ANALYZING CO-CREATION PROCESS IN CLUSTER INDUSTRY USING AGENT-BASED SIMULATION, CASE STUDY: BATIK INDUSTRIAL CLUSTER IN SOLO

Utomo Sarjono Putro, Institut Teknologi Bandung, Indonesia, utomo@sbm-itb.ac.id
Dhanan Sarwo Utomo, Institut Teknologi Bandung, Indonesia, dhanan@sbm-itb.ac.id
Pri Hermawan, Institut Teknologi Bandung, Indonesia, prihermawan@sbm-itb.ac.id
Shimaditya Nuraeni, Institut Teknologi Bandung, Indonesia, shimaditya@sbm-itb.ac.id
Khrisna Ariyanto, Institut Teknologi Bandung, Indonesia, khrisna@sbm-itb.ac.id

ABSTRACT

This paper proposes an agent-based model that describes the emergence of an industrial cluster. The mechanism referred in this study was obtained from the field study that was conducted in Batik industrial clusters in Solo. Using the constructed simulation model, virtual experiments were carried out under various industry conditions. The result suggests that forming a cluster is a natural strategy for a group of similar industries to survive. In long term, if there are so many industries produce similar product, only the producers that agglomerate with other industries can survive.

Keywords: *industrial cluster, agent-based simulation, decision making, computer simulation*

INTRODUCTION

Industrial cluster is aggregation of similar businesses together with their supplier and customer. The presence of common suppliers, customers, and even complementary in same geographical region to reduces total cost in accessing each other. There had been a lot of researches that addresses the structure, benefits and characteristics of industrial clusters. However, not many studies that discuss how an industrial cluster may emerge from the bottom-up interaction among agents. This paper propose a generic agent-based model that might describe the emergence of an industrial cluster in various industry conditions.

The mechanism that is proposed in this study comes from the field study that was conducted in Batik industrial clusters in Solo. Batik is traditional clothing that has become an identity of Indonesian, especially in Java area for hundreds of years. Among various batik craft centers in Java, Solo (Surakarta) batik is considered as the appropriate representative of Javanese traditional culture. This can be understood since the past, Solo was known as a center of a great empire of Mataram that controlled most of Java region.

Having developed over a long period of time, batik industries in Solo suffered a declined in the 80s. However, Solo batik industry in growing back in 2008 with the emergence of industrial clusters batik in the city. From the beginning of 2008, the amount of Batik Industrial cluster in Solo started to grow, with so many innovations, big market (consumers), low cost and high profit margin. This shows the economic contribution of the industrial cluster to the region. The dynamics and the economic importance of local industries that was happen in Batik industrial clusters in Solo make it suitable to study the mechanism of the industrial clusters formation.

LITERATURE REVIEW

By definition, industrial cluster is aggregation of similar businesses along with their supplier and customer. The development of industrial cluster is marked by some substantial factors such as technological transfer, knowledge transfer, the development of skilled workers, and infrastructure [1]. Porter [2] argued competition as a driving force of the growth of industrial cluster, since clustering is a dynamic process. Fruitfulness of a company in a competition increases customer demand, the growth generates contagion effect toward other companies in the cluster to develop. Nadvi and Schmitz [3] argued that the flow of both human and physical resources reduced investment risk, since the companies in the cluster support each other whether consciously or not. Close location with both supplier and customer

(and also other cluster components) eases their interaction [2]. Easiness to interact allows cluster elements to respond each demand and even technical problem effectively and efficiently. Evans [4] addressed that cost reduction is permitted by some similar business that locate in same region.

An industrial cluster often has unique character that is different to other clusters (even if their business is in the same sector). Interaction among some companies in the beginning of cluster development and the events faced evolve their identity. Therefore, industrial cluster would be very difficult to reorient industrially [5].

Reputation of a cluster in both innovating and maintaining their quality plays a very important role to sustainability of customer arrival and afterward affects the development of the cluster. Jacob [6,7] put forward that people tend to visit a location that allows them to find most of their needs, rather than travelling from area to area. In Solo, there are some center of batik crafts and commerce, such as Laweyan, Kauman and Pasar Klewer.

Table 1: The Size of Batik Industrial Cluster in Solo [8]

No	Item	Number of Worker	Investment	Production Value	Number of Business Units
1	Small Industry	24,954	57,859,790	4,239,889,800	1,061
2	Medium Industry	7,560	45,870,748	1,127,798,350	85
3	Large Industry	10,608	297,795,960	1,017,089,000	41
4	Non Formal	12,055	15,071,040	1,592,397,420	4,070
	TOTAL	55,177	416,633,538	7,977,174,570	5,257

By knowing the given characters of industrial clusters, this study will attempt to answer whether there is a generic mechanism that is able to describe the emergence of an industrial cluster in various industry conditions. This question will be answered by understanding what mechanism can describe the formation of cluster industry Batik in Solo, and to propose strategies to stimulate formation of cluster industry.

Agent-based simulation can be defined as a simulation of a system that consists of many software individuals that are called agents. In this simulation, agents can interact with each other and with their environment [9,10]. The aim of agent-based is not to make prediction. The main reason for this is because, social processes are complex and a simulation model will hardly poses sufficient accuracy for prediction. The function of the proposed model is to illuminate the core dynamics of the industrial cluster formation. This model can serve to clarify an abstraction, and strengthen human basic intuition [10,11] that explores plausible mechanisms that may underline observed patterns [12].

METHOD

This research began with conducting field study in batik industrial cluster in Solo. This field study aims to identify the historical dynamics of industrial cluster formation, the driving factors of industrial cluster formation and decison making rule of each agent in industrial cluster in Solo. This process was carried out by collecting secondary data from Solo city government and conducting interviews with stakeholders. The stake holders in this field study were batik entrepreneurs and officials from Solo city government. Based on the result of this interview the interaction mechanism and decision making rule that can represent the interactions that occur in the real world were synthesized.

The obtained interaction mechanisms and the decision making rules were then programmed as an agent-based computer simulation. The agent-based simulation in this study was constructed using NetLogo 5.0.3. By using the constructed simulation, virtual experiments were conducted under various industry conditions. In these experiments the average agent's wealth and the density of the emerging cluster were observed. The average agent's wealth indicates the profitability and the sustainability of the industries while the cluster density indicates how close the industries will be clustered.

This study draws conclusions from the obtained experimental results. In addition, policies that can support industrial cluster formation were also analyzed, based on the mechanisms that were identified in the field study in Solo.

MODEL

Based on the mechanism that was unfolded from the field study, an agent-based simulation model was constructed.

The proposed model consists of five sub models. First is agent's business and economic sub-model, including price determination, and profit and capital calculation mechanism. Second is agent's network model sub-model, which includes of how an agent develops his/her trade network. Third is agent's skill specialization sub-model, which differentiates the basic skill for consumer agent, producer agent, and supplier agent. Fourth is product and production sub-

model that includes mechanism of how to decide the quantity of needed material, how many products will be made, and the production and selling price calculation. Last is trading mechanism among agents.

There are three types of agents in this simulation, *i.e.* producer, consumer, and supplier. Each agent constructed in the simulation has needs (*i.e.*, for producers they need raw materials which are transformed into products), and competencies (*i.e.*, supplier has ability to process external resources into raw material, producers has ability to process raw material into finished product, while consumer has ability to consume finished product). The total number of agents is fixed during the entire simulation, while the positions of each agent are initiated randomly.

Initially, each agent is randomly connected to other agents and, only able to interact through this connection. The average number of agent's connections at the beginning of simulation is set by using initial-average-node degree parameter. The interaction among agents involving trading mechanism by using cash. The amount of cash owned by each agent at the beginning of simulation is initiated randomly.

$$Money_i = random\ (0,100) \tag{1}$$

During the simulation, first, each consumer agent randomly generates their demands of finished product. The demands of the finis product are generated randomly from 0 to 100. After that, consumer selects a producer with the cheapest price and delivery cost sort all from all available producers within his/her network. If there is no producer in a consumer's network, the given consumer should wait until the next iteration. If the amount of finished products owned by the selected producer is less than the consumer's demand, then the consumer will buy the rest of his/her demand from the second-cheapest producers.

After the trading mechanism between consumer and producer, each producer agent, choose suppliers from their connected network. The role for choosing the supplier similar with the consumer, which is producer chooses the supplier with the cheapest price and cheapest shipping/ delivery cost. The delivery cost from supplier *j* to producer *i* is calculated by multiplying the distance of producer *i* from supplier *j* by the cost per distance unit.

$$CD_{ji} = CPD\sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2} \tag{2}$$

Where CD_{ji} is the delivery cost from supplier *j* to producer *i*, CPD is the cost of delivery per distance unit, x_i and x_j are the x posititon of producer *i* and supplier *j*, whlie y_i and y_j is the y position of supplier *j* and porducer *i*.

The producer sets the demand of raw material by dividing the total of his/her money minus delivery cost by the price offered by the selected suppliers. If the amount of raw material owned by the selected cheapest supplier is less than the demands of the producer, then the producer will buy from the second cheapest supplier. The number of products that can be made by a producer is equal to the number of obtained raw material. The producer then set the price for the product as a function of total production cost plus 10% profit margin.

$$FP_i = \frac{\sum_{j=1}^{M}((MP_j * MQ_j) + CD_{ji})}{FQ_i} * 110\% \tag{3}$$

Where FP*i* is the price of finished product from producer *i*, MP_j is the raw material price from supplier *j*, MQ_j is the quatity of the raw material bought from supplier *j*, and FQ_i is the quantity of finished product produced by producer *i*.

For supplier agent, they convert the external resources into raw material. The cost for this process is assumed constant (fix). The number of external resources that can be converted into raw material is determined by dividing the total money of each supplier by the conversion cost.

$$FM_j = \frac{Money_j}{MC} \tag{4}$$

Where, FM_j is the raw material produced by supplier *j* and MC is the cost to convert external resources into raw material.

Each supplier will then set the price of raw material as a function of total production cost with 10% profit margin.

$$MP_j = MC * 110\% \tag{5}$$

After the trading mechanism is conducted by all agents, agents whose money is less than or equal to zero are eliminated from the simulation. Each remaining agent will then create new connection with other agent. The number of the eliminated agents will

then be replaced by generating random agent in random position and with random network.

After that, the average of agent's wealth (AAW) is calculated as the average of money that is owned by all agent.

$$AAW = \frac{\sum_{i=1}^{n} money_i}{N} \quad (6)$$

With N is the total number of agents

To indicates how close the agents are clustered, the density of the cluster (DC) was also calculated by dividing the number of agents with the number of occupied cells.

$$DC = \frac{N}{total\ occupied\ cells} \quad (7)$$

EXPERIMENTS

Experiment in this research aims to (1) test whether the constructed mechanism can describe the phenomenon of cluster industry formation, (2) to analyze the benefit of cluster industry formation to each agent. In these experiments the number of agent in each group were varied from 10 to 100, and the average node degree were varied from 1 to 10.

The experiment result show that for any number of agents, and any value of average node degree parameter, agents will survive if they are clustered each other as shown in Figure 1. The experiments results also show that the average of agent's wealth will increase as the density of the cluster increase, as shown in Figure 2 and Figure 3.

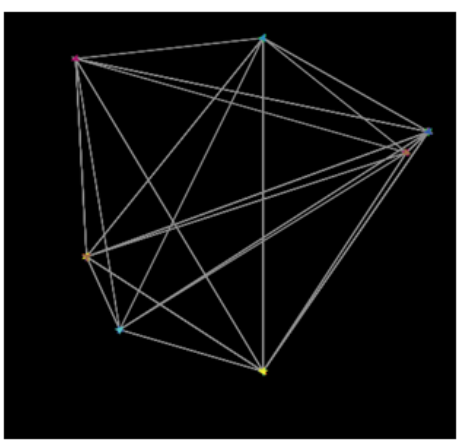

Figure 1: Agent's Network Interface in the Simulation

Figure 2: the Average of Agent's Wealth during the Simulation

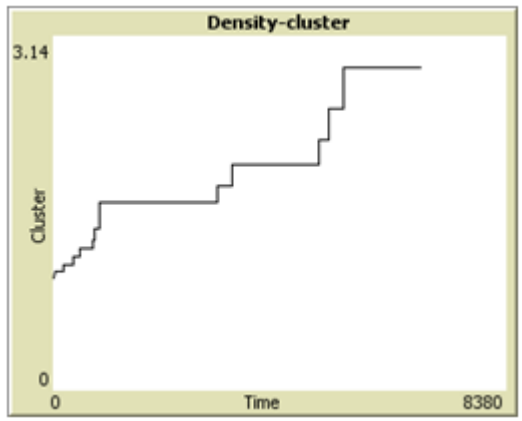

Figure 3: the Density of the Cluster during the Simulation

This result suggests that forming a cluster is a natural strategy for a group of similar industries to survive. Of course a cluster is not always emerging in the real world because there is the possibility that the entire industry within a region will be bankrupt before the cluster emerges.

CONCLUSIONS

Based on the experiment results, it can be concluded that the proposed mechanism can describe the emergence of industrial cluster as bottom-up interaction between agents with interdependency decision making. The basic decision making role is choosing the business partner (either producer or supplier) such that the lower price of the product be obtained. In long term, if there are so many industry produce similar product, only the producer that agglomerate with other industry can survive. As a result of the agglomeration, the average wealth of each agent will increase.

Considering the interaction pattern of industrial cluster there are several policy can be implemented to stimulate the industrial cluster formation, such as join-showroom, create waste-water treatment plant for several industries, renovate the facilities (access) to the cluster industries.

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