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Multi-Agent Simulation in the Inter-Organizational Trust Model and Knowledge Sharing in the Automotive Industry

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ABSTRACT

Two organizations can share knowledge to determine the success of their collaboration. Effectiveness in knowledge sharing affects organizational performance and trust between organizations. This study aims to identify the implementation of multi-agent simulations to increase trust in sharing knowledge between organizations. A multi-agent simulation approach was used in this study. The research model was adopted from previous research. Several hypotheses and path coefficients were tested in simulation models. This study showed that multi-agent simulation is suitable as a problem-solving method for complex issues such as knowledge sharing. In addition, this study identified individual factors such as likability and expertise in the success of knowledge sharing between organizations.

1. Introduction

The automotive industry is the sector that is responsible for product development. The automotive industry produces quality products. The selection of materials of the goods has strong influences. The supplier is one of the critical factors in the production line to meet the requirements of the component [1]. Time, quality, and quantity consistency can be used as a guide when measuring the performance of suppliers [2]. Through collaboration, the industry can combine the resources, skills, and knowledge of the supplier within the company. Furthermore, collaboration encourages good quality products [3]. Collaboration is expected to reduce transaction costs, improve productivity, increase profitability, and enhance the company's competitive advantage [4]. When part of the process of collaboration, companies can share the expertise they have. Knowledge sharing can help in problem-solving, designing products, improving manufacturing capability, and developing product quality [5]. Knowledge sharing within organizations

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helps companies develop new skills, develop best practices, and enhance work performance [6].

Several previous studies have discussed issues that affect the sharing of inter-organizational knowledge. Chen, Yin, and Len [7] concluded that inter-organizational trust in collaboration is a critical aspect of inter-organizational knowledge sharing. The high level of trust leads the organization to share helpful information with other organizations [8]. Furthermore, Ramadan and Samadhi [9] claimed that effective inter-organizational knowledge sharing is influenced by organizational aspects, personal aspects, and aspects of trust. Based on these studies, trust is a critical factor in the inter-organizational knowledge-sharing process. Trust is defined as the belief in a partner to achieve a positive outcome and not take action that negatively impacts. Although the model is pretty comprehensive, previous studies only use a statistical approach to explain the relationship between variables. The knowledge-sharing process is a dynamic process that involves interaction between people, systems, and the environment [10] [11]. Therefore, the knowledge sharing process is not sufficiently represented in the statistical models [10] [11].

As an alternative to the statistical approach, some previous researchers used a multi-agent approach to describe the knowledge sharing process [12] [11] [10]. A multi-agent approach can describe relationships between individuals involved in the knowledge-sharing process [10]. However, in the context of inter-organizational knowledge sharing, no work incorporates the idea of a multi-agent. In inter-organizational knowledge sharing, companies can try to protect their knowledge by limiting the knowledge-sharing process. Knowledge sharing between the business and its partners can improve its partners' competitive advantage [13]. Therefore, this study attempts to identify the use of multi-agent simulation to increase inter-organizational trust and knowledge sharing between manufacturers and suppliers in the automotive industry.

This study consists of four parts: introduction, methods of research, results, and discussion, as well as conclusions. The Introduction section discusses the background of this work. The research method addresses the approaches used in this study to solve problems. The results and discussion are discussed regarding the results of the simulation scenario. Finally, the final section is described in the summary of findings and suggestions for further study.

2. Methods

2.1 Research Design

The research design of the work is shown in Fig. 1. There were five major stages of this research. The first was the identification of conceptual models showing the structural models of the hypotheses. Second, the design of simulation models is focused on predictions and the flow of actual conditions that exist in the case under review. Third, implement an agent-based simulation software model in NetLogo. Fourth, the validation of the model to ensure that the model can be used to predict the system. Sixth, the generation to analyze and obtain findings related to the combination of inputs.

2.2 Conceptual Model of Inter-Organizational Knowledge Sharing

The conceptual model of this study used a model of inter-organizational knowledge sharing in the automotive industry developed by Ramadhan & Samadhi [9]. The conceptual model is shown in Fig. 2.

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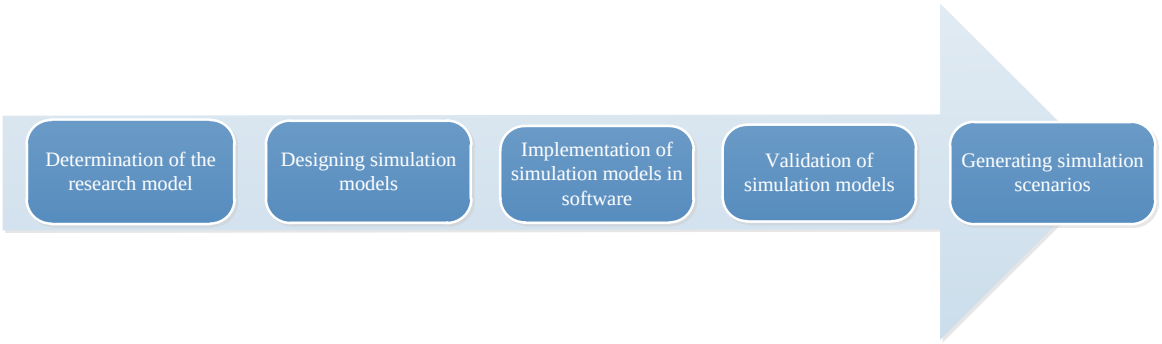

Fig. 1. Research Method

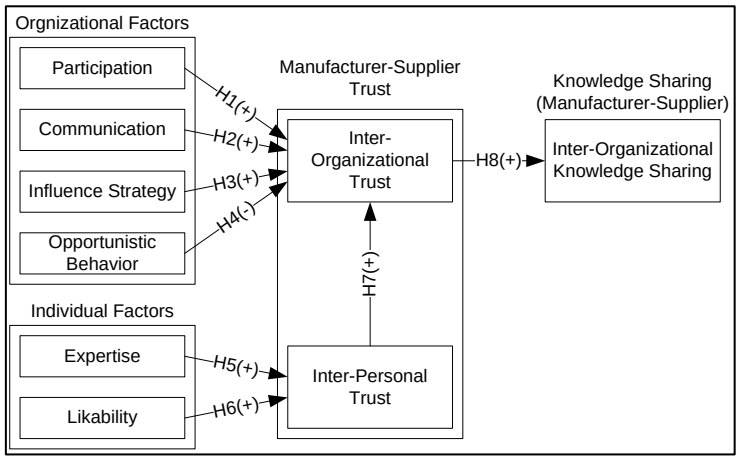

Fig. 2. Conceptual Model of Inter-Organizational Knowledge Sharing

Participation is defined as a measure of the extent of common commercial goals [9]. It was reviewed via supplier involvement in generating ideas, decision-making, and planning and goal setting [9]. The higher participation was carried out by partners and the higher trust between organizations. Communication can increase reliance on companies [13]. In this study, communication is the process of sharing information between the manufacturer and the supplier [14]. Influence strategy is a strategic mechanism to encourage organizational behavior in achieving organizational goals [7]. In this study, influence strategy means a strategy carried out by manufacturers or suppliers to improve coordination. Potential opportunistic behavior can occur in cooperation between companies [15]. In relationships between companies, the partner companies become opportunistic when organizational behavior is inconsistent and detrimental to the other companies [16]. In this research, opportunistic behavior is behavior that selfish and detrimental to other companies.

Furthermore, skill is the capabilities of each producer or supplier in building trust between companies [16]. Interactions that occur on manufacturers and suppliers of cooperation include buying and selling, technology, or upgrading competence. Based on these explanations, expertise can enhance personal confidence. Likability is defined as a manufacturer and supplier assessment related to friendliness, openness, and mutual personal delight [9]. A person's likability influences the personality of the automotive industry, cooperation, and interaction between individuals.

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Inter-personal reliance is a measure of individual confidence in employees from the buyer and supplier side [17]. Inter-personal reliance can affect inter-company dependence rationally at the organizational level [17]. Ramadan & Samadhi [9] explains that inter-personal confidence can affect inter-organizational reliance On the individual level. Reliance is an important aspect that facilitates business interaction and knowledge sharing between companies [7] [18]. Inter-organizational dependence is an essential factor that can increase inter-organizational knowledge sharing.

Based on the previous research, this study creates a hypothesis that assumes relationships between variables. The hypotheses were then verified by the partial least square model (SEM-PLS). The Hypotheses are presented in Table 1.

Table 1. Hypothesis

Hypothesis (H)
H1: Participation has a positive influence on inter-organizational reliance.
H2: Communication has a positive influence on inter-organizational reliance.
H3: Influence strategy has a positive influence on inter-organizational reliance.
H4: Opportunistic behavior has a negative influence on inter-organizational reliance.
H5: Expertise has a positive influence on interpersonal trust.
H6: Likability has a positive influence on interpersonal trust.
H7: Inter-personal trust has a positive influence on inter-organizational trust.
H8: Inter-organizational trust has a positive influence on inter-organizational knowledge sharing.

2.3 Data collection

Data were collected by a questionnaire. Data were obtained from manufacturers that have suppliers. The sampling method used purposive sampling. The purpose was to ensure the compatibility of questionnaire respondents with existing content. Based on questionnaires, data was collected around 120 responses, and only 97 data can be processed.

2.4 Determination of Input-Output Simulation

Inter-organizational Knowledge Sharing (IKS) was the result of the study. IKS has a scale from 0 to 100. 0 was a low value, and 100 was a very high value. Individual-level was the main problem of this study. Two significant variables that influence producer and supplier dependency were skills and likability. Those two factors act as dependent variables. The value of the two elements was combined with independent variables at the organizational level. Independent variables were participation, communication, influence strategy, and opportunistic behavior.

2.5 Determination of Agent, Attributes, and Behavior

Manufacturers and suppliers in the automotive industry were objects in knowledge-sharing activities. Individual company workers interact with their supplier employees. Thus, there were two types of agents in individual producers and their suppliers. Both of the agents interacted more with the producer agent. Factors that affect the process of sharing knowledge between the two types can be identified. Agent attributes and behavior of agents are shown in Table 2. Attributes were assigned to each agent of skill and likability. Each agent has a different identity (ID). The agent's behavior in this process is sending and receiving knowledge.

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Table 2. Agent, Attribute, and Agent Behavior

Agent Type	Attribute	Agent Behavior
Individual Manufacturer	ID, Expertise, Likability, IPT	Send and receive knowledge
Individual Supplier	ID, Expertise, Likability, IPT	Send and receive knowledge

2.6 Design of Multi-agent Simulation Model

Multi-agent simulation is a simulation model that emphasizes individual agents as sub-components. Individual agents interact with each other to influence the whole system [19]. Previous research has shown that multi-agent methods can solve complex system problems [20] [11] [21] [12] [22]. There were two levels of analysis in the simulation model: the individual and organizational levels. The organizational level directly influenced inter-organizational trust (IOT). Producers and suppliers' influence were the factors at the organizational level. In this model, producers can act as senders of knowledge. Suppliers act as receivers and senders of expertise. Thus, the IoT value can be average. Individual-level factors are the main focus of this simulation model because interactions between agents modeled the individual level.

Moreover, interactions between agents were identified to determine the effect of individual-level on IOT. It affected knowledge-sharing between organizations (IKS). Furthermore, the simulation process of flow was designed. The simulation begins with the initialization of the time and value of organizational characteristics (participation, communication, influence strategies, and opportunistic behavior). This value is an independent variable parameter. It is a characteristic of producers and supplier companies. A simulation flow diagram is presented in Fig. 3.

2.7 Simulation Model Validation

The model validation process was divided into two steps. The first step was model validation, and the second was extreme validation (replication). Model validation aimed to measure model sensitivity by a random process. Excessive validity was implemented to examine the output value.

3. Results and Discussion

3.1 Results Hypothesis and Path Coefficient

The hypothesis test used the SEM-PLS method. The results of testing the hypothesis are shown in Table 3. Based on the path coefficient values in Table 3, it can be written as:

IOT = 0.199 * Par + 0.208 Com + 0.221 * IS - 0.263 * OB + 0.188 * IPT ..... (1)
IPT = 0.216 * Expert + 0.399 Lika ..... (2)
IKS = 0.465 * IOT ..... (3)

IOT: Inter-Organizational Trust; Par: Participation; Com: Communication; IS: Influence Strategy; OB: Opportunistic Behavior; IPT: Inter-Personal Trust; Expert: Expertise; Lika: Likability; IKS: Inter-Organizational Knowledge Sharing.

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Table 3. Acceptance hypothesis

Hypothesis	Path Coefficient	P-Value	Conclusion
H1	0.199	0.032	Accepted
H2	0.208	0.023	Accepted
H3	0.221	0.023	Accepted
H4	-0.263	0.004	Accepted
H5	0.216	0.030	Accepted
H6	0.399	0.004	Accepted
H7	0.188	0.011	Accepted
H8	0.465	0.000	Accepted

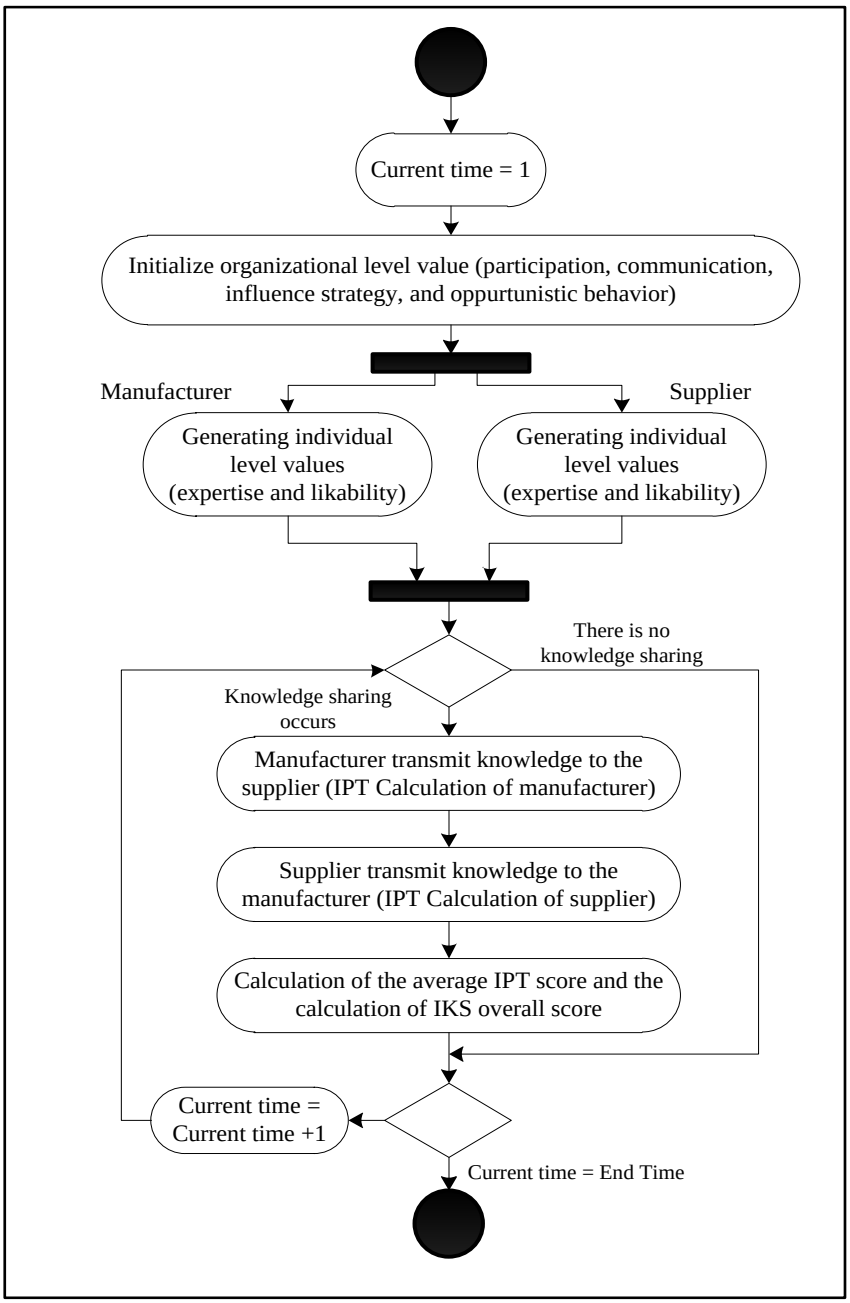

Fig. 3. Flow Simulation Model of Knowledge Sharing between Agent

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3.2 Model Validation Results

The results of model replication are shown in Fig. 4. Based on Fig. 4, there are no values that exceed the upper bound and lower bound. Replication is implemented on several system characteristics. The characteristics of the system are the number of suppliers in manufacturing agents. There is low, medium, and large scale. It is concluded that the random process in this simulation model is good and did not include a sensitive simulation model.

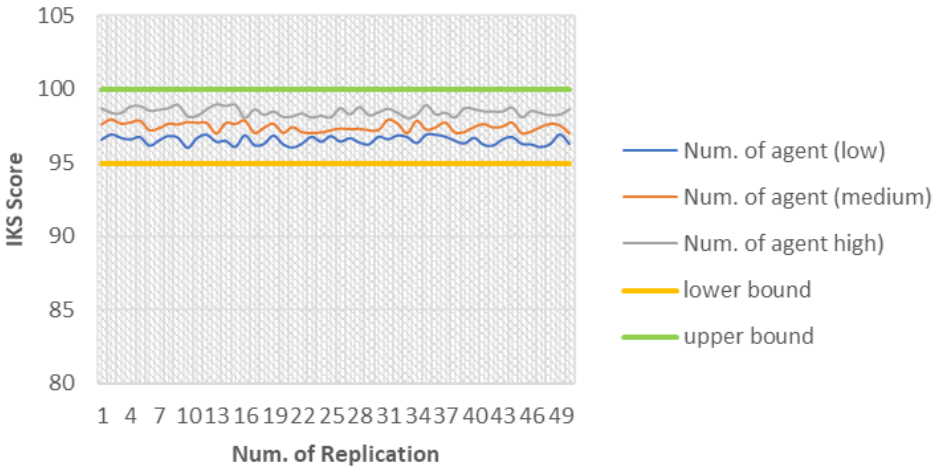

Fig. 4. Replication Output

The results of extreme validation are presented in Table 4. It explains that the less the value of organizational level (participation, communication, influence strategy, and opportunistic behavior) and individual level (expertise and likability). Therefore, the amount of IKS can be smaller. These results prove that the tone of the simulation model is logically by actual system conditions. Thus, it concludes that the simulation model is overall valid and can create simulation scenarios.

Table 4. Extreme Validity Simulation Model

Organization Level Score	Individual Level Score	IKS Score
Low	Low	0.50
Low	High	13.85
High	Low	86.43
High	High	99.79

3.3 Multi-agent Simulation Results

The main focus of this study is to study the effect of individual characteristics (expertise and likability) in increasing inter-organizational knowledge sharing on the relationship between manufacturers and suppliers. Details about the scenarios generated are shown in Table 5.

In all scenarios, it makes several possibilities for individual characteristics in making the process of sharing knowledge. The scenario results are shown in Table 6. It found that collaborating organizations have low organizational value. The level of skill and likability of each interaction did not help increase the knowledge-sharing between

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organizations. It is consistent with the results of several previous studies [23] [24]. According to Zhang and Jiang [24], organizational characteristics influenced knowledge sharing. The aspects of organizational culture determined the effectiveness of sharing knowledge carried out by an individual [23] [25] [26].

Table 5. Research Scenarios

Scenario	Explanation	
1	The Company does not have policies that support a culture of knowledge sharing in the company or inter-company.	The parameter values for participation, communication, influence strategy, and opportunistic behavior are low
2	The company began to aware and implemented a knowledge-sharing culture among companies	The parameters of participation, communication, influence strategy, and opportunistic behavior are moderate
3	The company implements a culture of knowledge sharing between companies well and has policies related to knowledge sharing	The parameters of participation, communication, influence strategy, and opportunistic behavior are high

Table 6. Results from Scenarios

Expertise	Likability	IKS Score		
		Scenario 1	Scenario 2	Scenario 3
Low	Low	0.50	51.97	86.43
Low	Medium	4.83	56.30	90.77
Low	High	9.16	60.63	95.1
Medium	Low	2.84	54.31	88.78
Medium	Medium	7.17	58.64	93.11
Medium	High	11.5	62.98	97.44
High	Low	5.12	56.66	91.12
High	Medium	9.52	60.99	95.46
High	High	13.86	65.32	99.80

Based on the results of scenario 2, the organizational factor value is moderate. The individual factors of each manufacturer and supplier employe are sufficient to increase inter-organizational knowledge sharing. The results from scenario 3 show that organizational value factors are very high, although individual factors are low. Besides, a knowledge-sharing culture still has good results.

Moreover, the results show that the likability factor in individuals is more important than the expertise factor from the three scenarios. Based on the results of previous studies, a person's personality can affect the effectiveness of knowledge sharing [27] [28] [29]. One of the goals is to develop new ideas [24]. Therefore, having competence and experience makes people a good friend to share knowledge [24]. Besides, it concluded that the better was organizational levels' value, and the smaller was the influence of the individual level. The three scenarios' findings show some differences in the parameters at the organizational and different levels. Manufacturers, as an organization, must provide support in terms of policies related to the knowledge sharing the culture of their employees. If no policy-related, no matter how good the supplier's ability to share knowledge. Furthermore, if a new manufacturer starts to prioritize policies to familiarize his employees with a knowledge-sharing culture, then it is better to choose individual

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suppliers who are fun and open (high likability). Therefore, it is easy to share knowledge with manufacturer employees.

4. Conclusion

This study simulates the effect of individual and organizational character in increasing trust between organizations and knowledge sharing using a multi-agent approach. This study shows that the likability factor is an essential factor in increasing knowledge sharing between organizations. Based on these results, an individual is likely to share his knowledge when interacting with individuals. Therefore, an individual who represents the company in collaboration should be prioritized a delightful personality. Furthermore, the results obtained in this study are the role of different individual characteristics depending on company conditions. In companies that have not yet implemented a knowledge-sharing culture, likability has a crucial role in increasing the knowledge-sharing process between companies. Companies with knowledge-sharing and individual characteristics did not have to play a significant role in sharing knowledge between companies. For further research, it is better to develop conceptual models of knowledge sharing between organizations. Subsequent studies consider the mechanisms and media sharing of knowledge as the factors that influence the success of knowledge sharing. Besides, further research can consider feedback effects on the success of knowledge sharing in previous interactions that affect the characteristics of the individual or organization within the next interaction.

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