industrial estate depend on them. In addition, the industry often needs more raw material availability and dynamic price changes, so these factors cannot be controlled. Thus, logistic and energy costs are uncontrollable variables because the cost of using them depends on price changes from external vendors.

In terms of the mechanism of the relationship between endogenous variables that apply empirically to the business system of industry, potential customers will get to know industrial products through 4 (four) ways, namely: advertising, direct sales effort, word of mouth, and media attention (Sterman, 2002). Theoretically, the increase in sales will increase the company's profit, which is more significant with a sequential impact on (1) expanding market access and (2) increasing demand, which, of course, will (3) increase sales. Empirically, the industrial business system in the industrial estate has the exact mechanism as the theoretical mechanism as meant by (Sterman, 2002).

4.4 Reinforcing Feedback Loop R4 (Academic/University)

High-quality human resources can increase innovation capabilities to enhance industrial estate productivity (Porter, 1998, 2000). As shown in the positive feedback loop in Fig. 7, this can spur the competitiveness of industrial estates and impact the rapid development of industrial estates that require more professional human resources. To meet the need for high-quality human resources, it is necessary to be supported by many universities or research institutes (Lin, Tung and Huang, 2006). Besides, collaboration and information sharing between industry and academia is essential to closing the gap between industry and academia and accelerating the creation of new technologies (Chida, 2009).

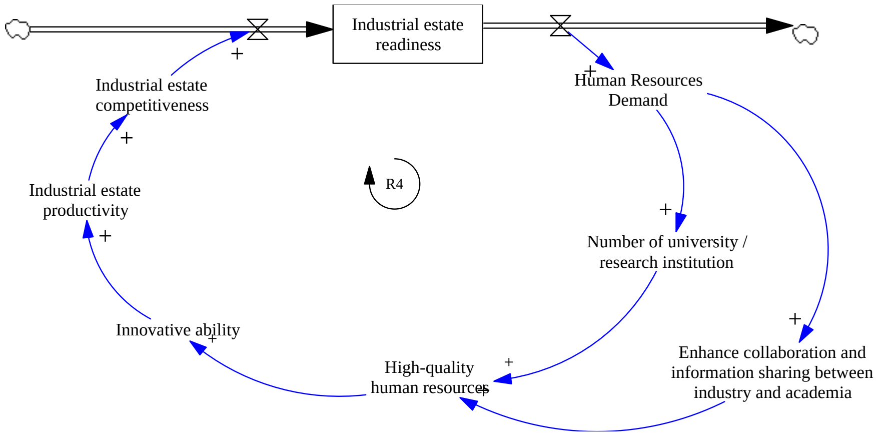


Figure 7 - Reinforcing Feedback Loop R4 – composing academic readiness

4.5 Reinforcing Feedback Loop R5 (Regulation/Government)

Government regulations that support industrial estate can be implemented to attract investment both from within and outside the country to increase the competitiveness of industrial estate. In addition, these regulations can positively impact local economic growth (Geng, Zhu and Haight, 2007). For example, the government can provide financial policies through loan facilitation with lower interest rates, lighter tax obligations, and discounts on land and utilities. In addition, the government can provide policies related to the environment to provide a beneficial economic impact, such as added value from solid waste generated from an integrated waste management system in industrial estates (Fig.8).

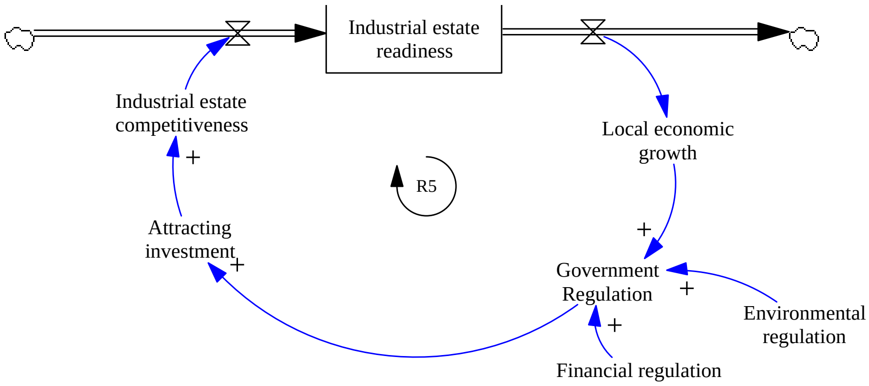


Figure 8 - Reinforcing Feedback Loop R5 – composing regulation readiness

4.6 Reinforcing Feedback Loop R6 (Industrial institutional)

Fig. 9 shows that institutional readiness will increase companies' innovation capability to enhance the competitiveness of industrial estate and compose industrial estate readiness. Increasing the readiness of industrial estates will encourage an increase in the scale of production that will affect the readiness of production facilities, the readiness of the transformation towards Industry 4.0, and the readiness of the company's technology. These factors affect institutional readiness in an industry. An industrial estate supported by knowledge resources and collaboration with research institutions is considered to have the opportunity to expand the production scale of the companies within it (Lin, Tung and Huang, 2006).

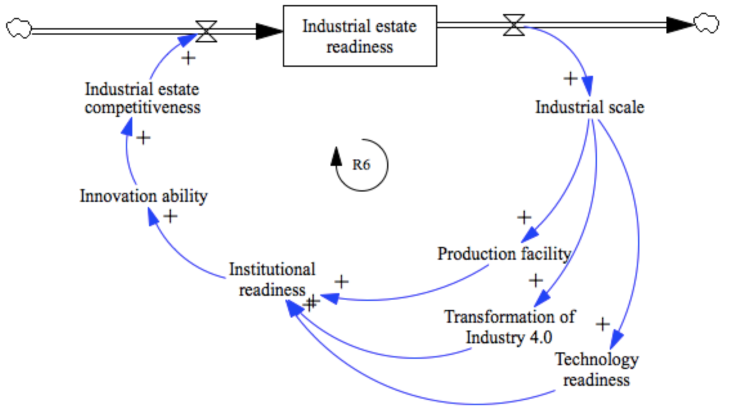


Figure 9 - Reinforcing Feedback Loop R6 (Industrial institutional)

The entire feedback loop above describes how the causal loop diagram of industrial estate readiness is obtained (Fig. 10).

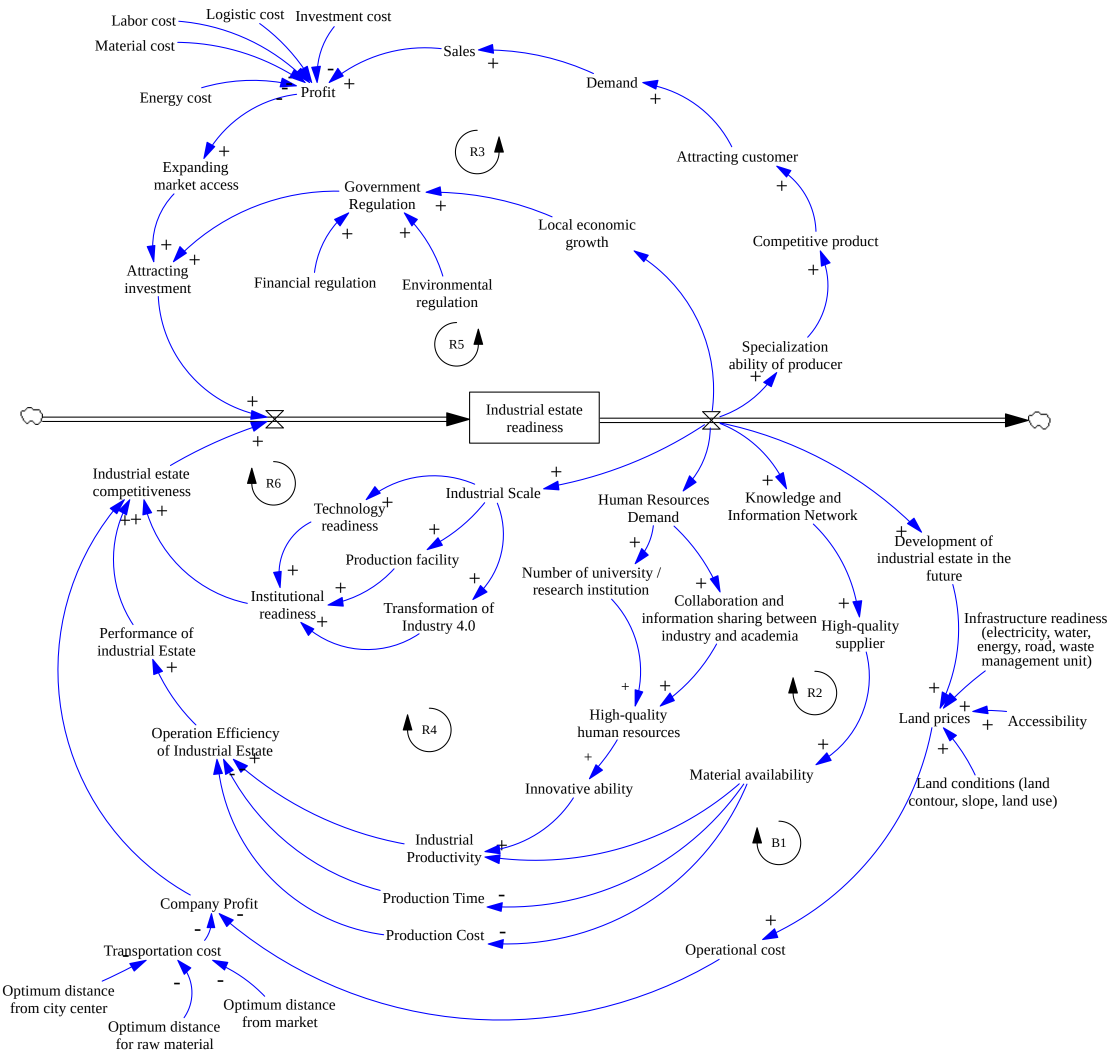


Figure 10 - System dynamics diagram of the industrial estate readiness

The results of the CLD with a system dynamics approach (cause-and-effect relationship based on the diagram) which composes the readiness of industrial estates in Indonesia in the Industry 4.0 era, as well as an effort to deal with the problems of industrial estate development in Indonesia, offers the following policies recommendations:

a. Policymakers must prepare a readiness measurement before industrial estate development considers all the aspects that influence it. In addition, it is also necessary to evaluate the assessment of industrial estates that have been operating to know which stage of readiness they are at and what aspects need to be improved. Since the early stages of planning and development of IE, the regulations set by the Government must have been met. This will accelerate each stage of IE development. The Government can continue to provide support by providing convenience in the licensing process, which is currently integrated by Online Single Submission (OSS) (Humas Kemensetneg, 2024).

b. Selection of the proper location also needs to consider regional regulations related to spatial planning and regional plans to minimize problems in land acquisition and permits by applicable regulations.
c. The location selection also needs to consider the connectivity of the industrial estate with public infrastructure such as roads, ports, and others that are available and planned. In addition, it is also a location that makes it easy to access energy, water, and raw materials.
d. To increase the equity of industrial estate outside the Java region, it is necessary to increase the marketing of industrial estate locations to attract investors who want to invest in industrial estate development in Indonesia. Government policy intervention also needed to keep land prices competitive. According to Jayabuana (2017), government intervention is needed so land prices are not entirely left to market mechanisms. Although land prices in IE are considered higher than outside IE, they can be strengthened by offering other advantages such as complete infrastructure, easy access to transportation, complete permits, and other advantages. Competitive land prices in IE impact land prices or land rental prices offered to industrial tenants, so it can attract more industrial tenants to operate in IE. This will increase the occupancy of industrial tenants in IE.
e. The management of industrial estate also needs to be strengthened to increase the occupancy rate of the industrial estate being managed. The IE management company can also be an investor in the IE, so it must be able to prepare complete facilities and infrastructure for industrial activities in the managed IE. The IE company must have the ability and understanding of all regulations that must be met and have a straightforward business process for the long term. The IE company must be able to map the attractiveness of the IE by selecting the right anchor industry so that the industry can attract other industries in an interconnected and related industrial network (UN Industrial Development Organization, 2019). This can create an industrial symbiosis that provides benefits for all industries involved in it.
f. The supply chain in IE is important in supporting the efficiency and productivity of industrial operations in IE. A smooth network and distribution from raw materials to finished product distribution can encourage smooth industrial operations. There is a need to use the latest technology and adopt Industry 4.0 in the supply chain in IE to support the efficiency of logistics costs and improve the smooth flow of materials, financial flows, and digital information flows. In addition, it also provides benefits in significantly reducing operational costs (Telkom University, 2024).

5 CONCLUSION

This study resulted in factors composing the industrial estate readiness through a clausal loop diagram with a system dynamics approach. Factors that compose the readiness of an industrial estate include:

a. Selection of the right industrial estate location by considering transportation and operational costs will maximize profits for the industry, thereby increasing the competitiveness of industrial estates. This will impact the future readiness and development of industrial estates to affect the price of the surrounding land, where infrastructure readiness, land conditions, and accessibility also influence land prices.
b. Supply chain readiness: High-quality suppliers will provide the materials the industry needs to increase productivity, reduce production time, and reduce costs, impacting an industrial estate's operational efficiency. This can improve an industrial estate's performance, thereby increasing its competitiveness and composing industrial estate readiness. Furthermore, increasing industrial estate readiness will enhance knowledge and information networks to obtain quality suppliers.
c. Market readiness: A company's profits are affected by material costs, labor costs, logistics costs, energy costs, and investment. By increasing profits, companies can expand market access so that the industry can attract investment, increase industrial scale, and create industrial estate readiness. This can enhance specialty capabilities so that products are

more competitive and preferred by customers and impact increasing demand. With increasing demand, it will enhance sales and affect company profits.

d. Readiness of human resources supported by academia: The competitiveness of the industrial estate composing industrial estate readiness increases the demand for human resources. It will encourage universities and research institutions that provide quality graduates. High-quality human resources are considered to have innovation capabilities that drive industrial estate productivity. Collaboration and information sharing between industry and universities also strengthen the quality of human resources.
e. Regulatory readiness: The existence of government regulations that support industrial estate (financial and environmental regulation) is considered to attract investment and increase its competitiveness. This will compose industrial estate readiness and impact local economic growth.
f. Institutional readiness is influenced by the readiness of production facilities, transformation towards industry 4.0, and technology readiness. This will increase innovation and industrial competitiveness to increase industrial scale.

The study presents a cause-and-effect relationship model based on the diagram for industrial estate readiness as a recommendation for designing a readiness measurement tool for industrial estate development in Indonesia. It can also complement existing readiness documents as evaluation material in developing industrial estates in Indonesia. By considering every factor contributing to industrial estates's readiness, we proposed several policy recommendations for their development. This model is expected to be beneficial for IE decision-makers and policymakers, including the government and other stakeholders, to develop the IE by measuring the readiness of industrial estates from all aspects so that the IE can attract more industrial tenants and optimize the IE occupancy rate will be optimal.

The present study has limitations, as it is still qualitative SD. Besides, no model validation or empirical data can be presented in this study. This study is still preliminary, so there are many opportunities for expanding the scope of this research. Further studies are needed to quantify the model by obtaining empirical data through surveys of related stakeholders, deeper interviews with related experts, and empirical data processing. The development of practical measurement indicators is also expected to complement this study.

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