ISSN No:-2456-2165

Assessing Incentive-Based Motivation on the Team Productivity by an Agent-Based Model

Luki Iswara, Rudi Fakhrul Rozi, Vincent Istifar,
A.G Kalay, Fergyanto E Gunawan,
Industrial Engineering Department , Bina Nusantara University, Jakarta, Indonesia 11480

Abstract:- Several types of work in an organization sometimes need to be completed as a team or a small group of workers. The work productivity of a team is determined by the contribution of each team member. Apart from the lack of ability of workers, teamwork productivity will be problematic when individual team members' motivations for their needs are not met. The motivations explored in this study is incentive-based motivation including achievement motivation, affiliation motivation and power motivation. The aim of this research is to explore how the influence of worker's motivation in a team to productivity, in term of completion time of a given task through simulation by an agent based model. Simulations calculate completion time of the task for each combination motivation profile of workers at different level of task difficulty. The simulation result show when the difficulty level of the task is high, high achievement and high power motivation are needed to produce the best productivity. And at a low task difficulty level, it requires high achievement and affiliation motivation to get the best productivity.

Keywords:- *Agent-Based Model, Productivity, Incentive-Based Motivation, Worker Ability*.

I. INTRODUCTION

In an organization there is often a need to complete certain work done in teams consisting of a small group of workers. The work productivity of a team is deter-mined by the contribution of each team member. To maximize work productivity, generally an organization will recruit workers who have a good level of educa-tion and experience. Apart from the lack of ability of workers, teamwork productivity will be problematic when individual team members' motivations for their needs are not met.

Motivation is an internal state that awakens us to action, moves us in a certain direction, and keeps us engaged in certain activities [8]. Motivation directs goal selection, influences choices, and determines the value of incentives. Incentives are intended to motivate someone to act, individuals use the value of the incentive to determine whether to act or not [13]. Incentive-based motivation depends on individual desirability and guarantees of reward after the behavior is completed. Three types of motivation are specifically discussed in incentive-based motivation research in the workplace, namely achievement motivation, affiliation motivation, and power motivation [3].

Achievement motivation encourages humans to strive to be the best by developing self-performance and social standards [3]. Individuals with a high need for achievement motivation prefer a goal with a moderate level of difficulty, which has a high probability of success and a reward proportional to the difficulty. Based on the value of the incentive for suc-cess, the highest level of motivation for the need for achievement is related to the level of difficulty of moderate goals [13].

Affiliation motivation encourages humans to seek social interaction and maintain contact with others in a way that both parties experience as mutually satisfy-ing, stimulating, and enriching [3]. Individuals with a high need for affiliate motivation prefer easier goals, because they have a higher likeli-hood of success despite smaller rewards. Based on the success value incentive, the highest level of motivation for individuals with high affiliation needs is associated with easy goals [13].

Power motivation encourages humans to seek benefits in social competence, access to resources, or social status [3]. Individuals with a high need for power motivation prefer more difficult goals, because they have a lower likelihood of success but greater rewards. Based on the value of the success incentive, the highest level of motivation for individuals with high power needs is associated with difficult goals [13].

In [6], Merrick & Shafi present a mathematical model that describes an individual's tendency to choose goals based on individual needs for achievement, affiliation, and power. The S_{ach}, S_{aff}, and S_{pow} variables represent the strength of the individual's need for achievement, affiliation, and power and define the individual motive profile.

Productivity can be referred to as the amount of work accomplished in one unit of time through the factors of production [4]. Productivity is a measure that shows how well the resources are used to achieve a specific goal in terms of quantity and quality in a given time frame. Effectiveness and efficiency are significant predictors of productivity [7]. In [5], Jennifer and George argue that worker performance contributes directly to the level of effectiveness, efficiency, and even the achievement of organizational administrative goals. According to [1] the

level of worker productivity depends on the degree to which workers believe that certain motivational desires will be fulfilled

Ability is a person's personality based on the environ-ment, how to get along, and the level of knowledge. All of which can be obtained from a variety of experiences or can also be brought from birth, meaning from the inheritance of the family (parents) [9]. In [12], Stepen P. Robbins defines ability is the capacity and capability possessed by each person individually to carry out tasks in the work for which they are responsible.

Models are representations of several real systems [14]. Agent-based modeling is an alternative methodology that uses simulation to describe individuals (i.e. agents) of the system and allows collective observations formed by agents as well as the properties that emerge from the system [11]. The main feature of the agent-based model (ABM) is the ability to define interactions be-tween similar or different agents, or interactions between agents and their environment [10].

The main purpose of the study was to assess the effect of individual motivation and the ability to perform the task team. This study uses an agent-based model. Agent-based models are widely used to understand the features that arise from complex systems [10]. In this case, its is the time of completion of the task by a team.

We organize the paper into three parts, namely, Section 2 describes procedure used in develop model and de-scribe the related mathematical models and formulas, Section 3 shows the computational results for some combination profile set and finally, Section 4 summarize the research.

II. RESEARCH METHODE

In this study, an agent based model was created follow-ing Overview, Design Concepts, and Details (ODD) procedures [11]. The ODD procedure is a standardized layout for describing an individual and agent based simulation model (ABM). ODD consists of seven elements which can be grouped into three blocks, namely an overview, design concepts, and details (Table 1).

Table 1. Overview, Design Concepts, and Details (ODD) procedures

	Elemen Protokol ODD
Overview	1.Purpose and pattern 2.Entities, state variables, and scales 3.Process overview and scheduling
Design concepts	4.Designconcepts -Basic principles -Emergence -Adaptation -Objectives -Learning -Prediction -Sensing -Interaction -Stochasticity -Collectives -Observation
Detail	5.Initialization 6.Input data 7.Submodels

In this section, also we describe the computational procedure used in the model to calculate the individu-al's contribution to the team's cumulative contribution. Precisely, we quantify the level of motivation, ability, and experience of each worker to complete a task as-signed to a team. According to [10], the contribution of each worker to the given task to a team can be quantified by:

$$W_C^j = Tend \,.\, W_A^j \qquad (1)$$

Where W_C^j represent the J_{th} worker's contribution, W_A^j is the J_{th} worker's ability.

Tend a factor describing the workers tendency to contribute to the task. For a team consisting of T_W number of workers, the total cumulative team contribution is computed by the previous team contribution added with the new team contribution

$$\text{Team}_C = \text{Team}_C + \sum_{j=1}^{T_W} W_C^j \qquad (2)$$

The value of Tend is one for a worker who is willing to contribute to his or her best ability and zero for otherwise. The Tend is computed by:

$$Tend = \frac{1}{3.249629}\left[\left(\frac{S_{ach}}{1+e^{20\left(.25-\left(1-I_{ach}\right)\right)}} - \frac{S_{ach}}{1+e^{20\left(.75-\left(1-I_{ach}\right)\right)}}\right) + \left(\frac{S_{aff}}{1+e^{20\left(I_{aff}-.3\right)}} - \frac{S_{aff}}{1+e^{20\left(I_{aff}-.1\right)}}\right) + \left(\frac{S_{pow}}{1+e^{20(.6-I_{pow})}} - \frac{S_{pow}}{1+e^{20(.9-I_{pow})}}\right)\right] \qquad (3)$$

where s_{ach}, s_{aff}, s_{pow} are parameters for three types of motivation, namely, achievement,affiliation, and power. Each motivation parameter takes the value of one for low motivation and two for high motivation. The other variables, denoted by I_{ach}, I_{aff} , I_{pow}, describe the incentives associated with each motivation type. Their values are determined probabilistically (Merrick and Shafi, 2011).

The achievement motivation s_{ach} is determined by the probability of completing a task relative to the task difficulty (P_1). Mathematically, it is computed by

$$P_1 = \frac{100 - T_{DV}}{100} \quad (4)$$

where T_{DV} is the task difficulty value, which is assigned to a discrete random value within the range of one and a hundred. The affiliation motivation s_{aff} is determined by the probability of completing a task relative to the worker's experience with similar tasks (P_2). Mathematically, it is computed by:

$$P_2 = E_i \quad (5)$$

and

$$Ei = \frac{1}{T_W}\sum_{j=1}^{T_W} E_i^j \quad (6)$$

Where E_i^j is the experience of the jth worker on the ith task. The experience value is one if the worker has the experience and zero if they do not.

The Task Difficulty Level (T_{DV}) is mapped to three types of work experience,namely, E_1, E_2, and E_3, with the following consensus:

$$E_1 = 1 \quad \text{if} \quad T_{DV} = [1, 33] \quad (7)$$

$$E_2 = 1 \quad \text{if} \quad T_{DV} = [34, 66] \quad (8)$$

$$E_3 = 1 \quad \text{if} \quad T_{DV} = [67, 100] \quad (9)$$

Finally, the power motive is determined by the probability of completing a task relative to proximity to completion (P_3). It is computed by:

$$P_3 = \frac{Team_C}{T_{WL}} \quad (10)$$

where $Team_C$ denotes the team contributing towards the task and T_{WL} is the task workload. The team completes a given task if $Team_C \geq T_{WL}$. The task work load T_{WL} depends on the task difficulty value:

$$T_{WL} = T_{DV}\, e^{\alpha T_L} \quad (11)$$

The variable T_L denotes the time since the task is initiated. For α with a small positive value, the task is getting harder with time. In the otherside, for α a small negative value, the task is easier with time. For α equals to zero, the task difficulty level is constant with time.

Having quantified the three types of probabilities, we compute the three types of motivation with the following formulas:

$$I_{ach} = 1 - \frac{P_1+P_2+P_3}{3} \quad (12)$$

and

$$I_{aff} = I_{pow} = 1 - P_1 \quad (13)$$

The sequence of computation is depicted in Figure 1.

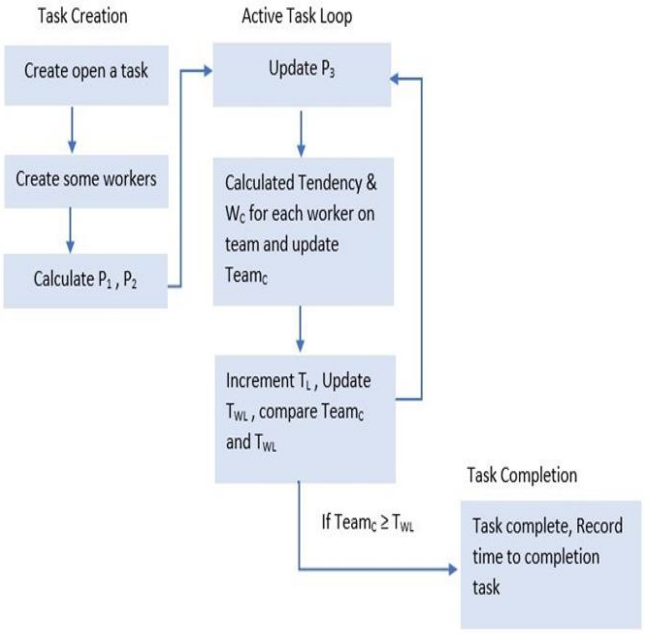

Figure 1. The sequence of computation of the team effort to (7) complete a task at a determined difficulty level (8) (9)

III. RESULT & DISCUSS

In observing team productivity, namely the time it takes the team to complete a task, a simulation is carried out involving 20 worker agents and 20 tasks with 27 combinations of motive profile distribution, consist of achievement motivation (S_{ach}), affiliation motivation (S_{aff}) and power motivation (S_{pow}) as in Table 2. We simulated the model and collect the output 30 times for each of motive profile set.

Probability distribution of each motive profile with a high value (2) is described by the value of y_1, y_2, y_3. Observations were made on task difficulty (T_{DV}) with high difficulty and low difficulty. The worker ability variable (W_A) were chosen randomly with a uniform distribution for values 1 to 5.

Profile set 14 corresponds to the baseline scenario in which all workers are equally likely to have high or low values in each motivation type ($y1 = y1 = y1 = 0.50$).

ISSN No:-2456-2165

Table.2 Parameter set of 27 different motive pro

Profile Set	y_1 (Sach)	y_2 (Saff)	y_3 (Spow)
1	0.75	0.75	0.75
2	0.75	0.75	0.5
3	0.75	0.75	0.25
4	0.75	0.5	0.75
5	0.75	0.5	0.5
6	0.75	0.5	0.25
7	0.75	0.25	0.75
8	0.75	0.25	0.5
9	0.75	0.25	0.25
10	0.5	0.75	0.75
11	0.5	0.75	0.5
12	0.5	0.75	0.25
13	0.5	0.5	0.75
14	0.5	0.5	0.5
15	0.5	0.5	0.25
16	0.5	0.25	0.75
17	0.5	0.25	0.5
18	0.5	0.25	0.25
19	0.25	0.75	0.75
20	0.25	0.75	0.5
21	0.25	0.75	0.25
22	0.25	0.5	0.75
23	0.25	0.5	0.5
24	0.25	0.5	0.25
25	0.25	0.25	0.75
26	0.25	0.25	0.5
27	0.25	0.25	0.25

Figure 2 shows a visualization of the simulation in Netlogo software [15]. The black box on the right shows the movement and interaction of agent workers and as-signments. the pentagon symbol as a task, and a sym-bol of the people as workers. Workers who have been assigned to a specific task will move toward that task. The task status will be active after all team members are in the task, and the task will be complete when the team member's contribution exceeds the work load value. While the left side consists of the 'setup' button to confirm the variable value, the 'go' button to start the simulation, the 'slider' box to define the number of workers and the number of tasks, the 'chooser' box to select the level of the task and to select the distribution of the three motive profile. Meanwhile, the "output" box consists of the output the number of tasks com-pleted, and the average time for completion task.

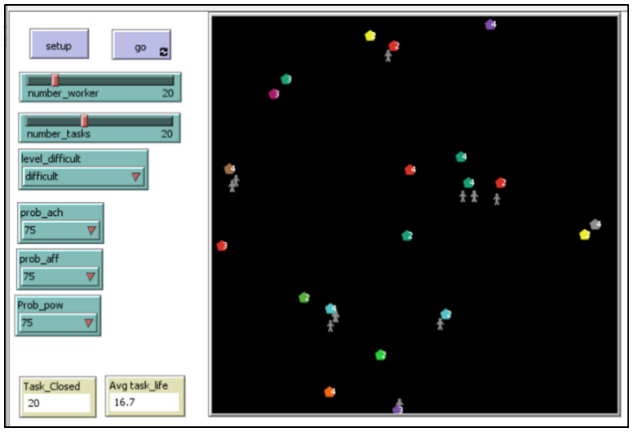

Figure 2. Model simulation impact workers motivation to completion time of tasks.

a. Motivation impact on high difficulty tasks

Figure 3 shows the simulation results at a high level of task difficulty (67 <= TDV <= 100) for a profile set that has a better value than the baseline profile (case-14).

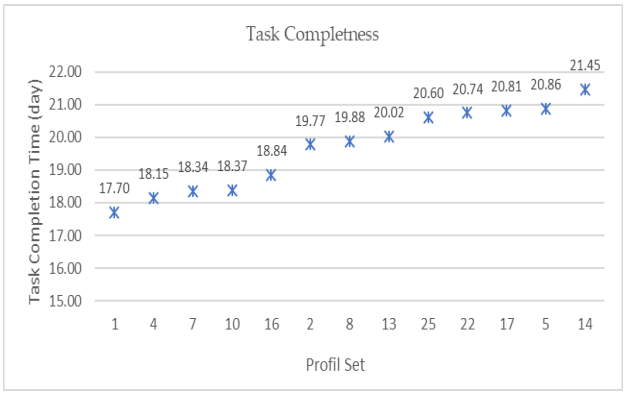

Figure 3. Effect of motivation on the team capability to complete difficult tasks

The three profile sets with the best productivity, name-ly profile set (1, 4, 7) have values $y1 = 0.75$ and $y3 = 0.75$. This result suggest that in situation where diffi-culty of task is consistently high, high power motiva-tion and high achievement motivation of the workers will result in the best productivity.

b. Motivation impact on low difficulty tasks

While in figure 4 show the simulation results at low level of task difficulty (1 <= TDV <= 33) with the profile sets that has a better value than the baseline profile (case-14). The three profile sets with the best productivity, namely case (2, 3, 1) have a value of $y1 = 0.75$ and $y2 = 0.75$. This shows that under low diffi-culty task conditions, high achievement motivation and high affiliation motivation will result in the best productivity

ISSN No:-2456-2165

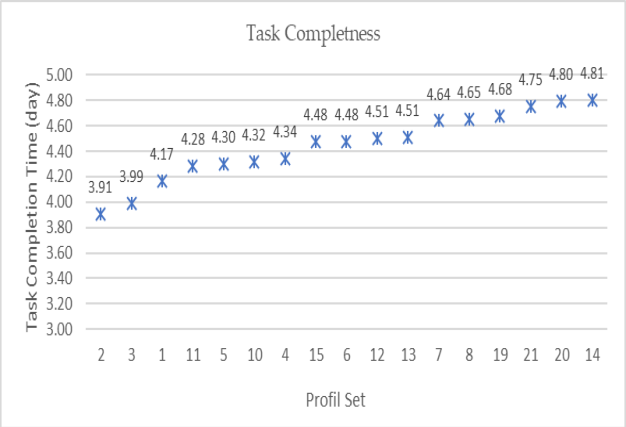

Figure 4. Effect of motivation on the team capability to complete easy tasks.

IV. CONCLUSION

The research is to observe and analyze how the influence motivation of workers on productivity in a team. The measured productivity in term of the time to complete the task which is generated from an agent-based simulation is using the Netlogo software, involving worker agents and assignments.

The observation simulation of incentive based motivation resulted in the conclusion that when the difficulty level of the task was high, workers with high achievement motivation and high power achievement were needed to produce the best productivity. And at a low level of task difficulty, it requires high achievement motivation and high affiliation motivation from workers to get the best productivity.

REFERENCES

[1]. Antomioni, D. (1999). "What motivates middle managers?" Journal of Industrial Management, Nov,-Dec., Vol.41, No 6, pp. 27-30
[2]. Dobre, O. I. (2013). Employee motivation and organizational performance. Review of Applied Socio-Economics Research, 5(1), 53-59.
[3]. Heckhausen, J., & Heckhausen, H. (2008). Motivation and action. New York: Cambridge University Press.
[4]. International Labour Organization (2005). Number of work related accidents and illnesses continues to increase, ILO and WHO join in call for Prevention Strategies Press Release
[5]. Jennifer, M. & George, G. R. (2006). Contemporary Management. Creating value in organizations. New York, USA: McGraw- Hill/Irwin.
[6]. Merrick K, Shafi, K. (2011) Achievement, affiliation, and power: Motive profiles for artificial agents. Adaptive Behavior, 19 (1), 40-62.
[7]. Nwannebuife, A. S. (2017). Effect of employee motivation on organizational productivity. Master Thesis,Covenant University, OTA, Nigeria. Retrieved 17 Oct, 2020, from http://eprints.covenantuniversity.edu.ng/
[8]. Ormrod, J.E. (2004). Human Learning (4th ed.). Upper Saddle River, NJ: Pearson.
[9]. Pengertian Kemampuan (Ability), Konsep, dan Contohnya. Diakses pada November 4, 2020, from https://dosensosiologi.com/kemampuan.
[10]. Pietrantonio, J.D. (2018). A Computational Model of Team-based Dynamics in the Workplace: Assessing the Impact of Incentive-based Motivation on Productivity. Retrieved 4 Feb, 2020, from https://dsc.duq.edu/etd/1424
[11]. Railsback SF, Grimm V. (2012). Agent-Based and Individual-Based Modeling. Princeton, NJ: Princeton University Press.
[12]. Robbins, Stephen P. 2003. Perilaku Organisasi. Jakarta: Salemba Empat.
[13]. Schreiber, J. B. (2016). Motivation 101. Springer Publishing Company.
[14]. Starfield, A. M. Smith, K.A. & Bleloch, A. L. (1990). How to model it: Problem solving for the computer age. McGraw-Hill, New York.
[15]. Wilensky, U. (1999). NetLogo [Computer software]. Retrieved from http://ccl.northwestern.edu/netlogo/.