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FORMATION MODELLING FOR INTER-AGENT NEGOTIATION AND COLLABORATION WITH THE SAME VALUE SYSTEM

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Abstract

Collaboration is essential in integrating resources, data, and information to ensure organizational performance and competitive advantage. Negotiation is defined as inter-agent collaboration between employees or members from different teams in the organization, which is crucial to achieving the goals. The success factor is related to mental processes between interacting agents, which are influenced by the conditions of their team. This study aims to analyze inter-agent collaboration based on sharing the same value system influenced by various organizational elements, which are considered as variables in this study. These are communication of organizational strategy, flat and hierarchical team organization structure, ambidextrous leadership of their team leaders, knowledge-intensive environment, and knowledge absorption. Given the complexity of the research, which seeks to examine agent dynamics within processes and their interactions with organizational environment elements, the study has adopted the Agent-based Modeling and Simulation (ABMS) method. ABMS is highly effective for modeling and analyzing the intricate relationships and behaviors of agents, making it well-suited for exploring dynamic systems. As a recognized soft systems approach, ABMS aligns with the study's objective of understanding complex organizational interactions. The method's strength lies in its ability to translate real-world conditions into computational models that simulate various organizational scenarios and dynamic conditions. To enhance this approach, the researchers developed a framework called DARMA, short for Development of Artificial Representative Designs in Modeling Agent-based and Simulation, which serves as a methodological advancement in the implementation of ABMS. Several findings of this study show that ambidextrous leadership of team leaders and different types of team organization structures affect inter-agent collaboration. Flat team structures produce higher inter-agent collaboration types than hierarchical team structures that produce more simple inter-agent collaboration types.

Keywords: agent-based modelling; inter-agent collaboration; negotiation; same value system; team structure; ambidextrous leadership; knowledge absorption

1. Introduction

Organizations enhance their competitive advantage by fostering collaboration and integrating diverse resources to drive innovation (Lusch et al., 2010). Traditionally, hierarchical structures were the dominant mechanisms for managing collaboration, as they provided control and efficiency (Knez in Dickson, 2000). However, modern organizations increasingly adopt team-based structures that emphasize cross-functional interactions and flexibility (Warner & Wäger, 2019). While this shift enhances adaptability, it also introduces challenges in alignment, coordination, and maintaining a shared purpose across diverse teams (Schneider, 2020). Previous research has explored how structural changes impact organizational responsiveness and resource sharing (Gittel, 2016), yet understanding the mechanisms that facilitate inter-agent collaboration—particularly within teams that share value systems but exhibit cognitive diversity—remains an open question.

Cognitive diversity, defined as variations in thinking styles, expertise, and problem-solving approaches, plays a critical role in organizational decision-making and innovation (Wang et al., 2016). While a shared value system fosters trust and alignment among team members, cognitive diversity introduces new perspectives that can enhance problem-solving but also create coordination difficulties (Stein, Frey, & Flache, 2024). Prior studies have examined demographic diversity, but research on how cognitive diversity influences collaboration within structured organizational settings remains limited (Qu et al., 2024). Furthermore, the role of ambidextrous leadership in integrating cognitive diversity while preserving shared value systems is underexplored (Fernández-Pérez de la Lastra, Martín-Alcázar, & Sánchez-Gardey, 2022). Addressing how organizations can optimize collaboration by leveraging cognitive diversity within shared value systems represents a critical research gap, as visualized in Figure 1.

Figure 1. Interaction between Elements to Enhancing Inter-agent Collaboration

Source: Author

This study examines the interplay between organizational communication, ambidextrous leadership, cognitive diversity, and shared value systems in shaping inter-agent collaboration. While previous research has explored hypergame theory in competitive decision-making (Sasaki & Kijima, 2016), its application in collaborative environments involving cognitive diversity has not been thoroughly examined. Using Agent-Based Modeling and Simulation (ABMS), this study models how cognitively diverse agents navigate shared value systems and collaboration dynamics. Unlike prior research that focuses solely on structural or behavioral influences, this study integrates cognitive diversity as a crucial parameter in inter-agent collaboration modeling, providing a novel perspective on balancing innovation-driven diversity with structured coordination mechanisms. Figure 1 represents the conceptual framework that maps the role of leadership, team structure, communication, and knowledge-sharing in shaping inter-agent collaboration within shared value systems.

This research contributes to organizational behavior, strategic management, and computational modeling literature by offering a structured framework for optimizing collaboration in knowledge-intensive environments. It expands the application of hypergame theory to collaborative contexts, introduces cognitive diversity as a key driver in inter-agent collaboration, and provides practical insights on managing cognitive differences through strategic leadership and communication. The findings are expected to inform both theoretical advancements and managerial practices in designing adaptive team structures.

2. Literature Study

Organizations have the complex reality of various elements and phenomena. Researchers focus on several organizational elements that interact directly with the collaboration process between teams and agents within them.

2.1. Communication of Organization Strategy and Awareness of purposes

Wang et al. (2021) stated that shared vision, usually seen as a top-level concept, facilitates information and resources flow and exchange within the organization as a relational process to strengthen the coordination efficiency, understanding facilitation, constructing robust cooperation, and communication basis. Whether top management's strategic awareness message is more effective in influencing boundary personnel. Previous research studies also concluded that leadership capabilities, specifically in hybrid workplace conditions, significantly affect the awareness of members' goals in their organizations (Nugroho and Hermawan, 2022).

Awareness describes an individual's comprehension reflection about why the change is being made, the nature of the change, and the risk of not changing (Hiatt, 2006). Angtyan (2019) conclude several factors that influence the change awareness of the people: (a) individual view an existing state, (b) how a person views a situation, (c) the reliability of the sender's, (d) false informa1tion or rumours spreading, and (e) the rationale for the change is debatable. There are three stages of situational awareness relating to various mental models from Endsley (2018) study, namely: (a) perception of the elements in the environment, (b) current situation comprehension meaning in relation to the operator's responsibilities and objectives, (c) mental image ability to guide future projection.

Communication of organizational strategy intensity related to the agent's awareness of purpose affects inter-agent collaboration. The occurrence of awareness of purposes from members is set based on probabilities that can be assigned a value and at this study's intended value based on the (Nugroho and Hermawan (2022) previous research as real-world environment data.

2.2. Ambidextrous Leadership

Leaders must be flexible, synthesized in dialectical thinking that negates the dichotomy and yields knowledge, and connect various shared knowledge contexts inside and outside the organization (Nonaka and Takeuchi, 2019). Organizational and leader ambidexterity mixed to solve the dilemma between exploration and exploitation in highly competitive environments (Fernández-Pérez de la Lastra, Martín-Alcázar and Sánchez-Gardey, 2022). Raisch et al. (2009) stated two modes of organizational learning, exploration and exploitation, as the prominence of organization ambidexterity to utilize their resources. Exploration focuses on new possibilities with several generic terms, i.e., innovation, discovery, experimentation, and flexibility; on the other side, exploitation focuses on old certainties with several generic terms, i.e. efficiency, refinement, selection, and execution. Exploration and exploitation are essential but often compete for scarce organizational resources and attention.

Guo et al. (2020) studied ambidextrous leadership using 'loose–tight leadership' as leader–member exchange to study management dynamics from the perspective of power in the organization. Leader–member exchange is the relationship between leaders and other individuals, emphasizing an effective, mature, and reciprocal exchange which benefits all parties. The influence of ambidextrous leadership of team leaders in sharing value systems focuses on exploiting their work and exploring various opportunities for developing future work for their team members to their team structure. This research investigates the effect of ambidextrous leadership of team leaders to the agent's same value system and enhancement of inter-agent collaboration.

2.3. Team Organization Structure

Demands forms of organization quite differ from bureaucracies because of rapid technological changes, devolution, scarce resources, and rising interdependence that make an increasingly 'networked' world (Barley et al., 2017). Lee and Edmondson (2017) emphasized this phenomenon's several terms, including less-hierarchical organizing, flat organizations, and team-based work. Less-hierarchical organizing defines as efforts to adapt the managerial hierarchy to make more decentralized authority relative to classic unity of command hierarchical principles, supervision of lower offices by higher offices, and obedience to superiors. Decentralized authority is implemented by decreasing the number of levels of formal authority (i.e., "flattening" the formal hierarchy) or by creating a more equitable distribution of authority across existing hierarchical levels. Zhang et al. (2014) stated that flatness is an organizational state with few levels in the hierarchy or chart and a few management levels in the chain of command. Few chains of command tiers reduce hierarchical costs or barriers associated with cross-functional communication and shortens the length of decision-making to make joint decision-making and cooperation (Zhang, Zhao and Qi, 2014). At lower levels of centralization, authority is assigned to lower echelons, increasing their feelings of psychological ownership of the products at their responsibilities and their feelings of responsibility and reducing internal resistance (Walheiser et al., 2021).

Organization members in self-managed teams that make more decision-making on behalf of the organization delegate managerial authority to groups of individuals who are close to and experts (Lee and Edmondson, 2017). In a collaborative community, members can self-organize and self-manage (actor-oriented), which is increasingly used as an emerging organizational form in knowledge-intensive environments (Haakonsson et al., 2017). A low degree of centralization of the decision-making process can complement and enhance the knowledge performance that may result from formalization and complexity (Zhou and Li, 2012). Xu, Wu and Evans (2022) conclude from their study that tall and hierarchical teams produce less novelty often develop existing ideas relative to flat, egalitarian teams, and increase short-term citations but decrease long-term influence.

Considering various discussions and research results in the literature above, in this study, the organizational structure is focused on agent autonomy and decision-making difference between hierarchical and flat organization structures. This study explores the differences in hierarchical and flat team structures between interacting agents in producing higher inter-agent collaboration.

2.4. Cognitive Diversity and Team Collaboration

Cognitive diversity refers to the differences in thinking styles, knowledge, skills, and values among individuals within a team or organization (Wang et al., 2016). Unlike demographic diversity, which is based on observable characteristics, cognitive diversity influences how individuals process information, approach problem-solving, and generate innovative solutions (Qu et al., 2024). Research suggests that teams with high cognitive diversity tend to enhance creativity, adaptability, and decision-making quality, as they integrate multiple perspectives to address complex challenges (Kanchanabha & Badir, 2021). However, cognitive diversity does not automatically result in better collaboration; instead, it can create coordination challenges, communication barriers, and potential conflicts when team members struggle to align their differing mental models (Rocca & Tylén, 2022). Managing cognitive diversity effectively requires strong leadership and structured communication to ensure that diverse perspectives are synthesized into collective decision-making (Meeussen et al., 2018).

In inter-agent collaboration, cognitive diversity can either enhance or hinder team effectiveness depending on how well it is integrated into the shared value system. On one hand, a diverse cognitive landscape broadens the team's problem-solving capacity, leading to more innovative solutions and improved adaptability (Stein, Frey, & Flache, 2024). On the other hand, excessive divergence in cognitive approaches can cause fragmentation and misalignment, reducing the team's ability to operate cohesively (Basharat & Spinelli, 2008). Studies highlight that a balance between cognitive diversity and a strong shared value system is critical for optimizing collaboration, as it allows for both creative exploration and coordinated execution (Lix et al., 2022). This study examines how inter-agent collaboration can integrate cognitive diversity while maintaining a cohesive strategic vision to foster organizational resilience and long-term innovation.

2.5. Sharing the Same Value System

Real-world interactions and disputes can be described, analyzed, modeled, predicted and determined for the possible resolutions or equilibria by hypergame (Kovach and Lamont, 2019). Sasaki and Kijima (2016) have introduced the hypergame concept, described as a linked set of perceptual games, rather than as single moves, that deals with players who may misperceive

some components of a game and interpret as expressing a particular player's perception of the situation.
Sasaki and Kijima (2016) explained a poly-agent system of models of decision situations by four different types: simple hypergame, symbiotic hypergame, hypergame sharing the same value system, and ordinal non-cooperative game. The hypergame sharing the same value system level happens after each agent shares the understanding of the situation and produces a sort of consistency between the interpretations, then become perceives other's preference with global consistency where both agents believe face the same game. The concept of hypergame in this study used in four different types of decision situation models as a conception of an agent's mental model in interacting with other agents to develop collaboration. The agents are in a condition of shared understanding of the situation, then work with other teams to produce a sort of consistency between the agents. In this study, the hypergame concept does not use in a mathematical equation approach but applies in the mental model conception of agents and includes it in the modelling process.

The focus of this study is on information by iterating interactions, they can improve the perceptions close to the true nature's game. The hypergame shares the same value system level as intra-organization agent interaction that facilitates collaboration happens. The same value system is formed in a condition when an agent already has an awareness of purpose sourced from the communication of organizational strategy and an understanding of the important value of ambidexterity in exploiting current jobs and exploring future job opportunities that are influenced by ambidextrous leadership. The occurrence of the same value system sharing in the agent's interaction is set based on probabilities that can be assigned a value, and in this study, the intended value is based on the researcher's previous research as real-world environment data.

2.6. Knowledge-Intensive Environments and Absorption Levels

The organization's success depends on its members' ability to collaborate in knowledge-intensive environments (Haakonsson et al., 2017). Fernández-Pérez de la Lastra, Martín-Alcázar and Sánchez-Gardey (2022) conclude that knowledge is the main component of any different intellectual capital configuration (through human capital, social capital, or organizational capital) to gain an organization's strategic goals pursued. Von Krogh, Nonaka, and Rechsteiner (2012) study reveals that the knowledge-creating process inspires the organization to do more than strive to be profitable or focus on the competition but also survive and envision the future.

The exchange of knowledge and skills as a central part of operant resources from one party/individual to another party/individual is part of the premise that forms the basis for the formation of services and products (Vargo and Lusch, 2016). People create knowledge by combining tacit and explicit knowledge in their social interaction with each other and the environment (Von Krogh, Nonaka, and Rechsteiner (2012)). Inkpen and Tsang (2005) stated that managing collaborations skill and the development of knowledge absorptive capacity are serendipitous benefits of collaboration. Access to knowledge is reflected as a fundamental and pervasive concern in inter-organizational collaborations.

Organization concert and effort to create a knowledge-intensive environment is essential for business success by strengthening knowledge re-growth. Employee development and knowledge programs range from classic ones such as employee competency training, self-learning, monitoring periodic work evaluations, coaching programs, specific project/ad-hoc assignments, community sharing, rolling of work and assignments, certification targets, and improvement of business group cycle. Furthermore, each agent has a knowledge level as mastery level of knowledge, considering the assumption that when the inter-agent collaboration process involves agents with sufficient levels of knowledge, it will be a differentiator from the quality of the collaboration carried out.

2.7. Inter-agent Collaboration

Son and Rojas (2011) defined collaboration as in which two or more individuals or organizations that have common objectives work together as a reciprocal process by sharing resources and knowledge to seek more benefits. There are several kinds of collaboration terms used by several researchers: inter-organizational collaborations (Kaya, 2019), supply chain collaboration (Cao and Zhang, 2011), collaborative community (Haakonsson et al., 2017), and intra-organizational collaboration (Kaya, 2019). Inter-agent collaboration in this study researcher defines as activities of working and sharing between each agent as a representation of different teams or work units in the internal organization.

Thomson, Perry and Miller (2007) contribute five key dimensions of collaboration that construct the process of collaboration are: (a) governance as working rules on behavior and relationship, (b) administration as action implementation and management, (c) mutuality as beneficial interdependencies experience on a shared or differing interests for an issue, (d) norms as longer-term "psychological contract" based on trust, relationships, and reputation, (e) autonomy that's sourced from agency involvement between self-interest and collective interest.

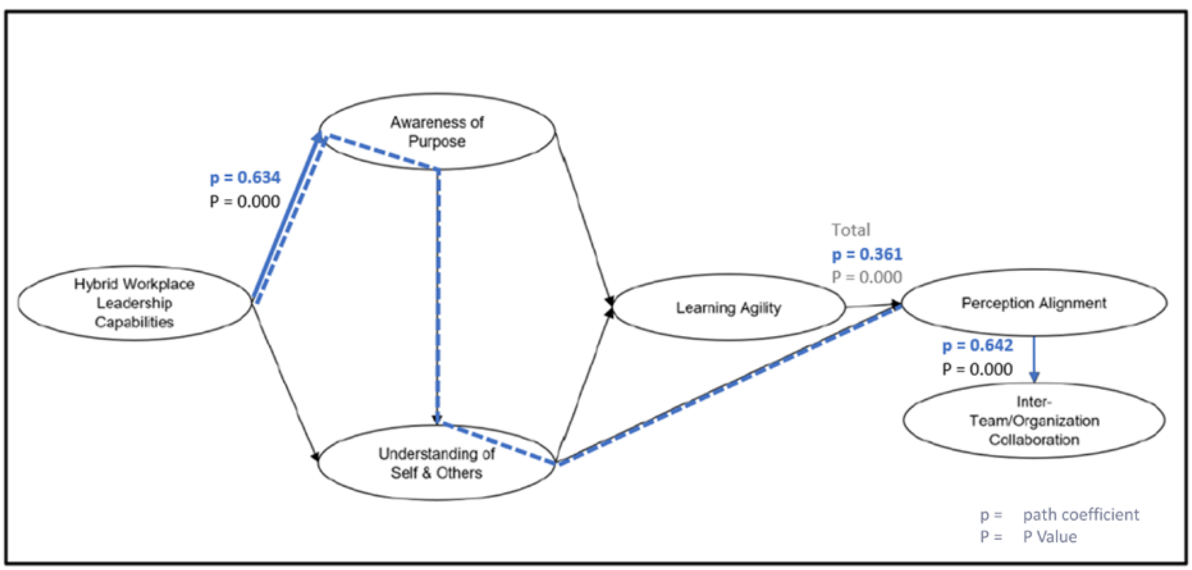
In this study, inter-agent collaboration becomes the dependent variable which is influenced by various other variables that have been described previously. The occurrence of inter-agent collaboration in the agent's interaction is set based on probabilities that can be assigned a value. This study's intended value is based on Nugroho and Hermawan (2022) previous research as real-world environment data.

2.8. Agent-Based Modeling

Filatova et al. (2013) explains that ABMS as a modelling and simulation technique has the primary added value ability to represent human actors/agent behavior becomes more interactions, realistically, heterogeneity, evolutionary learning, accounting for bounded rationality, and out of equilibrium dynamics, combined with the dynamic heterogeneous representation of the spatial environment representation. However, no model will completely represent reality, but it helps to understand phenomena better. Building realistic but simple societal models is the main barrier to this approach because most social and psychological theories are not expressed simply in a way implemented in computer models. Although models that do not reflect actual socio-cognitive processes, even if "artificial", this does not mean they are not realistic because they can clarify the system's dynamics under diverse conditions to support policy assessment useful or produce interesting result situations to explore more in-depth investigation. Therefore, it is essential for decision-makers and modelers to always pay attention to the assumptions and imitations of a model from the studies being conducted.

The ABMS model study needs to fill in parameter values to determine the strength of the relationship when an increase in an element is associated with an increase in a related element. Previous research that used to fill these values was titled "Strengthening Collaboration through Perception Alignment: Hybrid Workplace Leadership Impact on Member Awareness, Understanding, and Learning Agility" (Nugroho and Hermawan, 2022).

Figure 2. Path Coefficients in Total Effect for Parameter Assumption



Source: Author

This research was conducted from April to May 2022, using a survey questionnaire as a measurement tool with variables: Hybrid Workplace Leadership Capabilities, Awareness of Purpose, Understanding of Self & Others, Learning Agility, Perception Alignment, and Inter-Team/Organization Collaboration. Previous research used a quantitative approach with PLS-SEM by utilizing bootstrapping process application; there are path coefficient results between constructs in total effect to see the significance and strength of the relationship between constructs as shown at figure 2. These results used as probability values or several parameter assumptions setting in this ABMS study.

3. Research Method

ABMS is a method to model complex systems based on agents with their autonomous behavior and interaction (Macal and North, 2010). Nguyen, Marilleau and Ho (2008) stated that agent-based simulation models are powerful tools and are increasingly popular among researchers in the modelling and simulation of complex systems. This study uses NetLogo as a computer application program based on Wilensky and Rand (2015). A set of interaction rules arrange agents' actions and consider relevant information of the environment to evoke agents' behavior that evolves in ABMS. (Kroshl, Sarkani and Mazzuchi, 2015).

There are three sequential steps that consist of several research sub-processes to build agent-based modelling and simulation, namely: input, process, and output, as seen in Table 1.

Table 1. Research Model Development Process

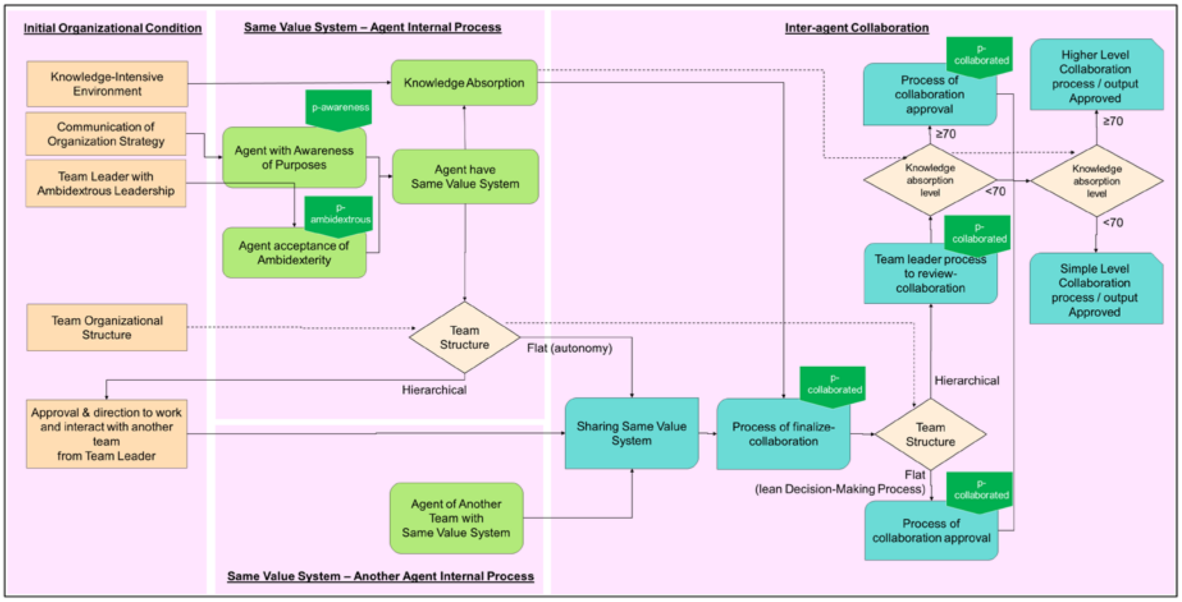
INPUT	PROCESS	OUTPUT
➢ Research Questions ➢ Research Purposes ➢ Literature Review ➢ Conceptual Design	➢ Behavior Target Content ➢ Conception ➢ Modeling Representation ➢ Coding Implementation	➢ Alternative Scenario Development ➢ Simulation of Alternative Scenario ➢ Analysis ➢ Conclusion

Source: Authors

3.1. Conceptual Design

The conceptual design contains various variables that are the target of research to determine the content and conceptions explored during modeling. Three stages conceptualize in this agent-based modelling study starting from the initial condition of interaction, sharing the same value system, and the last inter-agent collaboration, as seen in Figure 3.

Figure 3. Conceptual Design



Source: Author

The initial condition of interaction have four elements of organization: (a) communication of organization strategy related to the intensity of its presence in the organization environment, (b) team leader with ambidextrous leadership related to the ownership of this ability by the team leader, (c) knowledge-intensive environment related to the knowledge-intensive level conditions in the organization, (d) team organizational structure is separated into two differentiating conditions between hierarchical or flat team structure.

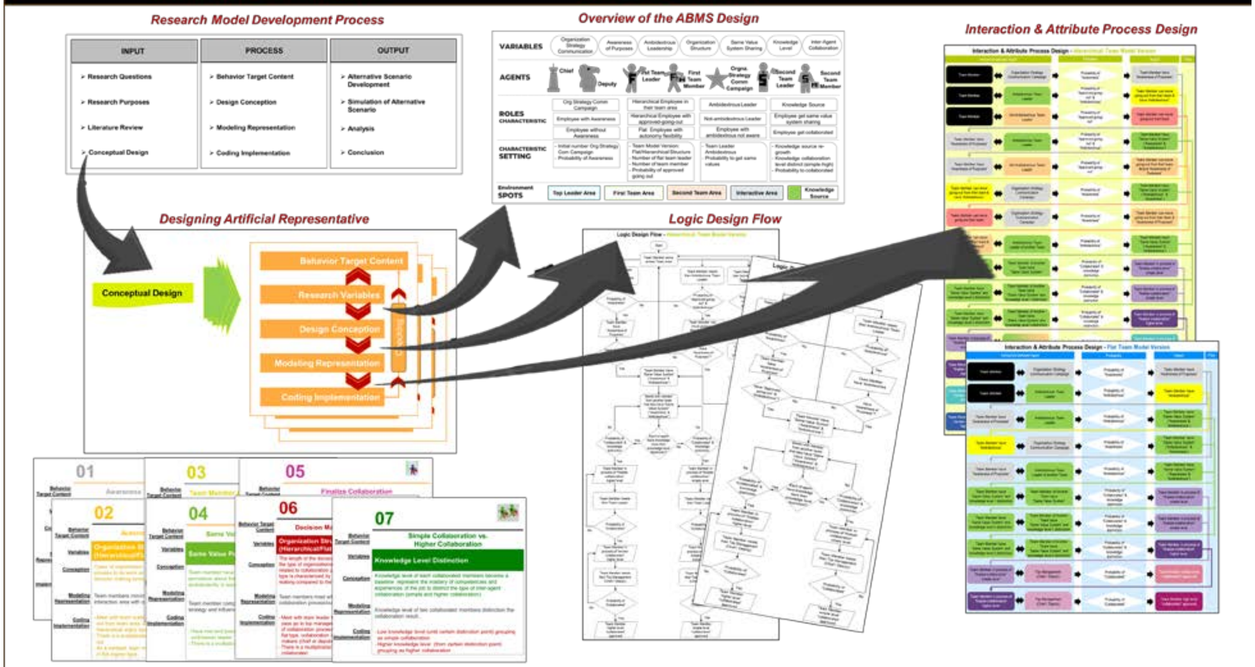
Then in the second stage, there are attributes and behavior of team members as agents in the environment and the team, namely their ownership of awareness of purposes due to the communication of organizational strategy and the influence of leaders regarding working in an ambidextrous manner. Sharing the same value system happens when two agents already have the same value system, which becomes his capital when interacting with agents from other teams. For agents in a hierarchical team, work interactions with agents from other teams depend on approval and direction from the team leader, in contrast to agents from flat teams who are more autonomous. When an agent interacts with an agent from another team, if both have the same value system that is equally formed, there will be a process of sharing the same value system relationship. It will become the foundation for further interaction in the collaboration process.

Finally, the third stage is about realizing inter-agent collaboration. Conceptually it needs to be a reminder that the interaction process builds collaboration between agents who are representatives of the team and needs to get approval to make the process or product resulting from their interaction recognized as a team collaboration. In this case, the team structure will differentiate the stages in decision-making, where flat teams have a leaner decision-making process compared to hierarchical teams, especially in terms of collaboration involving agents with high knowledge absorption thinking (higher collaboration).

3.2. Agent-based Process Development

Conceptual framework design translates to research model process by Designing Artificial Representative Models on Agent-based (abbreviated to DARMA framework), as seen in Figure 4.

Figure 4. Designing Artificial Representative Models on Agent-Based



Source: Author

The DARMA framework identifies research variables from the conceptual design that is prepared, considering the behavior target content that arises from variables and relationships between variables. Then defining the conception of the flow and interaction between related variables possibly happening and the alternative impact or result on the real world conceptually wanted to be captured in the model. This concept must translate into a modelling representation programmed in the application. Researchers must consider the programming process, logic, algorithm, and coding limitations that can translate into the representation model.

Based on this framework, the cascade down the detail of each research variable for inter-agent collaboration visualization is in Table 2.

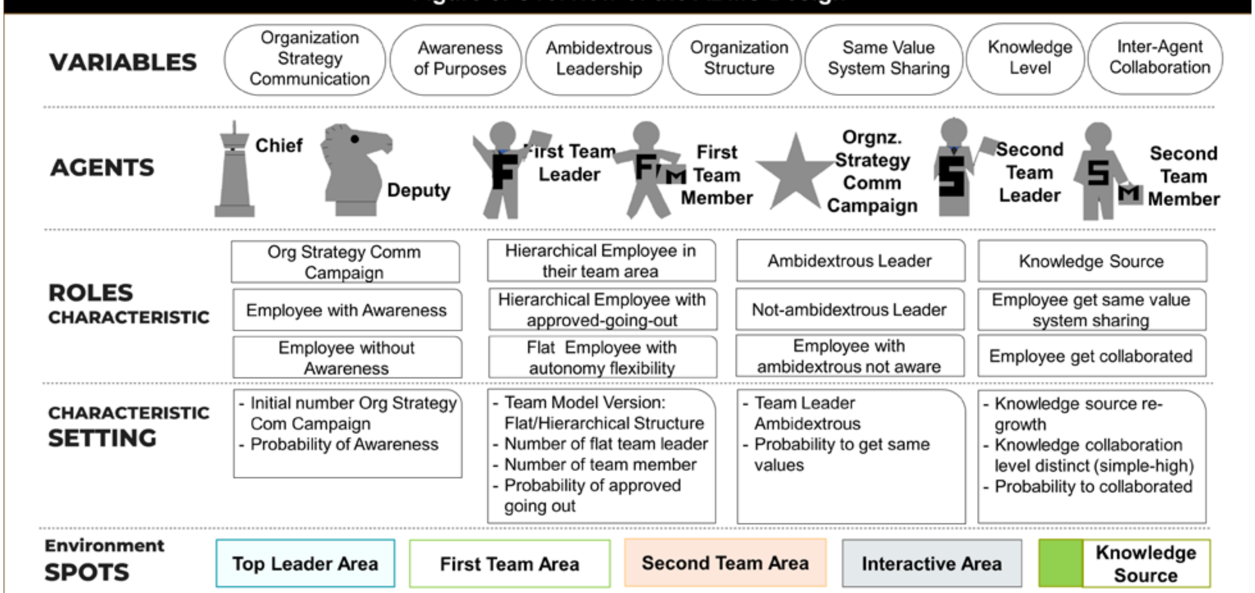
Table 2. Designing Artificial Representative Models on Agent-based for Inter-agent Collaboration

	1	2	3	4
BEHAVIOR TARGET CONTENT	**AWARENESS TEAM MEMBER**	**AUTONOMOUS TEAM MEMBER**	**TEAM MEMBER ACCEPTANCE OF AMBIDEXTERITY**	**SAME VALUE SYSTEM TEAM MEMBER**
VARIABLES	Internalization of Organization Strategy Communication	Organization Structure Types (Hierarchical/Flat)	Leadership Type	Same Value Perception
CONCEPTION	Organization strategies communication campaign/activities to gaining organization members awareness in thinking and doing job.	Types of organization structure reflect on hierarchical/flat process to do work activities (i.e., autonomy, flexibility, decision making tiering)	Leadership type and capabilities of team leader/coordinator/seniors to manage and influence team member in exploiting current job and exploring future development	Team member have same fundamental organization value perception about their organization strategy awareness and ambidexterity in exploiting current and exploring future.
MODELING REPRESENTATION	Team members interaction with organization strategy communication campaign, with probability to capture/internalize it.	Team members moving out procedure from their team to interaction area with other team members	Leaders/seniors interaction, also as value transfer/influence, with team members from their or other teams.	Team member completely get awareness of organizational strategy and influencing by ambidexter leader.
CODING IMPLEMENTATION	- Meet with stars as representative of organization strategy communication campaign - There is a multiplication with the probability value of possible awareness - Stars can be custom, represent of degree of campaign in organization	- Meet with team leader to get approval and order to moving out from team area, as representation rigid boundaries for hierarchical organization type. - There is a multiplication with the probability of approve going out - As a contrast, team members have flexible autonomy to move in flat organization type.	- Interaction with leaders/seniors that have ambidexterity value for influencing members to adopt and have mindset to develop collaboration - Team members may be influenced by the ambidexterity of their leaders/seniors but do not yet have awareness of organizational strategy	- Have met and passed the process with the star and ambidexter leader - There is a multiplication with the probability of same value
	5	**6**	**7**	
BEHAVIOR TARGET CONTENT	**FINALIZE COLLABORATION**	**DECISION MAKING OF COLLABORATION**	**SIMPLE COLLABORATION VS. HIGHER COLLABORATION**	
VARIABLES	Inter-agent Collaboration	Organization Structure Types (Hierarchical/Flat)	Knowledge Level Distinction	
CONCEPTION	Matching with other agent that's have organizational same value perception as foundation to doing job, after series of agent interaction with various value.	The length of the decision-making process is influenced by the type of organizational structure, including decisions related to collaboration processes or outputs. The hierarchical type is characterized by layers of process stages in decision	Knowledge level of each collaborated members become a baseline represent the mastery of competencies and experiences of the job to distinct the type of inter-agent collaboration (simple and higher collaboration)	

		making compared to the flat type.		
MODELING REPRESENTATION	Interaction and matching process between members from different teams, based on organization strategy and ambidexterity perspective as fundamental organizational same value.	Team members meet with decision makers to get approval on collaboration process/output	Knowledge level of two collaborated members distinction the collaboration result.	
CODING IMPLEMENTATION	- Meet with team member from other team that have same value - There is a multiplication with the probability value of collaborated	- Meet with team leader to review the collaboration, and if pass go to top management (chief or deputy) to get approval of collaboration process / output in hierarchical type. But in flat type, collaboration approval directly to final decision makers (chief or deputies). - There is a multiplication with the probability value of collaborated	- Low knowledge level (until certain distinction point) grouping as simple collaboration - Higher knowledge level (from certain distinction point) grouping as higher collaboration	

Then process developed of each variable and agent simplify on one page overview of ABMS design, as seen in Figure 5.

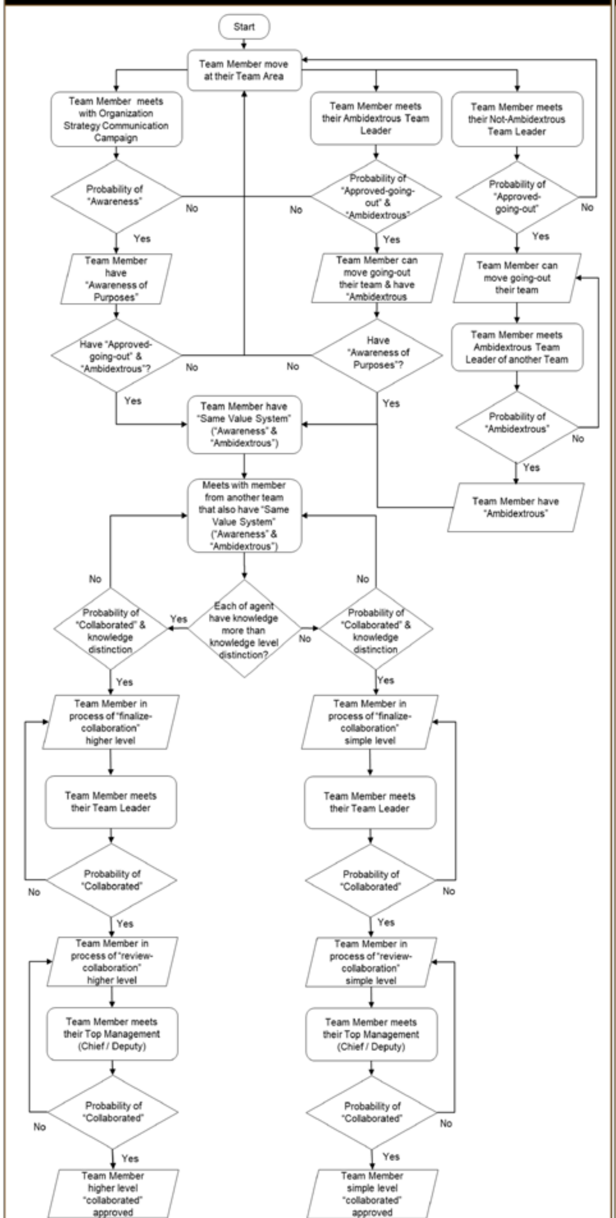
Figure 5. Overview of the ABMS Design



Source: Author

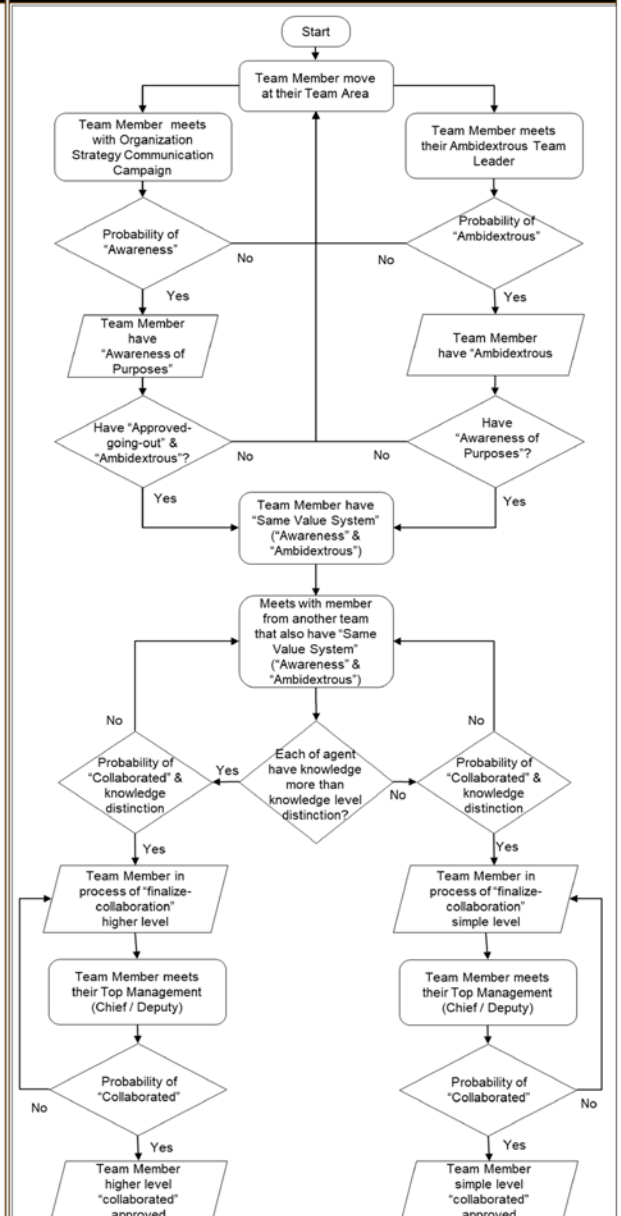
Researchers were detailing model representation drawn in the logic design flow of the model that's break down the process to implement the design. Logic design flow describes the sequential and stages details of the variables in the running model between agents in this study's agent-based model and simulation. The logical design flow of this research for the hierarchical team model version is in Figure 6 and for the flat team model version in Figure 7.

Figure 6. Logic Design Flow of Hierarchical Team Model Version



Source: Author

Figure 7. Logic Design Flow of Flat Team Model Version

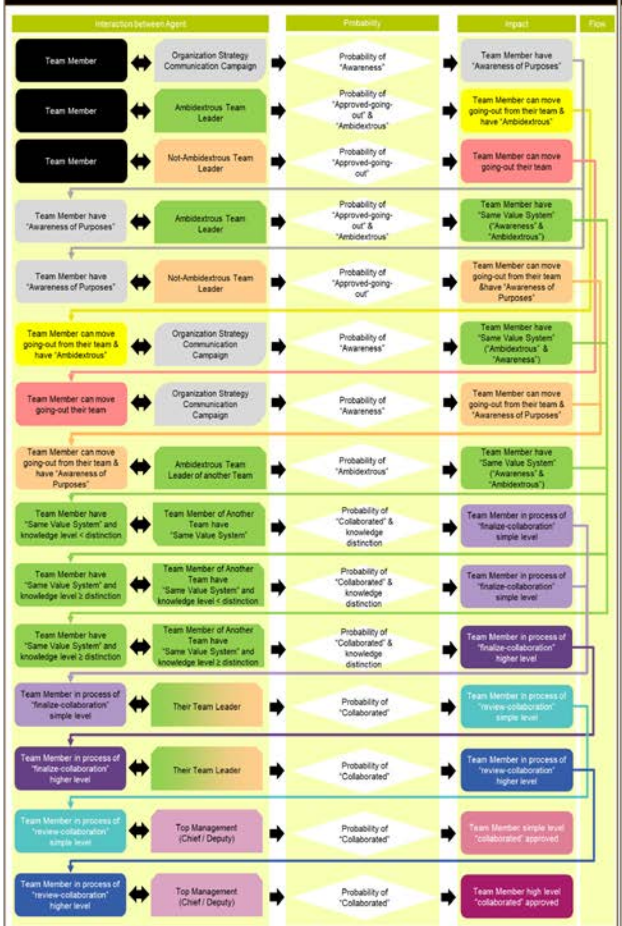


Source: Author

3.3. Agent's Behaviors and Attributes

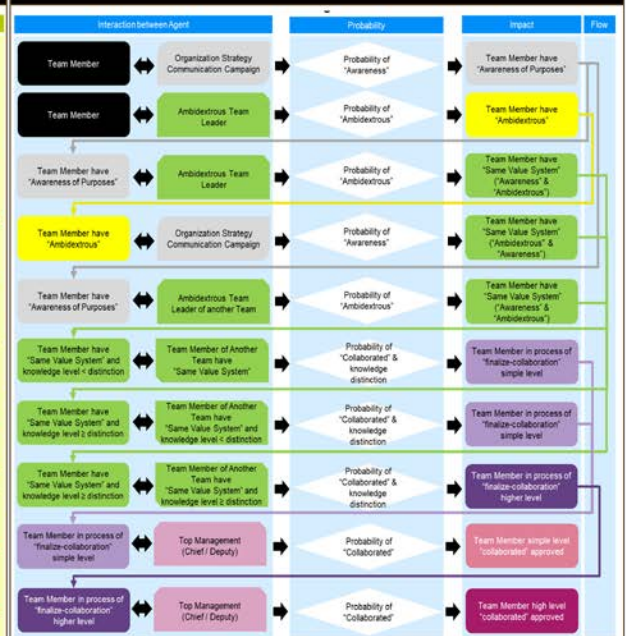
Based on logic design, step-by-step interaction details are built to set-up each agent's behavior and attribute with several parameter settings. The behavior settings as the basic parameters of each agent consist of movement spot, behavior setting, attribute change impact and real-world representation. Step-by-step interaction details with impact on changes in color and status attributes of team members are shown in Figure 8 for the hierarchical team model and Figure 9 for the flat model version.

Figure 8. Interaction Detail for Hierarchical Team Model



Source: Author

Figure 9. Interaction Detail for Flat Team Model



Source: Author

3.4. Agents & Environment Customization Setting

The agent-based model is structured to simulate several scenarios of different agent and environment conditions and analyze the results. Several settings related with situations, attributes, and parameters of agents and environments can be customized on various simulation scenarios as shown in Table below.

No	Agent Behavior	Value	Source & Date
1	Team structure	- Flat structure allows multiple leaders - Hierarchical structure has one leader per team\n- Random structure chosen	Burns & Stalker (1961) Mintzberg (1979) Tushman & O'Reilly (1996)

		by the program	
2	Team leader	- Ambidextrous leader manage both exploration and exploitation strategies effectively - Non ambidextrous leader manage either exploration or exploitation strategies - Random leader chosen by the program	O'Reilly & Tushman (2013) Mom et al. (2009) Gibson & Birkinshaw (2004)
3	Team member	Customizable for the first and second teams	Gupta et al. (2006)\n[8] Lavie et al. (2010)
4	Communication	Proportion of communication intensity compared to the number of team members in each team	Gibson & Birkinshaw (2004) Jansen et al. (2009) Cao et al. (2010)
5	Knowledge growth	Flexible schedule options; replicates real-life scenarios of skill and knowledge development through structured and unstructured learning activities	March (1991) Levinthal & March (1993) Gupta et al. (2006)
6	Knowledge level	- Simple collaboration\n- Higher collaboration	Nonaka & Takeuchi (1995) Grant (1996) Nugroho & Hermawan (2022)
7	Inter-agent collaboration	- Probability of awareness - Probability of approved going out - Probability of ambidexterity - Probability of collaboration - Perfect probabilities - Random 50:50 probabilities	Simsek (2009) Nugroho & Hermawan (2022) Raisch & Birkinshaw (2008)
8	Cognitive Diversity	- Low: Agents have similar thinking styles and predictable decision-making processes. - Medium: Agents exhibit moderate diversity in thinking, leading to balanced creativity and efficiency. - High: Agents demonstrate significant variation in cognitive styles, increasing innovation but requiring strong integration mechanisms.	Wang et al. (2016); Qu et al. (2024); Rocca & Tylén (2022)

3.5. Agent-based Modeling and Simulation Scenario Implementation

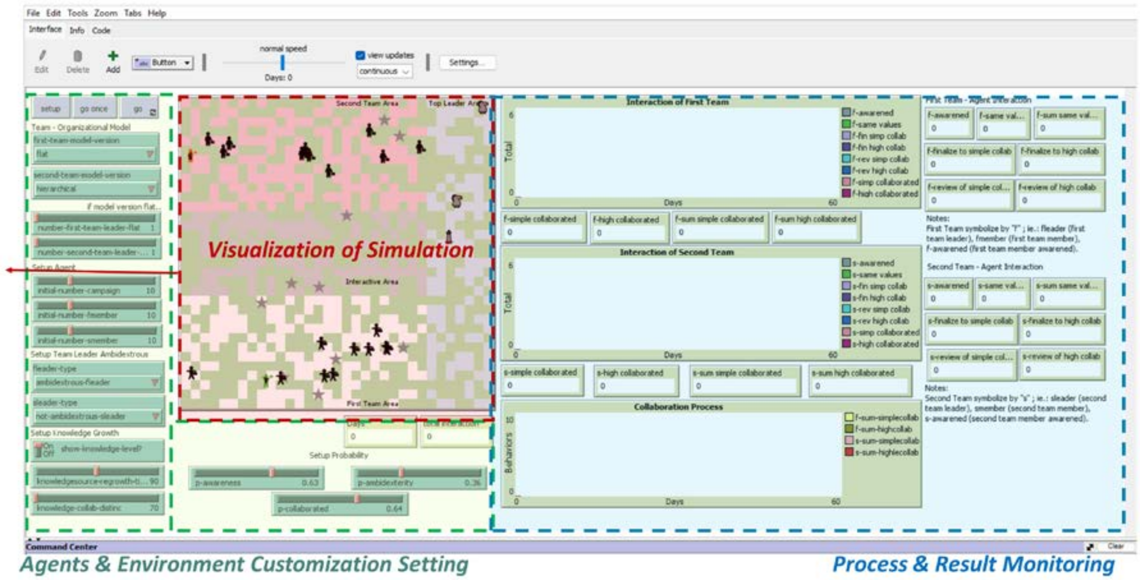
The visualization of the ABMS model in Netlogo 6.2.2. application is shown on Figure 10 based on the design, parameters, flow, and characteristics. The analysis was carried out using the ABMS modeling developed to run simulations. The agent and environment are set according to the scenario sequence studied. Determination of the scenario chosen by cascading down each condition of variables and interactions between agents that may arise within the organization.

Each major scenario has several sub-scenarios in it that describe alternative conditions of each research variable variation selected, for comparison analysis between conditions.

Results of each alternative condition in the sub-scenario assembled to get the pattern for the research analysis process. There are four major scenarios simulated as summarized in Table below.

Scenario	Description	Variables Tested
Scenario 1	Tests the proposition: "The intensity of communication of organizational strategy related to agent awareness of purpose affects inter-agent collaboration".	- Communication of organizational strategy - Awareness of purpose - Inter-agent collaboration
Scenario 2	Tests the proposition: "Ambidextrous leadership of team leader affects agent same value system and enhances inter-agent collaboration, especially in hierarchical teams".	- Ambidextrous leadership - Same value system - Inter-agent collaboration
Scenario 3	Tests the proposition: "Differences in hierarchical and flat team structures between interacting agents result in more collaboration in flat structures".	- Team organizational structure - Knowledge absorption level - Inter-agent collaboration
Scenario 4	Tests the proposition: "Strengthening knowledge re-growth impacts inter-agent collaboration, especially in both flat and hierarchical teams".	- Knowledge-intensive environment - Inter-agent collaboration - Team organizational structures

Figure 10. The Visualization of ABMS Model



Source: Author

The scenarios in the model represent processes of four years (4 X 365 days) or 1460 ticks' days simulation in the NetLogo 6.2.2 program, considering that most scenarios within that time have produced saturated patterns. Furthermore, each alternative scenario runs in the 25 times iteration process, and the average result of the iteration becomes data for analysis of each proposition.

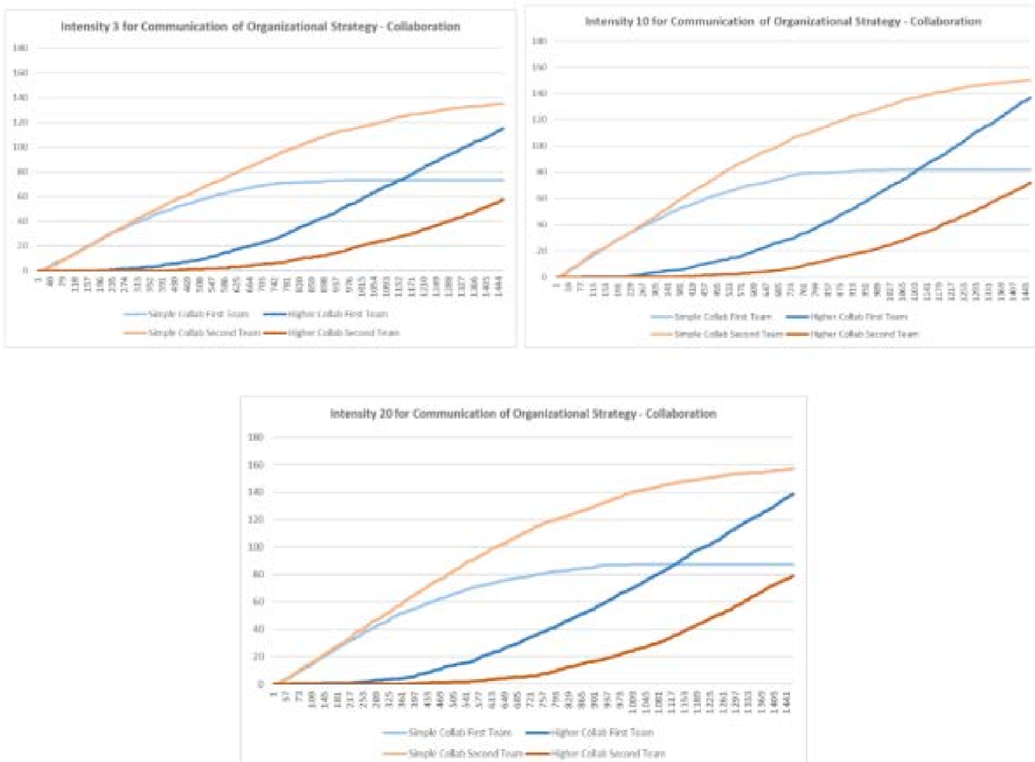
4. Findings And Discussion

4.1. Simulation Scenario Result Analysis

4.1.1. Communication of Organizational Strategy and Inter-Agent Collaboration

The simulation of the model shows in Figure 10 as a graph of the dynamics of inter-agent collaboration affected by various communication of organization strategy intensities (a scenario in this study from 3, 10, and 20). Based on a comparison of the results between the three graphs in Figure 11, the pattern of line shifts of the four types of inter-agent collaboration shows an increase between the graph with increasing communication intensity.

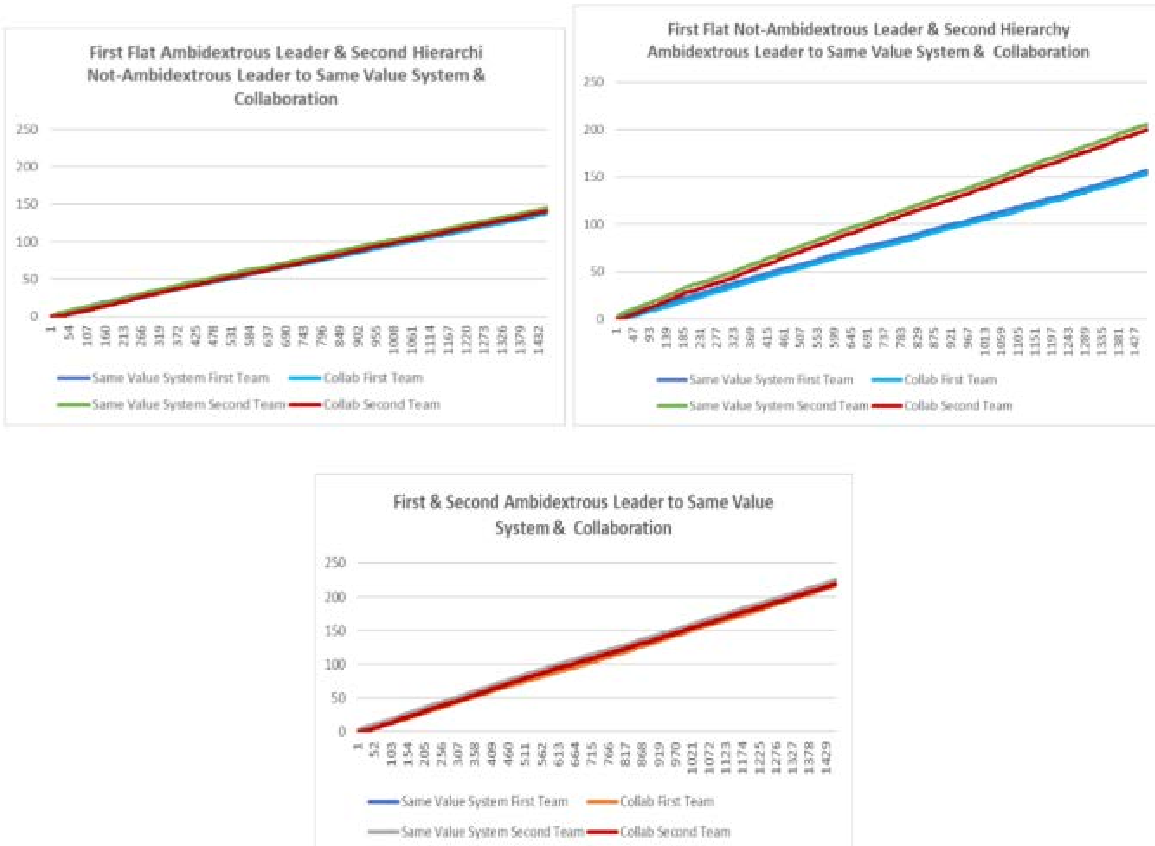
Figure 11 The Dynamics of Inter-Agent Collaboration Affected by Various Intensity of Communication of Organization Strategy



Source: Author

Simulation of the team leaders with (or without) ambidextrous leadership impacts the appearance of the same value system and inter-agent collaboration in the flat and hierarchical team shown in Figure 12. The ambidextrous leadership in the hierarchical team leader affects the number of appearances of the same value system followed by the emergence of inter-agent collaboration.

Figure 12. Impact of Ambidextrous Leadership to same value system and inter-agent collaboration



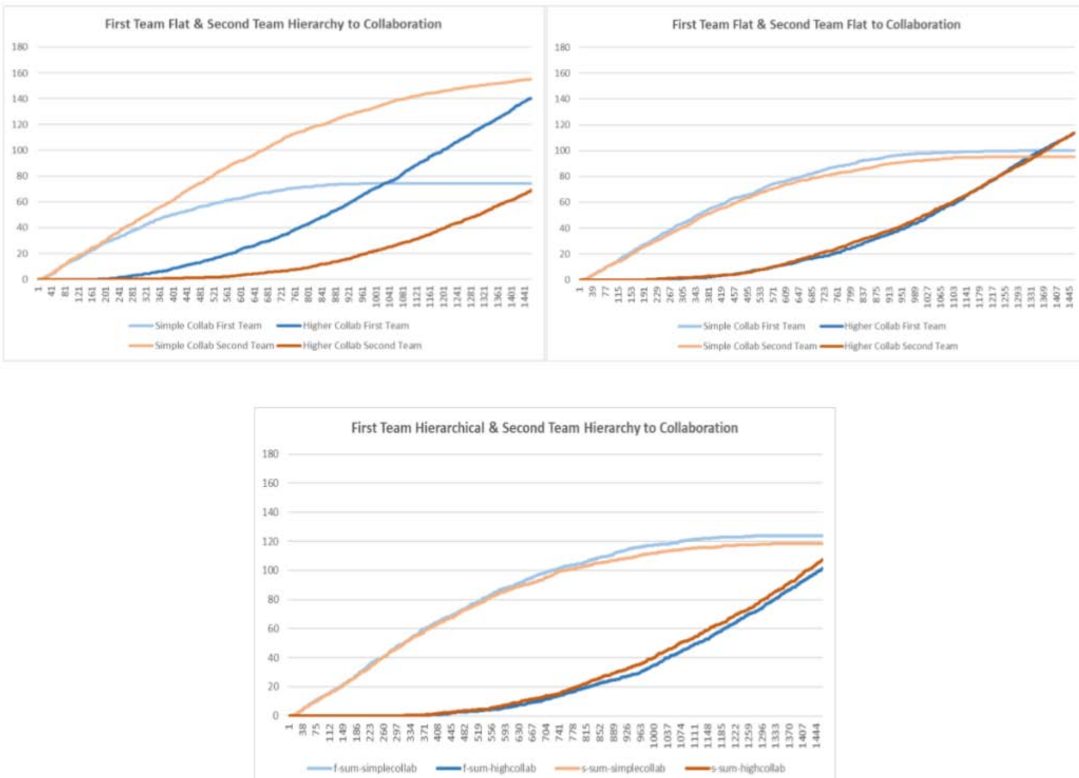
Source: Author

Meanwhile, when the flat team and the hierarchical team are both led by a team leader with ambidextrous leadership, all the teams together produce the same number of same value systems and inter-agent collaboration, which is relatively high compared to the two previous conditions.

4.1.2. Hierarchical and Flat Team Structures and Inter-Agent Collaboration

The structure composition between teams greatly influences the dynamics of forming inter-agent collaboration. A simulation of the dynamics of inter-agent collaboration affected by different team structures between the hierarchical and flat teams is shown in Figure 13. The graph in this figure represents these situations sequentially: (a) the first team is flat, then the second team is hierarchical, (b) the first and second teams are flat, (c) the first and second teams are hierarchical. Interaction between flat and hierarchical teams results in inter-agent collaboration with higher types of inter-agent collaboration patterns that appear more in flat teams, and conversely, simple types of inter-agent collaboration appear more in hierarchical teams. The results of simple types of inter-agent collaboration in the condition that the two teams met in a hierarchical manner showed the most significant number, forming the largest total collaboration. Conversely, when the two flat teams met, there were fewer simple types of inter-agent collaboration and a reduced total number of collaborations compared to the others.

Figure 13. Knowledge Re-growth of Knowledge-Intensive Environment and Inter-agent Collaboration



Source: Author

The graphic result in Figure 14 visualizes the effect of knowledge source re-growth on inter-agent collaboration with simulations of knowledge source re-growth become shorter sequentially from 182, 120, 90, 60, to 30 days. Higher types of inter-agent collaboration will grow faster in both flat and hierarchical teams when the intensity of knowledge source re-growth is shorter, but simple types of inter-agent collaboration decrease significantly as seen at Table 3.

Figure 14. The Dynamics of Inter-Agent Collaboration Affected by Knowledge Re-growth of Knowledge-Intensive Environment

Source: Author

Table 3. Recapitulation of Inter-Agent Collaboration - Knowledge Re-growth of Knowledge-Intensive Environment

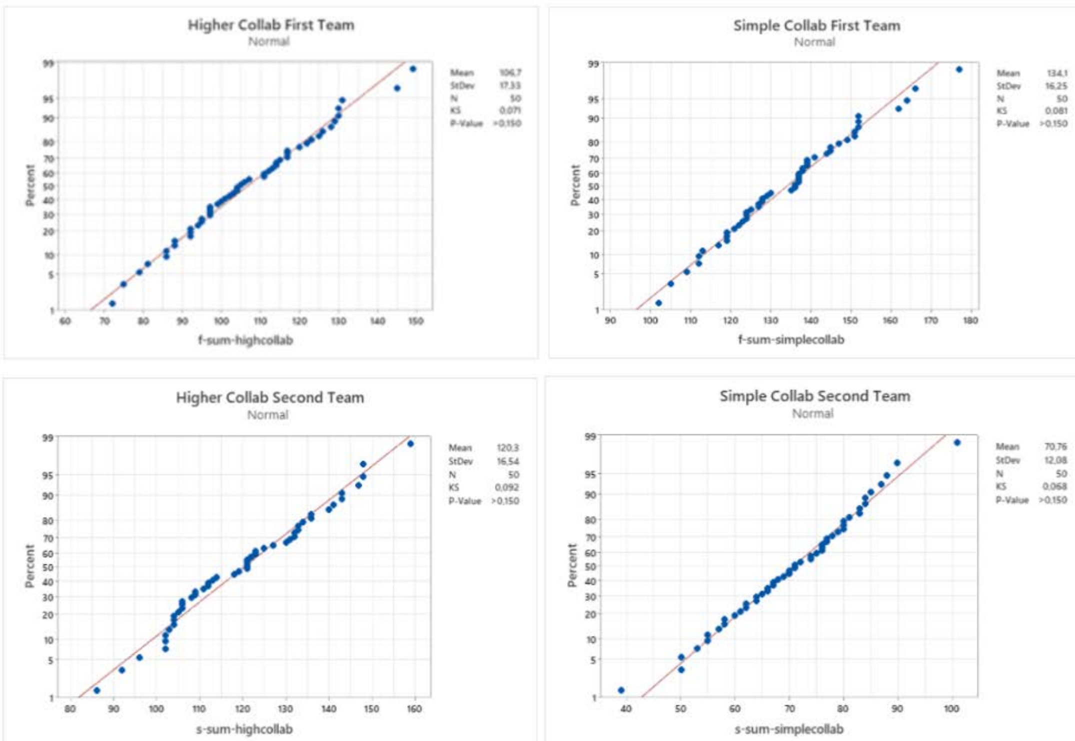
Knowledge Source Re-growth	Simple Collab First Team	Higher Collab First Team	Sub-Total Collab First Team	Simple Collab Second Team	Higher Collab Second Team	Sub-Total Collab Second Team	Total Collab
182 days	92.392	66.666	159.058	135.983	26.628	162.611	321.669
120 days	65.653	90.125	155.778	109.971	51.167	161.138	316.916
90 days	48.735	108.656	157.390	90.523	70.477	160.999	318.389
60 days	35.624	122..438	158.062	65.436	100.211	165.646	321.708
30 days	21.944	137.540	159.484	36.881	129.224	166.104	325.588

Source: Complied by Authors

4.2. Agent-based Model Verification and Validation

There is testing for verification and validation processing to increase confidence in the modeling results that developed based on the ABMS approach. Railsback and Grimm (2019) stressed the need for validation approaches, especially for an ABMS, that consider a model valid based on the qualitative and subjective evaluations of its contextual adequacy rather than on an objective representation of the system under study.

Figure 15. Normality Test of Scenario Replication



Source: Author

Following are some matters related to verification and validation:

- Model verification is a process to determine whether the abstract or conceptual model is correctly translated to the programming implementation (Railsback and Grimm, 2019). The verification process in NetLogo 6.2.2 programming found in the code writing at "Check" menu. This menu will light up and display a message if there is missing, incorrect or unable to run programming logic when the program implemented. Models of this study has been checked and tested working well to produced diagrams and results.
- Model validation is a process to determine the extent to which the conceptual model developed is sufficiently reasonably accurate to reflect conditions in the real world and the output of the simulations is consistent with real-world output (Railsback and Grimm, 2019). There are several validation techniques to test the developed modeling.

- Internal validity was checked by running the model for several replication simulations using different random seeds to see the sample replications' inconsistency (large variability). In this study, 50 replications were carried out for a model scenario, and statistical analysis resulting as normal distribution with p-value more than 0.05.
- Sensitivity Analysis was performed to determine if changes in the model inputs affect the model output as expected (Hunter and Kelleher, 2022). Changes in components/settings have an impact on changes in results in various testing scenarios, thus indicating that this model has a sensitivity.

4.3. Discussion

This study integrates fundamental organizational elements that influence agents' internal values and cognitive processes in forming inter-agent collaboration using the hypergame conception and agent-based modeling and simulation (ABMS). The Designing Artificial Representative Models on Agent-based (DARMA) framework developed in this study enables the translation of real-world organizational dynamics into an artificial environment for computational simulations. These results provide insights into how organizational design, leadership, and structural configurations influence collaborative behaviors, offering implications for business management and public policy in optimizing team performance. Cognitive diversity emerges as a crucial factor in shaping these collaborative dynamics, as it enhances innovation and problem-solving while simultaneously introducing coordination complexities that organizations must navigate effectively (Wang et al., 2016; Rocca & Tylén, 2022).

The findings suggest that enhancing communication about organizational strategy significantly improves inter-agent collaboration. The simulation results indicate that as communication intensity increases, inter-agent collaboration strengthens, supporting Wang et al. (2021), who found that a shared vision enhances team members' commitment and behavior alignment. However, the impact of communication is more pronounced when cognitive diversity is considered, as diverse cognitive styles allow teams to process and interpret strategic messages differently, leading to richer discussions and greater adaptability (Qu et al., 2024). Similarly, the flat team structure generally fosters higher inter-agent collaboration, as it enables greater autonomy and flexibility in decision-making (Takahashi, Kijima & Sato, 2004). However, the effect of team structure on collaboration is amplified when cognitive diversity is present, as diverse agents seek robust and suitable counterparts to leverage unique talents and competencies, reinforcing cross-functional problem-solving (Kanchanabha & Badir, 2021).

Leadership plays a key role in bridging cognitive diversity and collaboration. The results demonstrate that ambidextrous leadership strengthens the formation of shared value systems, leading to more robust inter-agent collaboration, particularly in hierarchical teams. This aligns with Danişman, Tosuntaş, and Karadağ (2015), who found that leadership fosters organizational learning and knowledge integration. However, when both hierarchical and flat teams are led by ambidextrous leaders, collaboration dynamics shift—hierarchical teams experience higher cognitive alignment, while flat teams sustain divergent yet synergistic problem-solving approaches (Stein, Frey, & Flache, 2024). Cognitive diversity further amplifies the effect of leadership, as diverse cognitive inputs require strong guidance to synthesize perspectives, align team efforts, and drive knowledge integration (Meeussen et al., 2018).

The study also highlights the role of knowledge re-growth dynamics in inter-agent collaboration. Findings indicate that shorter knowledge re-growth cycles lead to increased higher-order collaboration, supporting Vargo and Lusch (2016), who emphasize that knowledge exchange strengthens organizational relationships and co-creation of value. However, cognitive diversity influences how knowledge is absorbed and applied teams with high cognitive diversity demonstrate greater learning agility and adaptability, making them more effective in leveraging new knowledge to drive collaboration and innovation (Lix et al., 2022). Organizations should therefore design customized learning programs that account for both team structure and cognitive diversity, ensuring that knowledge is effectively integrated and applied across diverse teams.

Overall, this study confirms that cognitive diversity acts as both an enabler and a challenge in inter-agent collaboration. While it enhances innovation, adaptability, and problem-solving, it can also lead to fragmentation and misalignment if not managed effectively. To optimize collaboration, organizations must balance cognitive diversity with structured leadership, communication, and shared value systems (Basharat & Spinelli, 2008). Future research should further explore contextual mechanisms that enable cognitive diversity to be fully leveraged without causing disruptions in team coordination and collaboration dynamics.

5. Conclusion

This research integrates real-world organizational behaviors with computational modeling through Agent-Based Modeling and Simulation (ABMS), demonstrating how key organizational elements such as leadership, communication strategies, team structure, and knowledge management influence inter-agent collaboration. The findings highlight that cognitive diversity plays a significant role in shaping collaboration dynamics, as diverse teams generate more innovative solutions but require effective coordination mechanisms to maintain alignment. The study confirms that ambidextrous leadership strengthens shared value systems, fostering collaboration, especially in hierarchical teams, whereas non-ambidextrous leadership limits collaborative efficiency in flat structures. Furthermore, knowledge re-growth accelerates higher-order collaborations, particularly in cognitively diverse teams, reinforcing the importance of continuous learning environments for sustaining long-term collaboration.

From a theoretical perspective, this study contributes to organizational behavior, strategic management, and ABMS literature by emphasizing the interaction between cognitive diversity, leadership, and team structures in collaboration dynamics. The results suggest that organizations should optimize cognitive diversity by balancing creativity with structured alignment mechanisms, ensuring that diverse perspectives enhance rather than hinder collaboration. Additionally, flat structures facilitate more dynamic collaboration, while hierarchical structures provide stability for structured decision-making, reinforcing the need for contextual leadership strategies to bridge these different collaboration models.

Practically, the study offers actionable insights for organizational leaders and managers. Organizations should strategically incorporate cognitive diversity into team composition, ensuring that diverse thinking styles are supported by strong communication channels and shared values. Investing in ambidextrous leadership development is crucial for fostering synergy between hierarchical and flat teams, while targeted knowledge-sharing initiatives can enhance team adaptability and long-term innovation. Strengthening strategic communication improves collaboration, but it must be carefully calibrated to avoid diminishing returns. Future research should explore empirical validation of these findings in different industries and cultures, incorporating external factors such as market conditions and cultural influences to provide a more comprehensive understanding of inter-agent collaboration dynamics.

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