Simulation of Employment Environment Using Multi-agent Model

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Abstract: Increasing non-regular employees is one of social problems in Japan. This problem makes such workers' employment conditions so unstable that they ready to be dismissed at any moment. Accordingly, it is also a problem that their future employment conditions are unexpected. We carry out a computer simulation with a multi-agent model as a method to deal with this problem. By approximating the conditions of employments virtually, we attempt to find the interrelations between the real world and the result of the simulation. Then, we expect future conditions of employments using the found interrelations. We employed Q-learning for the company agents learn how many workers should employ. Our model will contribute to analyze the social problem of employment issue in Japan.

Keywords: Artificial Intelligence, Multi-agent Systems, Labor Market

1 INTRODUCTION

There are two main types of work in Japan: fixed-term employment and permanent employment. Fixed-term employment can range from temporary, contract, and part-time workers. On the other hand, permanent employment includes regular employment workers and permanent contract employees.

The difference between fixed-term employment and permanent employment depends on whether there is an employment period that is passed when a labor contract is concluded. In the case of fixed-term employment, the contract period is determined at the time of the employment contract, and employment is limited to that period. If the employer wishes to continue employment at the end of the term, a new fixed-term contract is signed. Thus, the renewal of the contract can be determined by the employer.

Fixed-term workers account for about 40% of the total working population in Japan in 2019 according to the Ministry of Health, Labor and Welfare. It can be said that fixed-term workers are an indispensable workforce in economic activities. However, fixed-term employees are not guaranteed continuous employment and cannot be said to have long-term economic stability. It is difficult to build a life plan that requires a long-term perspective, such as marriage or childbirth, based on its fixed-term employment.

Therefore, in 2013, the Government of Japan enacted a law that allows a fixed-term employee to convert a labor contract to a permanent employment form by applying for a fixed-term employee if the employee is employed for five years. This implies that fixed-term employment that renews contracts in the long term is substantially equivalent to being employed in permanent employment. It also aims to reduce economically unstable workers.

In this way, the law aimed at reducing the number of unstable workers with fixed-term employment and providing broad economic stability. However, at the time of the enactment of this law, a phenomenon called "suspension" that was against its purpose occurred.

Suspension means that a fixed-term employer stops renewing a labor contract before it qualifies for conversion to permanent employment. Simply put, leave fixed-term employees before they become permanent employment.

Currently, measures and laws are in place to address this suspension. However, companies say that the cost of maintaining permanent employees is higher than that of fixed-term employees. In particular, the regular employees cannot easily be fired, which is inconvenient for adjusting the workforce.

Thus, the amendment to the Labor Contract Law originally provided long-term fixed-term workers with the right to convert to permanent employment in order to secure the financial stability of fixed-term workers. The reality, however, was that workers who might have been employed in the long term if they were in fixed-term employment were fired before they were eligible for their permanent employment conversion. It is presumed that this law did not originally achieve the purpose.

In this study, we propose a method to eliminate the discrepancy between the purpose of the law and its result. Prior to the enforcement of the law, a multi-agent system simulates and verifies that the law produces the desired result. This is expected to provide guidelines for amending laws that differ from the purpose, and avoid adversely affecting society. In this paper, we also conduct experiments on the proposed method and discuss its validity.

2 Amended Labor Contracts Act 18

In Japan in 2010, the ratio of regular and non-regular workers was about 60% for regular workers and about 40% for non-regular workers [1] (Fig. 1). Most of these non-regular workers have fixed-term employment. In this way, fixed-term workers are indispensable in the working environment in Japan.

Fixed-term workers are not guaranteed economic stability. Permanent employment of fixed-term employees depends on whether the contract is renewed by the employer before the contract expires. Therefore, it can be said that 40% of the workers were in an economically unstable environment after the end of their employment period, with no guarantee of continued employment.

The Japanese government revised the labor contract law in 2013[2].The legislation of labor contract act 18 in Japan was amended in 2013 as following:

"Article 18 (1) If a Worker whose total contract term of two or more fixed-term labor contracts (excluding any contract term which has not started yet; the same applies hereinafter in this Article) concluded with the same Employer (referred to as the "total contract term" in the next paragraph) exceeds five years applies for the conclusion of a labor contract without a fixed term before the date of expiration of the currently effective fixed-term labor contract, to begin on the day after the said date of expiration, it is deemed that the said Employer accepts the said application. In this case, the labor conditions that are the contents of said labor contract without a fixed term are
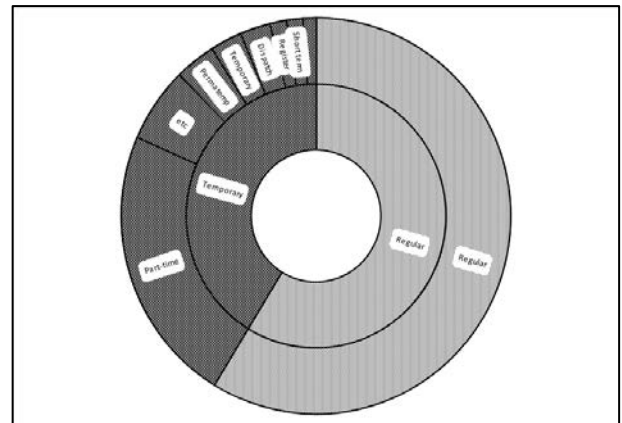
Fig. 1 Ratio of Workers by Occupation
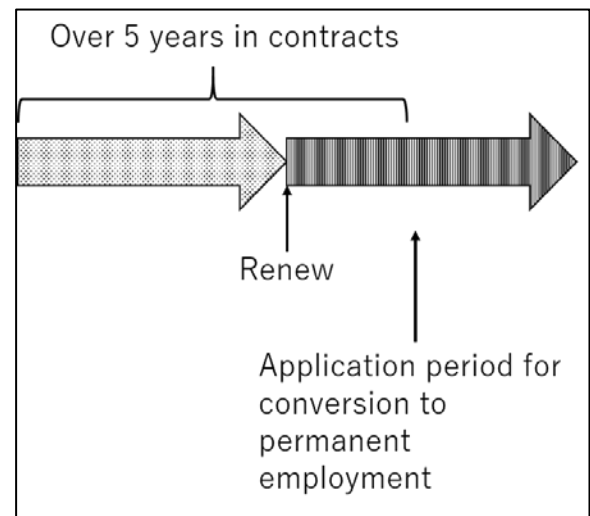
Fig. 2 Sequence of Conversion to Permanent Employment

to be the same as the labor conditions (excluding the contract term) of the currently effective fixed-term labor contract (excluding parts separately provided for with regard to the said labor conditions (excluding the contract term))."

The law stipulates that if a contract for fixed-term employment is renewed for more than five years, the person's offer gives the right to convert from fixed-term employment to permanent employment (Fig. 2). As a result, it was hoped that 40% of fixed-term employees will be converted to permanent ones and that workers' economic stability will be improved.

However, the enforcement of this law did not promote the permanent conversion of fixed-term employees as intended. Conversely, contract employment was suspended before those who were employed in fixed-term employment had the right to convert to permanent employment. This is called "refuse to renew" in Japan.

Under this suspension, the employer stops renewing the contract before five years. This removes the obligation to hire fixed-term employees as permanent employment.

This problem is cost dependent. First, fixed-term employees can be retired at the end of the term for the convenience of the employer. That is, when the amount of work in the business is large, a large amount of employment can be employed, and when the amount of work decreases, the fixed-term employee can be retired. In this way, fixed-term employees can adjust their workforce as needed.

However, permanent employees, like regular employees, cannot be fired without special reasons. In addition, since benefits and other conditions are different from those of fixed-term employees, the unit costs of labor is higher than that of fixed-term employees. These facts resulted in the above suspension of employment.

However, this was contrary to the law's goal of ensuring the financial stability of fixed-term employees, but rather less.

At present, the Japanese government discloses guidelines and takes measures against this suspension, but it has not been completely prevented because it is not fundamentally illegal.

The reason why this happened is that the content of the law directly fulfills its purpose, but it does not indirectly achieve the purpose. It is considered that

Therefore, it is useful to simulate the contents of the law to estimate the indirect effects of such problems.

3 Learning Algorithm

In this study, in simulating the contents of this law, a simulation is performed using a multi-agent system. The simulation has an employer agent and a worker agent, and the employer agent needs to determine whether to "employ" or "continue hiring" the worker. In the proposed model, Q-learning, one of reinforcement learning, was used for this decision. In this way, the employment agent learns whether or not they can be used based on the amount of work at that time.

3.1 Q Learning

Q Learning is one of the reinforcement learning methods. It is an unsupervised learning model where the agent learns through the interaction between the agent and the environment (Fig. 3).

The learning algorithm in Q-Learning [3] is expressed as the following expression (1), where Q is the function
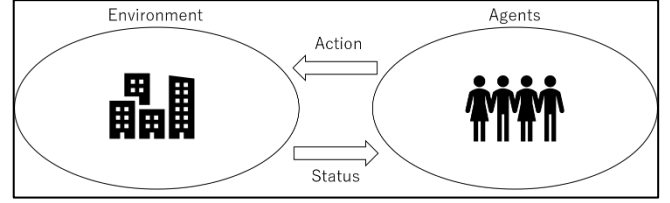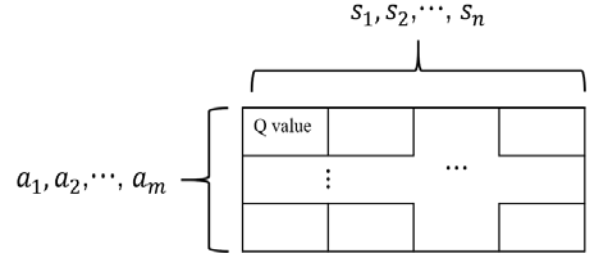

Fig. 3　Model of Q-learning

Fig. 4　Q table

which returns Q value for a state s_t and an action a_t at the time t; α is the learning rate how Q values is updated; r is a reward for the state and the action; and γ is discount rate how future Q value of the state s_{t+1} and the action a_{t+1} received. The Q value simply means that the value of evaluation on s_t with action a_t.

$$Q(s_t, a_t) \leftarrow Q(s_t, a_t) + \alpha \left(r_t + \gamma max_{a_{t+1}} Q(s_{t+1}, a_{t+1}) - Q(s_t, a_t) \right) \qquad (1)$$

In Q-Learning, the Q value is managed with multi-dimension array called "Q table".

The expression (1) means updating algorithm of the Q table.

Conceptually, as shown in Fig. 4, the Q Table has states on the horizontal axis and actions on the vertical axis, and the Q value is assigned to each element. Taking the study in this study as an example, suppose that an employer agent can take a job seeker by hiring or not hiring. This is the vertical axis of the Q Table. There are also conditions such as the amount of work that must be done this year. These are the states and the horizontal axis. In Q Learning, when you take an action that is in a certain state, the Q value that indicates how good the selection has been is updated and the learning proceeds. In this case, assume that a job seeker has been hired in state s. If the action later gets a big reward, the reward becomes gradually propagated to the past action, and the Q value of the Q Table corresponding to "hiring" in state s will be updated to become increase.

Thus, in Q Learning, the Q value of the Q Table is updated, and actions based on the state are selected based on this table.

3.2 Selection Method of Action

In Q learning, the action for the state is determined by the Q value of the Q Table. At this time, learning changes depending on how the action is selected.

In this model, the ε-Greedy method is used. In this method, a random selection is performed with a probability of ε, and an action with a maximum Q value is selected at other probabilities. Similarly, using the example of whether to hire, when the state is s, the action of hiring / not hiring can be selected. At this time, it is determined randomly with the probability of ε, and at other probability, the Q value when hiring in state s and the Q value when not hiring are compared, and the action with the highest Q value is selected.

4 Labor Market Simulation on Multi-agent System

The following agents are used in the labor market multi-agent system proposed in this study.

· Employer Agent

· Employee Agent

Hereinafter, details of each simulation will be described.

4.1 Procedure of Simulation

The simulation in this study repeats the following procedure with one year as one cycle.
1. Allocate Employer's workload for the year
2. Unemployed Employees apply for the selected Employer
3. Employer tests Employee
4. Employees who pass in 2) will be employed as fixed-term employment
5. Employee does work. Profit again
6. Employee decides whether to renew the contract of the employed employee
7. Employees who reach retirement age stop working
8. Add a new Employee

In 1), the work load is assigned based on actual Japanese GDP statistics. In 2), Employee selects an applicant based on the profits gained from Employer so far. Currently, only one company is selected per year. 3) is determined by Employer's Q Learning. 4) In the current system, all workers are initially employed as fixed-term employees for one year. This is because this study focuses on the trends of fixed-term employees and the learning content of Employer. Regarding 5), this study assumes the postulate of "equal pay for equal work". Therefore, the employer will receive a profit proportional to the amount of work provided by the Employee. 6) is determined by Employer's Q Learning as in 3). For 7) and 8), the adjustment of the working population is required.

One cycle of these procedures is set as 1 year = 1 cycle, and this scenario is repeated for 40 years. This is because the available GDP data is for 40 years.

4.2 Employer Agent

Employer mainly performs the following processing.
1. Test the applied Employee
2. Determine renewal of contract for currently employed Employee

Both 1) and 2) are judged by Q learning, and their actions are "True" and "False".

The Q-Learning for the examination has the specific ation as followings:

· State

$$\frac{p - c + 1}{p + c + 1} \qquad (2)$$

Where p is the work load at the previous year, c is at current year. We use the value as the state which is digitized the ratio of differential value of p and c as 10steps.

Next, the following Q learning states used for renewing the contract are added to the Q learning states used for the test.

· State
1. Age of Employee
2. Length of service of Employee

In each case, as with the workload, after normalizing from 0 to 1, it is discretized in 10 steps.

The following rewards were used.

· Reward

$$v = \frac{a - p + 1}{a + p + 1} \qquad (3)$$

$$\mathrm{norm}(v, 0, 0.01) \qquad (4)$$

At this time, a is the amount of work assigned this year, and p is the amount of work that could be consumed this year. The function norm is a normal distribution function, with mean 0 and variance 0.01. The value of variance was set to 0.01 in order to increase the learning efficiency because it was known that v was small under the experiment.

With these, Employer makes employment and contract decisions.

4.3 Employee

Employee performs the following processing.
1. If you are unemployed, select one company by roulette based on the profit you have gained so far and apply for employment
2. Provide labor
3. Make profits with the workforce

The labor force in 2) is calculated using the following formula.

$$los + \beta \cdot age$$

At this time, los represents the labor force based on years of service, and age represents the labor force based on age. Loss is proportional to years of service, age peaks at age 43, and the return value of the funct

ion is 1: 3: 2 for working age of 15 years, peak age of 43 years, and ending age of 65 years, respectively. And These are based on data from the Ministry of He alth, Labor and Welfare.

5 Experiment Settings and Result

The settings which used in the experiment is as follo w:

・the number of Employer: 1

・the number of Employee: 20

・Learning times: 100 scenario

・Employer Q learning (Examination and Renew)

　・ε : 0.1

　・α : 0.9

　・γ : 0.5

The experiments were performed using 40 years of GDP data. Corporate agents repeat the last 40 years 1 00 times. The result is the average of 10 of the 100th data.

First, Fig. 5 shows the number of fixed-term employ ees employed by the company on the vertical axis, an d the work volume for the year assigned to the enterp rise on the vertical axis. In addition, the setting does not have the rule of conversion to permanent employm ent.

This shows that companies hire workers according to their assigned workloads and stop renewing their cont racts when workloads decrease. This is a behavior base d on reality, and it can be seen that the corporate age nt has learned a decision making method similar to re ality.

Next, Fig. 6 introduces the rule of conversion to per manent employment. In this experiment, the amount of GDP data used was small, so one scenario was limite d to 40 years. For this reason, the permanent job conv ersion rule is set to two years instead of the actual fiv e years. In this graph, the number of fixed-term emplo yees has declined significantly as compared to Fig. 5 a s we leave the initial stage. In other words, when the indefinite employment conversion rule is applied, corpo rate agents no longer actively employ workers in fixed -term employment. This cause can be seen in Fig.7.

Fig. 7 is the same experiment as Fig. 6; the first ax is is the number of employees, the solid line is the nu mber of fixed-term employees, and the broken line is t he number of permanent employees. At the beginning of the current model, the number of employees is 0, s o we are actively hiring. However, once the initial em ployer has been converted for a period of time, it no l onger employs fixed-term employees. In the latter half of the experiment, the fluctuations in the workload wer e adjusted by the number of fixed-term employees, and eventually converged to the realistic ratio of fixed-ter m and permanent employees. The number of permanen t employees has not changed much.
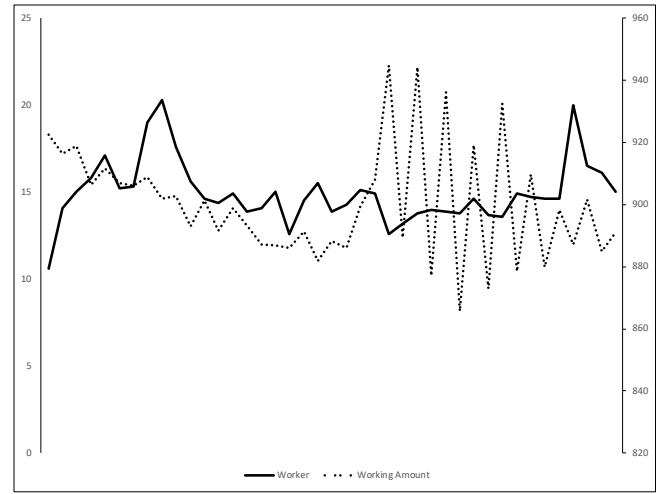
Fig. 5　GDP (Working Amount) VS Temporary Workers Without Conversion Rule
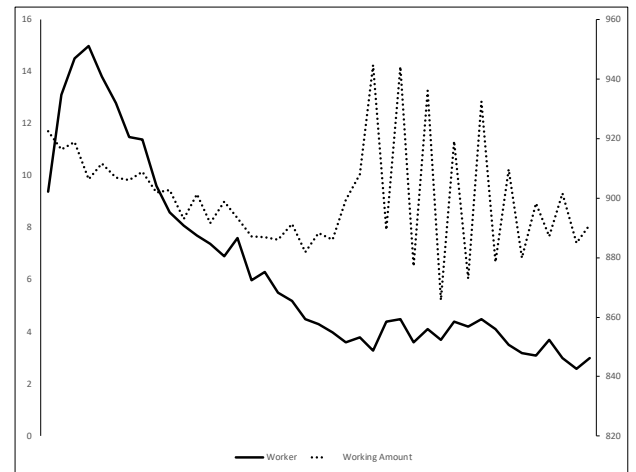
Fig. 6　GDP (Working Amount) VS Temporary Workers With Conversion Rule
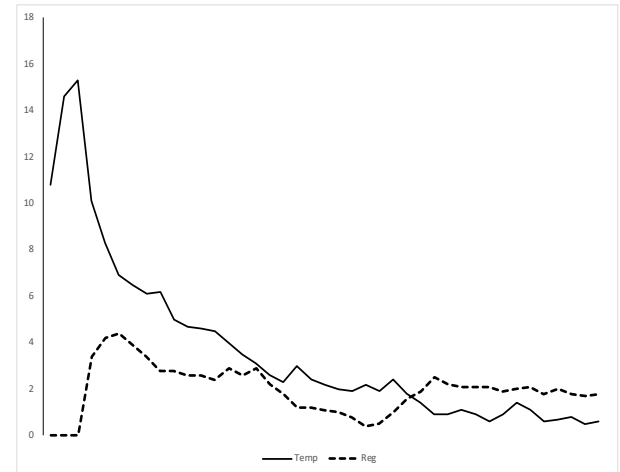
Fig. 7　Regular Workers VS Temporary Workers

These experiments suggest that 1) firms determine the ir employment situation from the previous year's and t his year's economic forecasts, and 2) changes in the a mount of work for fixed-term employees and for fixed -term employees. Use as an adjustment for In 3), work ers are seen as an immediate workforce rather than wo rk efficiency based on years of service, and after the c onversion rules have increased the number of permane

nt employees to a certain level, fixed-term You can se e that he was fired. This is because the number of per manent employees has not increased.

In this way, we were able to confirm the "real empl oyment" phenomenon, which is a real-life corporate ag ent using simple Q-Learning. In addition, it was confir med that the simple rule of indefinite conversion is no t a structure that improves the working environment th at encourages fixed-term employees to work indefinitel y, but rather a structure that is dismissed before the in definite conversion and deteriorates economic stability. .

CONCLUSION

In this study, we pointed out the difference between the intended effect of the law and its reality. I chose the Japanese Labor Contract Law as the subject. The labor contract law stipulated rules for converting fixed-term employees into permanent employment after a certain period of employment. The aim is to convert financially unstable fixed-term employees into financially stable permanent employees. This aimed to provide financial stability to workers who account for nearly 40% of the labor market. In reality, however, the phenomenon of "no hiring" occurred. The phenomenon was confirmed by multi-agent simulation. This suggests that the law was not in line with its purpose. In other words, the content of the law deviated from its purpose.

Prior to the enforcement of such laws affecting the social structure, it was shown that a method of estimating the effect using a multi-agent system was useful.

As a future work, in the current simulation, the representation of the state used for learning is rough. We need to elaborate on this and find out more about the causes of employment. You also need to change the parameters you are trying to learn to find a more appropriate one.

And since the current simulation system is tailored to the labor market, it needs to be made more general. This should allow for verification of laws other than the labor market.

ACKNOWLEDGMENT

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