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Model Analysis on the Improvement of Intrinsic Motivation at Japanese Companies

Ryohei Matsumura※

Abstract

This study expands on the agency model to analyze how Japanese companies intrinsically motivate their workers. Some previous studies have considered the intrinsic motivation of agents. However, they analyze monetary motivation methods that take into account workers' intrinsic motivation or a simultaneous analysis of monetary motivation methods and the cost of raising intrinsic motivation that also takes into account workers' intrinsic motivation.

However, while it is not always easy to change a monetary incentive system, the cost of raising intrinsic motivation is easier to change. Therefore, this study models the cost of raising intrinsic motivation as the only decision-making variable. The performance-based wage system (process-oriented pay) is regarded as a given (i.e., it is not regarded as a decision-making variable).

We obtained the following results:

1. When productivity is high, it is effective to spend money to increase intrinsic motivation.
2. When the weight of process-oriented performance-based pay is small, it is effective to spend money to raise intrinsic motivation (conditionally).
3. When cost sensitivity is low, it is effective to spend money to raise intrinsic motivation.

Keywords: Agency Model, Intrinsic Motivation, Cost of Raising Intrinsic Motivation, Process-Oriented Performance-Based Pay, Productivity

1. Introduction

This study expands on an agency model, mathematical model, to analyze how Japanese companies motivate their workers. In particular, this study focuses on intrinsic motivation, which is said to play an important role in creative problem solving.

Traditional agency models rarely consider the intrinsic motivation of the agents (i.e., the workers). Matsumura *et al*. (1998) proposed modeling agents that take into account intrinsic motivation. Matsumura and Kobayashi (2004) created a model of the cost of raising workers' intrinsic motivation. However, the former is an analysis of monetary motivation methods that takes into account workers' intrinsic motivation, while the latter is a simultaneous analysis of monetary motivation methods and the cost of raising intrinsic motivation that also takes into account workers' intrinsic motivation. As discussed later in this study, the cost of raising intrinsic motivation includes the cost of paying consulting firms that specialize in such issues and various other expenses such as the cost associated with the time spent considering job designs and suitable work assignments.

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In practice, there are few cases in which immediate changes can be made to monetary rewards or salary structures. However, measures can and should be implemented swiftly to redesign jobs and optimize assignments in order to increase intrinsic motivation.

In an agency model, what is particularly important is how to provide performance-based pay. Views are divided on this, as shown later in this study in the research survey section. There are also various problems associated with implementing performance-based pay. For this reason, without directly addressing the issue of monetary rewards, this study proposes and analyzes a new model in which the sole decision-making variable is the cost of raising intrinsic motivation. This differentiates the study considerably from prior studies.

The remainder of this study proceeds as follows. Section 2 analyzes prior studies that discuss performance-based pay or performance-based evaluations in Japanese companies. Section 3 describes the basic structure of agency models, and Section 4 proposes and analyzes two mathematical models that are specific to the issues addressed in this study. Finally, Section 5 concludes the discussion.

2. Performance-Based Pay in Japanese Companies

This section analyzes prior studies that discuss the implementation of performance-based pay in Japanese companies.

The first study to be discussed is that of Takahashi (2004), who concludes that all performance-based systems are faulty and explains in detail why they do not function effectively. In particular, this study emphasizes the effects of performance-based systems on intrinsic motivation. Citing Deci (1975), it stresses that performance-based systems reduce workers' intrinsic motivation.

It is also important to note that Takahashi (2004) calls into question the very idea of objective evaluation. The problems with objective evaluation can be expressed in an agency model. It has been confirmed mathematically that the introduction of performance-based pay is undesirable in an agency model if there is a problem with objective evaluation when there is a high degree of uncertainty regarding the results. In this case, it is desirable to have a smaller allocation coefficient for performance-based pay. With regard to the uncertainty of the results, the issue will be discussed later in this study in the section that deals with specific models.

Takahashi (2004) also suggests that competent or hard-working employees should be rewarded with more important work rather than with higher pay.

Nakamura (2006) neither completely supports nor completely rejects performance-based systems but adds that performance-based systems might not necessarily be faulty. In his work he explains the difference between a simple performance-based system and a process-oriented performance-based system. A simple performance-based system is a personnel evaluation system based on numerical data such as sales and profits. A process-oriented performance-based system is an approach that takes into account not only the results but also the process that leads to these results. Nakamura (2006) explains that the latter can function effectively depending on how creatively it is implemented. This point can also be expressed by an agency model. The simple performance-based system is a model in which the principal and agent share the results achieved by the agent. Many agency models follow this approach. On the other hand, the process-oriented performance-based system is a model in which the process, or the agent's effort, is inferred from the results and other data, and the agent is paid accordingly.

Nakamura (2006) basically affirms the argument made by Takahashi (2004) but raises the following

points:

(1) External rewards reduce intrinsic motivation.

(2) However, if the external rewards convey the message that the worker is "competent and self-determined," they may strengthen the worker's intrinsic motivation.

(3) External rewards themselves motivate people.

Nakamura (2006) argues that the effect of external rewards on the motivation of individual workers is negative for (1), sometimes positive or negative for (2), and positive for (3). He argues that there is no certainty that a combination of (1), (2), and (3) would be positive or negative.

Shimizu (2011) cites examples of failed performance-based systems and lists employee reluctance, hampered cooperation, and dissatisfaction with personnel evaluations as the reasons for the failure. Shimizu (2011) proposes a multidimensional evaluation method to rectify such problems. This is an attempt to evaluate the performance of organizational members more accurately by using not only the workers' financial achievements but also various types of information such as evaluations by their supervisors and colleagues. This approach is similar to the process-oriented performance-based system described by Nakamura (2006). Shimizu (2011) also emphasizes the motivational effect of letting people choose a job they prefer which is similar to the approach of Takahashi (2004).

All the studies above were carried out by Japanese researchers with Japanese organizations as the subject of analysis. While there may be some aspects that are similar to organizations in other countries, there may be many areas that are influenced by Japan's culture and values.

There are many people with theoretical backgrounds who are critical of performance-based systems. Their common understanding is that performance-based systems (at least simple performance-based systems) do not function effectively. Even so, many companies implement performance-based systems in one way or the other. Many studies have sought to revise such systems. Thus, this study mathematically analyzes how to spend money to raise motivation through means other than actively introducing performance-based pay.

3. Agency Models

Agency models are decision-making models that analyze how a principal, who is a decision-maker, motivates an agent, who is also a decision-maker, to make decisions that are in accordance with the principal's purposes in the face of uncertainty (Yachi, 1983; Ito, 2003; Ross, 1973; Spremann, 1987; Itami, 1976).

Examples of principals and agents include the organizations and workers analyzed in this study. Here is a simple way to describe the relationship: decision-making entities that outsource operations are principals; decision-making entities to whom operations are outsourced are agents.

Agents receive rewards from the principal for taking actions that are in line with the principal's objectives. In some cases, agents may be intrinsically motivated by the action itself. When an agent chooses one option or more from a group of options, the action can be modeled as a discrete variable. The agent's action can also be modeled as a continuous variable when the agent determines the amount of time spent on certain actions. Consider, for example, a situation in which a principle outsources the sale of a certain product to an agent. When the agent selects a method among multiple options, the action of the agent can be modeled as a discrete variable. When the agent makes a decision regarding the amount of time spent on the effort to sell the product, the agent's action can be modeled as a continuous

variable. The latter approach is chosen in this study.

When an agent makes a decision, environmental factors are added to that decision and certain results are produced. When there is a one-to-one correspondence between the agent's decision and the results (when environmental factors have no uncertainty), the principal will be able to control the agent by paying a reward that is entirely dependent on the results. In this case, all the efforts made by the agent will be rewarded. There will be no risk.

In general, however, there is uncertainty due to environmental factors. Even if the best possible method is chosen or the maximum effort is made, the desired results may not be achieved depending on the environment. In general, agents tend to be more risk averse than principals. If the results are greatly influenced by environmental factors with a high degree of uncertainty, closely linking the rewards with the results would be perceived as a disutility by agents.

Other disutility factors for agents include reduced leisure time, lost opportunities, and fatigue from work. On the other hand, there are also utility factors such as the rewards obtained and in some cases intrinsic motivation brought about by the work itself. One of the characteristics of agency models is that they posit that the agent accepts the principal's request (a contract is established) when the combined utility value is expected to exceed a certain level (equal to or above the reservation utility). According to the conventional view, the primary purpose of agency models is to analyze how to make contractual decisions to maximize the prinsipal's gain in such a situation.

Matsumura and Kobayashi (2004) expanded a traditional agency model by considering the cost of raising intrinsic motivation in addition to considering financial contracts. However, as mentioned in the introductory section, it is usually very difficult to rewrite a financial contract to reflect a change in circumstances once the contract is established. In contrast, the cost of improving intrinsic motivation can be flexibly changed. Thus, this study regards financial contracts as a given and focuses on how to determine the cost of raising intrinsic motivation.

4. Analytical Models

This section presents two analytical models that correspond to the differences in the risk perceptions of agents.

4-1. Model 1: Cases in which evaluation uncertainty has a direct negative effect on agents' decision making

1) Level of effort and the results

The level of the agent's effort is represented by the variable e which is a positive real number. The higher the value of e is then the greater the amount of effort. (All symbols except for random variables are assumed to be positive real numbers.)

Environmental factors were added to this level of effort to produce the results. The expected value of the size of the results produced when an agent puts in a unit of effort is expressed as p which is referred to as productivity. The expected value of the results is then expressed as pe.

Modeling with random variables is often used to show that the results are influenced by environmental factors other than the level of effort and productivity. However, in ordinary agency models principals are assumed to be risk neutral. Thus, there is no need to consider any uncertainty

in the results as far as the principals are concerned. Ordinary agency models consider the uncertainty of results because risk-averse agents perceive the uncertainty of results as a negative utility when they receive a portion of their pay based on their performance. This is an important factor when agents receive a portion of their rewards in the form of shares. Thus, this should be considered in the case of a simple performance-based system as mentioned in Section 2. Many agency models express the results in the form of the sum or product of the level of effort and the uncertainty of the environment.

However, in this study, we consider process-based wages where agents do not receive a portion of their rewards in the form of shares. Thus, it is not necessary to consider the uncertainty of the results. Risks and uncertainty are considered when evaluating the level of the agent's effort (i.e., the process).

2) Performance-based pay that emphasizes the process, rather than the results

The principal assesses not only the agent's results but also how their supervisors view their work attitude, evaluations from colleagues, and various other factors. Thus, the principal estimates the process and determines the effort-based pay (performance-based pay) based on that assessment. This is the process-oriented performance-based modeling described in Section 2. (The process in an agency model is the level of effort expended.)

In Model 1, mathematical modeling was performed as follows: The process cannot be estimated accurately; thus, it should be treated as a random variable. The noise included in the estimated value of the process is expressed as the variance and standard deviation of the random variable. When the noise is high (i.e., when the uncertainty is high) the variance and standard deviation of the random variable become high. Specifically, the level of estimated effort is set as $e\theta$ where θ is a random variable that represents various uncertainties, and as in Matsumura *et al.* (1998), it follows the normal distribution of mean 1 and variance σ^2.

The variable that represents the weight of the process-oriented performance-based pay received by agents is expressed as a. The larger the value of a. then the larger the ratio of process-oriented performance pay. Process-oriented performance-based pay is expressed as $ae\theta$. In this case, the expected value is ae and the standard deviation is $ae\sigma$. The risk perceived by the agent is expressed as $rae\sigma$ which is the standard deviation of process-oriented performance-based pay (which is expressed as a random variable), where r is a parameter that expresses the level of risk aversion of the agent.

If all performance-based systems are considered to be faulty (an issue discussed in Section 2), the value of a could converge to a value close to zero.

3) Fixed pay and the overall financial utility

Apart from the process-oriented performance-based pay, a fixed performance-independent salary is paid by the principal to agents. As a result, the monetary reward paid by the principle becomes $f + ae\theta$. Risk-neutral principals are interested only in the expected value $f + ae$, while risk-averse agents are interested in the value obtained by subtracting $rae\sigma$ from the expected value $f + ae$.

In this model, by differentiating the agent's utility function with the level of effort, which is a decision-making variable, the uncertainty of the results has an explicit impact. In other words, agents will directly consider the level of noise when determining their level of effort. This is a model in which agents lose a great deal of motivation when the estimation of the effort level is inaccurate.

In the context of agency theory, Holmstrom (1979), Desgagne (1996), and others have conducted

studies that consider the signals that indicate the level of effort other than the actual results. These studies argue that other signals if present should also be considered (without specifying to what extent). They also discuss whether mathematical models can be solved using a special method in the presence of multiple signals (signals for estimating the results). However, studies that examine how such signals should be emphasized, such as Matsumura (2010), are very limited.

4) Intrinsic motivation and the cost of raising it

In addition to the monetary utility mentioned above, agents also gain the utility produced by the work itself (i.e., the intrinsic motivation). Studies that examine the methods for measuring the magnitude of intrinsic motivation include Hackman and Oldham (1976 and 1980). Their study proposed the "motivating potential score" (MPS), a function that consists of the following five factors:

(1) the degree of diversity in skills and knowledge required for a job;
(2) the degree to which the job is coherent;
(3) the meaningfulness and importance of the job;
(4) the degree to which workers' opinions are reflected in decision-making such as how to do the job (i.e., the sense of self-determination as discussed by Deci(1971));
(5) the degree to which workers have access to information about the results of a job.

In this model MPS is expressed as i. The principle (i.e., the company) makes various efforts, such as hiring a consultant specializing in motivational issues or redesigning jobs, in order to increase the value of i. The cost of these efforts shall be called the "cost of raising intrinsic motivation."

As mentioned in Section 2, Takahashi (2004) argues that talented employees should be rewarded with interesting and challenging work. However, it is also clear that such work is finite (i.e., there is a problem of scarcity). It is difficult to give all employees a job that emotionally rewards them and provides a great sense of self-determination and self-competence. In other words, giving such a job to an agent involves the cost of taking it away from another. The comprehensive cost that includes such a cost shall be called the "cost of raising intrinsic motivation."

It is natural to assume that the higher this cost is, the greater the intrinsic motivation. However, common sense tells us that it is not the case that the higher the cost, the more rapidly intrinsic motivation increases. Thus, it may be natural to assume the law of diminishing returns which is a common assumption in economics. Taking this into account, the cost of maintaining intrinsic motivation at i shall be expressed as i^2.

Furthermore, previous mathematical models that incorporate both intrinsic motivation and performance-based pay do not consider the impact of monetary rewards on intrinsic motivation because doing so would complicate the analysis. However, the two mutually interact with each other. There is a well-known concept called "motivation crowding out" in which the introduction of monetary rewards lowers intrinsic motivation. Many studies, in addition to Deci, argue this point. However, some studies, such as those conducted by Staw (1977), indicate that intrinsic motivation increases when monetary rewards are introduced. Thus, the relationship between monetary rewards and intrinsic motivation is not straightforward. However, to avoid making the analysis overly complicated, this study ignored this issue as did Porter and Lawler (1968) and various other models.

5) Disutility of labor

When agents put in a large amount of effort, they experience disutility such as a decrease in leisure time. Some reductions in leisure time may be tolerated. However, when disutility increases to a certain level negative utility increases rapidly. Thus, as with many models, this study uses the function ce^2 where c is a parameter that represents the magnitude of the cost sensitivity.

6) Overall utility and the reservation utility of principals and agents

In an agency model, it is common to assume that the principal's utility consists only of the expected value of the money that he or she earns. This is also the case in this study. In addition, the principal is assumed to be risk neutral. Thus, the principal's utility function is expressed as follows:

$$PU = pe - f - ae - i^2$$

The total utility function of an agent is evaluated by the following equation which combines the monetary satisfaction that considers risk with the intrinsic utility and cost:

$$AU = f + ae - rae\sigma + ibe - ce^2$$

If this value exceeds the reservation utility RU then a contract is established. Thus, the principal's decision-making can be expressed as follows:

$$\begin{aligned} &\max_{i} \ PU \\ &s.t. \ \ AU \geq RU \\ &\quad e \in \operatorname*{argmax}_{e} AU \end{aligned}$$

The meaning of this equation is as follows: The principal determines the decision-making variable i to maximize his or her own utility function under two constraints that follow "*s.t.*". The first constraint shows that the sum of the agent's utilities exceeds the reservation utility. The other shows that the agent determines the decision variable e to maximize his or her own utility function.

Here is an explanation of how this latest research differs from the studies conducted in the past. Matsumura et al. (1998) studied how to provide monetary rewards in a situation in which the agent's intrinsic motivation is taken into account. This is similar to the present work with respect to the utility of the agent. However, the decision-making variables for the principal in this previous study were the distribution coefficients of performance-based pay and fixed pay. It is a model that assumes a simple performance-based system. Matsumura and Kobayashi (2004) added the cost of raising intrinsic motivation to the principal's decision variables and dealt with the issue of simultaneous determination of monetary rewards and the associated cost. At the same time, the parts regarding monetary rewards are modeling a simple performance-based system. However, as mentioned in Section 1, it is not always easy to change the compensation system, while the cost of raising intrinsic motivation is easier to change. In addition, as seen in Section 2, process-oriented performance-based pay is likely to function better in Japanese organizations than simple performance-based pay. Therefore, in this study, the cost of raising intrinsic motivation was the only decision-making variable. In this study, performance-based pay is process-oriented and is regarded as a given (i.e., it is not regarded as a decision-making variable).

In light of the various criticisms of performance-based systems as discussed in Section 2, there is a possibility that agency models will in the future begin to address the cost of raising intrinsic motivation

rather than dealing with monetary rewards. Of course, there will still be cases where external rewards will work well. Thus, there is no doubt that the conventional agency model analysis will be effective for certain types of issues.

As mentioned earlier, the case in which performance pay is completely eliminated can be analyzed by converging the value of parameter a to a value close to zero.

Solving the optimization problem with a specific function involves the following process: First, the agent determines the level of effort in order to maximize the value of his or her overall utility function.

$\partial AU/\partial e = a - ra\delta + ib - 2ce = 0,$

when solved it becomes

$$e = (a - ra\delta + ib)/2.$$

It is maximized at this point since $\partial^2 AU/\partial e^2 = -2c < 0$.

In order to maximize his or her own utility, the principal will seek to make the agent's utility equal to the reservation utility. This is because if the agent's utility is greater than the reservation utility, subtracting that amount from a fixed salary will not change the agent's level of effort. A contract will be established, and the principal's own utility will increase. Therefore, with respect to the principal, maximizing the value of the principal's own utility function would be the same as maximizing the sum of the principal's utility and the agent's utility. Therefore, i should be determined in such a way that the sum of the utility for the principal and agent is maximized.

Substituting the previously obtained

$e = (a - ra\delta + ib)/2c$ for PU and AU, the equation becomes

$$PU + AU = pe - i^2 - rae\delta + ibe - ce^2$$

$= (pa - pra\delta + pib)/2c - i^2 - (ra^2\delta + r^2a^2\delta^2 + ra\delta ib)/2c + (iba - ibra\delta + i^2b^2)/2c -$
$(a^2 + r^2a^2\delta^2 + i^2b^2 - 2ra^2\delta - 2ra\delta ib + 2aib)/4c.$

$\partial(PU + AU)/\partial i = pb/2c - 2i - (ra\delta b)/2c + (ba - bra\delta + 2b^2 i)/2c - (2b^2 i - 2ra\delta b +$
$2ab)/4c = 0.$

when solved it becomes

$$i = b(p - ra\delta)/(4c - b^2).$$

It is maximized in the range $\partial^2(PU+AU)/\partial i^2 = b^2 - 4c<0$. If it is not satisfied, (i.e., if $b^2 - 4c \geq 0$ is established) then i will infinitely diverge which is not realistic. Thus, the condition $\partial^2(PU + AU)/\partial i^2 = b^2 - 4c < 0^2$ is added.

This solution always satisfies the following properties:

$$\partial i/\partial p > 0,\ \partial i/\partial a < 0,\ \partial i/\partial c < 0$$

From this, the following can be stated:

1. When productivity is high, it is effective to spend money to raise intrinsic motivation.
2. When the weight of process-oriented performance-based pay is small, it is effective to spend money to raise intrinsic motivation.
3. When cost sensitivity is low, it is effective to spend money to raise intrinsic motivation.

4-2. Model 2: Cases in which the uncertainty of evaluation does not have a direct negative effect on the agent's decision-making

Model 2 is slightly different from Model 1 in the way in which the agent's risk is perceived. However, everything is assumed to be the same except for the part involving random variables. The level of estimated effort is expressed as $e+\theta$ where θ is a random variable that represents various uncertainties. As in the case of Matsumura and Kobayashi (2004), it is assumed to follow a normal distribution with an average of 0 and a variance of σ^2. It is also a commonly used method for creating a model. The risk disutility perceived by the agent is $ra^2\sigma^2/2$. This risk disutility does not include the level of effort. In other words, the agent does not directly dislike the noise when making decisions and only experiences an indirect impact through a.

To put it simply, Model 1 emphasizes risk and noise, while Model 2 does not. However, both are function settings that are often seen in prior studies, and they do not contradict each other significantly. The two models were created to comprehensively confirm the extent to which such function settings affect the conclusion and to conduct a more thorough analysis.

The utility for both is expressed as follows:

$$PU = pe - f - ae - i^2$$
$$AU = f + ae - ra^2\sigma^2/2 + ibe - ce^2$$

The optimization problem is solved as follows: First, the agent determines the level of effort required to maximize the value of his or her overall utility function.

$\partial AU/\partial e = a + ib - 2ce = 0$,

when solved it becomes

$$e = (a + ib)/2c.$$

Since $\partial^2 AU/\partial e^2 = -2c < 0$. It is maximized at this point.

Substituting the previously obtained $e = (a + ib)/2c$ for PU and AU the equation becomes

$PU + AU = pe - i^2 - ra^2\sigma^2/2 + ibe - ce^2 = (pa + pib)/2c - i^2 - ra^2\sigma^2/2 + (iba + i^2b^2)/2c - (a^2 + i^2b^2 + 2aib)/4c$.

$\partial(PU + AU)/\partial i = pb/2c - 2i + (ba + 2b^2i)/2c - (2b^2i + 2ab)/4c = 0$,

when solved it becomes

$$i = bp/(4c - b^2).$$

It is maximized within the range $\partial^2(PU + AU)/\partial i^2 = b^2 - 4c < 0$. The condition $\partial^2(PU + AU)/\partial i^2 = b^2 - 4c < 0^2$ is added for the same reason as in Model 1.

This solution always satisfies the following:

$$\partial i/\partial p > 0,\ \partial i/\partial c < 0$$

From this, the following can be stated:

1 When productivity is high, it is effective to spend money to raise intrinsic motivation.
2 The weight of process-oriented performance-based pay has no effect on the cost of raising intrinsic motivation.
3 When cost sensitivity is low, it is effective to spend money to raise intrinsic motivation.

5. Conclusion

This study analyzed the cost of raising intrinsic motivation using a model that has been significantly expanded from a traditional agency model. The following findings were obtained by analyzing two models that represent different ways of perceiving the risk for agents.

Both models yielded the insight that it is effective to spend money to raise intrinsic motivation when productivity is high and cost sensitivity is low.

The major difference between the two models is the relationship between the weight of performance-based pay and the cost of raising intrinsic motivation. The larger the ratio of performance-based pay then the lower the effectiveness of the cost of raising intrinsic motivation in a situation in which agents significantly reduce their effort when the noise and uncertainty associated with performance-based pay are large. However, if agents do not significantly reduce their effort even as the noise and uncertainty associated with performance-based pay remain large, the relationship between the ratio of performance-based pay and the cost of raising intrinsic motivation disappears. In fact, when the weight of performance-based pay is set to zero in Model 1, the solution exactly matches that of Model 2. This is an intriguing outcome.

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