Margin Rate Rule:
A New Drug Pricing Policy in Japan

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This article theoretically evaluates the drug pricing policy in Japan and suggest an alternative more efficient policy. The Japanese current pricing rule "R2 rule" causes high drug price and social inefficiency that is similar to the well-known double marginalisation problem. To solve this problem, we derive an alternative pricing rule that we name "margin rate rule". We show that the margin rate rule improves Pareto efficiency: the rule leads to both lower drug price and higher profit of the firms. There are three notable advantages in the margin rate rule. First, the government does not have to estimate the demand function, though it has the target price. The pharmaceutical firms, not the government, estimate drug efficacy, competition, and other demand information in pricing drugs. In this sense, the margin rate rule is a decentralised rule, and easy to manage. Second, the government can control the profit share between the firms and pharmacies in order to encourage pharmaceutical innovation. Third, the government can also control the drug-price margins so that meditations are not biased.

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1 Introduction

The characteristics of the pharmaceutical markets are different from country to country. The U.S. pharmaceutical market is basically the free market: there is almost no price regulation imposed by the government. Both the retail prices and wholesale prices of the drugs are determined in the market. The government does not intervene on the price of the drugs. On the other hand, the Japanese pharmaceutical market is the regulated market: there is price regulations on the retail price of the drugs. The government controls the retail price according to the "R2 rule" so that appropriate meditations are given to the appropriate patients at the moderate price. However, Which is more efficient pharmaceutical market, the unregulated market or the Japanese regulated market? Is there more efficient pricing rule than the current R2 rule? This paper answers to these questions.

In Japan, there are two discussions on the pharmaceutical markets. The first discussion is on the drug prices: whether the drug price is high or low? On the one hand, the pharmaceutical firms argues that the governmental price control (R2 rule) reduces the drug prices too much, and the drug prices in Japan are lower than those in other countries. On the other hand, patients and health insurance companies argue that drug prices in Japan are higher than those in other countries. It is difficult to conclude whether drug prices are high or low because the market structure and healthcare system is different from country to country. The second discussion is on the inventions of new drugs: the number of "made in Japan" new drugs is recently decreasing. It implies that the price control policy reduces the profitability of new drugs, and hence, the incentives to invent new drugs.

This paper models the Japanese pharmaceutical market and evaluate the current price control policy (R2 rule). We find that R2 rule leads to the similar allocations as the "double monopoly problem" leads to. This results give one answer to the two discussions above. (i) drug prices are too high. (ii) At the same time, the pharmaceutical firms' profits and hence the incentives for innovations are too low.

Then, we derive the alternative more efficient price control rule that we name "Margin Rate Rule". This rule leads to lower drug price and more profits of the firms. There are three notable advantages in the margin rate rule. First, the government does not have to estimate the demand function, though it has the target price. The pharmaceutical firms, not the government, estimate drug efficacy, competition, and other demand information in pricing drugs. In this sense, the margin rate rule is a decentralised rule, and easy to manage. Second, the government can control the profit share between the firms and pharmacies in order to encourage pharmaceutical innovation. Third, the government can also control the drug-price margins so that meditations are not biased.

There are not many literatures that theoretically analyse the pharmaceutical market, especially Japanese regulated pharmaceutical market. Canton and Westerhout (1999) models the Dutch pharmaceutical market. Bhattacharya and Vogt (2003) proposes a dynamic model of pharmaceutical pricing. Tanno and Hayashi (2013) is one of few papers that investigate the Japanese drug market from the viewpoint of industrial organisation. However, in the papers above, the economic consequences and efficiency of the governmental pricing policy are not analysed. This paper is the first paper that evaluates the current Japanese pricing policy and proposes an alternative policy.

This paper is organised as follows. In the section 2, the structure of the Japanese pharmaceutical market is overviewed. In addition, we see the aim and actual management of the current R2 rule. In the section 3, the Japanese pharmaceutical market and R2 rule are modelled. Then, we evaluates the R2 rule. In the section 5, we derive the alternative more efficient rule that we name Margin Rate Rule. In the section 6, we overview the characteristics of Margin Rate Rule. There are many advantages in implementing Margin Rate Rule. The section 7 concludes this paper.

2 the Japanese Pharmaceutical Market

In this section, we describe the Japanese pharmaceutical market that is mathematically modelled in the next section. The structure of the industry is presented in figure 1. There are three economic categories in this industry: 1) pharmaceutical firms and wholesalers, 2) hospitals and pharmacies, and 3) consumers. Note that the wholesalers are put in the same category as the pharmaceutical firms. The reason is that, in the Japanese pharmaceutical market, the wholesalers do not play important roles as the price makers. The margin rate of the Japanese pharmaceutical wholesalers are about 0.67 % which is very lower than the wholesalers in other industries. Because the wholesalers do not affect the drug prices much, we ignore the pricing of the wholesalers.

The relationships between the three categories are vertical. The pharmaceutical firms and wholesalers sell drugs to the hospitals and pharmacies. Then, the hospitals and pharmacies sells them to the consumers. There are 2 kinds of the prices: retail price and wholesale price. The retail price is the price at which the hospitals and pharmacies sell drugs to the consumers. The wholesale price is the price at which the pharmaceutical firms sell drugs to the hospitals and pharmacies. In the following, we see how both prices are determined in Japanese pharmaceutical market.

In Japan, the wholesale prices are determined in the market. In most of the cases, the wholesale prices are set by the pharmaceutical firms who are the price makers, because they have the patents for the drugs and hence monopolistic power more or less. Generally, the wholesale prices are lower than the retail price for the pharmacies to gain the positive profit.

On the other hand, the retail prices of the drugs are set by the government. If a pharmaceutical firm invents a new drug and it is listed in the National Health Insurance (NHI) Drug Price List ("NHI Price List"), national health insurance is applied to the drug. At that time, the initial retail price is determined by the government. There are two methods to determine the initial retail price. They are 1) comparison (with drugs of similar efficacy) based price setting , and 2) cost based price setting. The first method sets the similar price to other drugs of similar efficacy. The

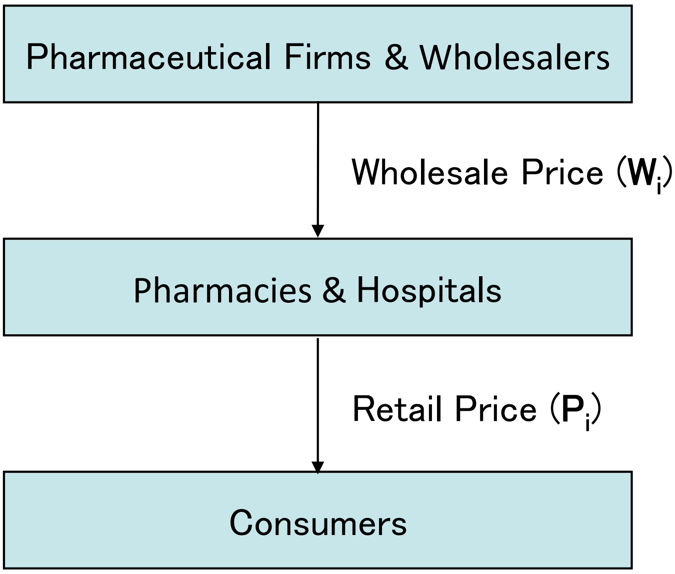

Figure 1: Structure of Pharmaceutical Market

second method estimates the production cost of the drug, and sets the price for the firms to gain appropriate profit. These methods determines the initial drug prices when they first come into the market.

In addition, and most importantly, the government revises the retail price every two years. Typically, the government gradually lowers the retail price over time. This price reduction is carried out according to what is called "**R2 rule**". R2 rule focuses on the difference between the retail price and wholesale price. If this difference becomes larger, the rule decreases the retail price so that the retail price is 2% higher than the wholesale price.

Consider the following example. The initial retail price of one drug that is set by the government (by comparison-based or cost based price setting) is 100 yen, and the initial whole sale price of the drug that is determined in the market is 98 yen. However, the wholesale price is affected by the competition, entry of other firms to the market, and inventions of drugs with similar efficacy. Suppose that other firms would invent new drugs with similar efficacy and the competition among firms would become intense. Then, the wholesale price would decrease from 98 yen to 90 yen. Then, the difference between the retail price (100 yen) and the wholesale price

(90 yen) becomes larger than before. As a result, "R2 rule" decreases the retail price from 100 yen to 92 yen i.e. 2% higher than the wholesale price.To be accurate, new prices of the drugs are revised according to

$$\text{New Retail Price} = \begin{pmatrix}\text{Weighted Average}\\ \text{Wholesale Price}\end{pmatrix} \times \left(1 + \text{VAT Rate}\right) + \begin{pmatrix}\text{2\% of}\\ \text{Old Retail Price.}\end{pmatrix} \tag{1}$$

The key lies in the competition among firms. Because the wholesale prices are determined in the market, the variations of the wholesale prices reflect the actual market competition. To set the retail prices, the R2 rule monitors the wholesale prices, and hence, the actual market competition. Applying the R2 rule, the government can set the retail price to reflect the actual competition. If the competition is fierce and the wholesale prices get lower, the retail prices also get lower.

Why does the government adopt this R2 rule? The government announces that the R2 rule is applied so that meditations are not "biased". We should notice that the profit for one drug (i.e. margin) of the hospitals and pharmacies is as follows. margin = retail price − wholesale price. The government is concerned that if the margin varies across drugs, hospitals tend to prescribe drugs with high margin, which can be regarded as "biased" meditations. Therefore, the Japanese government adjust the profit to 2% for all drugs.

Actually, the government is lowering the retail prices over time according to the R2 rule. The monopolistic firms take into consideration the R2 rule and compete with other firms in drug pricing. Then, we raise the questions. What is the economic consequence of the R2 rule? Does the R2 rule lead to high or low drug prices? In the next section, we model the Japanese drug market and evaluate the R2 rule.

3 The Model of the Pharmaceutical Market

In this section, the pharmaceutical market is modelled. In the subsection 3.1, as a benchmark, we model the hypothetical case in which the market faces no governmental regulation. In the subsection 3.2, we model the actual case in which the market has the price regulation, R2 rule. Finally, in the subsection 3.3, we compare both cases.

As we see in figure 1 in the previous section, there are 3 economic categories in the market: the pharmaceutical firms and wholesalers, the hospitals and pharmacies, and the consumers. In this paper, we denote the pharmaceutical firms and wholesalers as the **"firms"**, the hospitals and pharmacies as the **"pharmacies"**, and the consumers as the **"consumers"**. The relationships between categories are vertical. The firms sell drug i to the pharmacies at the wholesale price W_i, and pharmacies sells it to the consumers at the retail price P_i.

3.1 Hypothetical Unregulated Market

First, we consider the hypothetical unregulated market as a benchmark. There are 3 economic agents: the firms, the pharmacies, and the consumers. We assume that the firms and pharmacies are the price makers, especially, the monopolists. The wholesale price W_i and retail price P_i are therefore the monopoly price. Note that we can relax the assumption that the firms and pharmacies are monopolists. it is necessary for this study to assume that they are just price makers. Assuming that they are oligopolists does not change the results and conclusions of our model.

We model the consumers, the pharmacies, and the firms in order. In short, the Figure 2 is modelled backward, i.e. from the bottom to the top. First, the consumers, given retail prices (P_i), buy drugs from the pharmacies to maximise the utility that consists of the quantities of n kinds of drugs (X_i, $i = 1, 2, ..., n$) and the quantity of one kind of consumption good (C). We assume that the consumers' utility function takes the normal form, i.e. $\frac{\partial U(\cdot)}{\partial X_i} > 0$, $\frac{\partial^2 U(\cdot)}{\partial^2 X_i} < 0$,

$\frac{\partial U(\cdot)}{\partial C} > 0$, and $\frac{\partial^2 U(\cdot)}{\partial^2 C} < 0$. Then, consumer's maximisation problem is

$$\max U\Big(X_1, X_2, ..., X_n, C\Big) \tag{2}$$

$$s.t. \Sigma P_i X_i + C = I \tag{3}$$

where I denotes the income of the consumers. Solving this problem, we obtain the inverse demand function $P_i = P_i(P_1, P_2, ..., P_{i-1}, P_{i+1}, ..., P_n, X_i)$ for drug i.

Next, the pharmacies are the price makers. Given the wholesale prices (W_i), other drug prices $P_1, P_2, ..., P_{i-1}, P_{i+1}, ..., P_n$, and the inverse demand functions $P_i = P_i(P_1, P_2, ..., P_{i-1}, P_{i+1}, ..., P_n, X_i)$ of the consumers, the pharmacy i purchase drugs i from the firms, and monopolistically sell them to the consumers to maximise the profit[1]. Then, pharmacy i's maximisation problem is

$$\max_{X_i} P_i\Big(P_1, P_2, ..., P_{i-1}, P_{i+1}, ..., P_n, X_i\Big)X_i - W_i X_i \tag{4}$$

Note that, for each pharmacy i, the amount of purchase is equal to the amount of sale. Solving this problem, we obtain

$$W_i = \frac{\partial P_i(P_1, P_2, ..., P_{i-1}, P_{i+1}, ..., P_n, X_i)X_i}{\partial X_i}, \text{which is rewritten as} \tag{5}$$

$$W_i = MR_i. \tag{6}$$

In the first line, the left hand side is the wholesale price, and hence, marginal cost of the pharmacies. The right hand side represents the marginal revenue (MR_i) of the pharmacies. Notice that this function is also regarded as *the factor demand function of the pharmacies*. Since W_i is given, the right hand side determines the factor demand X_i.

[1]Note that we assume a hypothetical market in order to compare with the Japanese economy. Here, we make an assumption that the pharmacy i has monopolistic power only on the drug i. Though this is not a realistic assumption, this does not affect our results.

Finally, the firms are also the price makers. Given the factor demand function $W_i = MR_i$, the firm i produces drugs i, and monopolistically sell them to the pharmacy i to maximise the profit. Then, the firm i's maximisation problem is

$$\max_{X_i} MR_i \; X_i - c_i(X_i) \tag{7}$$

Solving this problem, we obtain

$$\frac{\partial c_i(X_i)}{\partial X_i} = \frac{\partial MR_i}{\partial X_i}. \tag{8}$$

The left hand side is the marginal production cost of the firms. The right hand side represents the marginal revenue of the firms. It is important that the marginal revenue of the firms is the derivative of the marginal revenue of the pharmacies, MR_i. The equation (8) determines the equilibrium X_i, and hence W_i and P_i for all i.

This model clearly leads to the classical double marginalisation problem: the pharmacies' marginal revenue (MR_i) means the factor demand of the pharmacies. Then, the firms' marginal revenue is one more derivative of MR_i, i.e. $\frac{\partial MR_i}{\partial X_i}$. This explanation is shown in figure 2. $\frac{\partial c_i(X_i)}{\partial X_i} = \frac{\partial MR_i}{\partial X_i}$ determines the equilibrium X_i. Note that, In the figure, we denote $\frac{\partial MR_i}{\partial X_i}$ as MR'. What is the consequence of double marginalisation? We see that

- the price is higher than the single monopoly, and
- the social profit in this economy is lower than the single monopoly

Note that the social profit refers to the total profit (the pharmacies' profit plus the firms' profit) in the economy. In addition, the the single monopoly refers to the situation where the firms produce the drugs and sell them directly to the consumers. In other words, in the single monopoly, there is no wholesalers in the economy. In this case, $\frac{\partial c_i(X_i)}{\partial X_i} = MR$ determines the equilibrium X_i. From the two characteristics of the double marginalisation, we can say that the double marginalisation is Pareto inefficient to the single monopoly because both the consumers' surplus and producers'

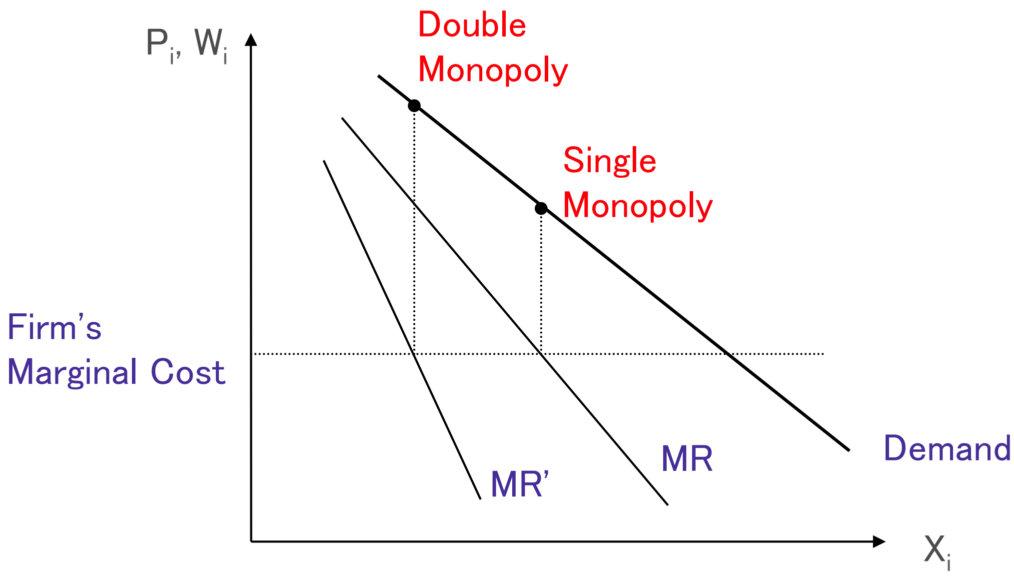

Figure 2: Double Marginalisation

surplus are lower than the single monopoly.

For the comparison to the Japanese market, we give an alternative representation of this economy in which we does not use inverse demand functions, but use demand functions. The firms and pharmacies' maximisation problems are solved with respect to the prices, not the quantities. First, the consumers solve the same problem as before. the demand function is $X_i = X_i(P_1, P_2, ..., P_n)$.

Next, the pharmacy i's maximisation problem is

$$\max_{P_i} P_i X_i\big(P_1, P_2, ..., P_n\big) - W_i X_i\big(P_1, P_2, ..., P_n\big). \tag{9}$$

Note that the amount of the pharmacy's purchase is equal to the amount of the pharmacy's sales for each i. When W_i is given, the pharmacies put some mark up on W_i and set $P_i = (1 + m_i)W_i$ where m_i denotes the mark up rate. This $P_i = (1 + m_i)W_i$ determines the consumers' demand $X_i = X_i(P_1, P_2, ..., P_i, ..., P_n)$ that is equal to the pharmacies' factor demand. Therefore the factor demand of the pharmacy i can be written as

$$X_i = X_i\Big[P_1, P_2, ..., (1+m_i)W_i, ..., P_n\Big]. \tag{10}$$

Finally, the pharmaceutical firm i's maximisation problem is

$$\max_{W_i} W_i X_i\Big[P_1, P_2, ..., (1+m_i)W_i, ..., P_n\Big] - c_i\Big(X_i[P_1, P_2, ..., (1+m_i)W_i, ..., P_n]\Big). \tag{11}$$

Solving this problem, we obtain the equilibrium W_i, X_i, and P_i. Here, in a different way, we can explain why double marginalisation occurs. We focus on the revenue of the maximisation problem above. For the firms to set W_i, the pharmacies' mark up rate is just a disturbance because it does not increase the first term W_i (the gain for selling one drug), but decrease the second term $X_i\Big[P_1, P_2, ..., (1+m_i)W_i, ..., P_n\Big]$ (the amount of sales). Then, the firms' marginal revenue with respect to X_i is smaller than the single monopoly. As a result, the equilibrium X_i is lower and the retail price P_i is higher than the single monopoly.

3.2 Japanese Regulated Market

Next, we model the Japanese regulated market. There are 3 economic agents: firms, pharmacies, and consumers. For simplicity, we assume that firms are the price makers, especially, monopolists. The wholesale price W_i is therefore monopoly price. However, P_i is determined by the government. As seen in the previous section, the Japanese government revises the drug prices according to the R2 rule:

$$0.98 \times P_i = W_i. \tag{12}$$

It controls the retail price P_i so that P_i is 2% higher than W_i. The notable feature of this R2 rule is that the adjustment 2% is fixed rate and applied to all drugs. We conclude that this kind of fixed rate rule causes inefficiency.

We model the consumers, the pharmacies, and the firms respectively. First the consumers behave the same as before. Given the retail prices (P_i), the consumers buy drugs from the pharmacies to maximise the utility that consists of the quantities of n kinds of drugs (X_i, $i = 1, 2, ..., n$) and the quantity of one kind of consumption good (C). Then, consumer's maximisation problem is

$$\max U\Big(X_1, X_2, ..., X_n, C\Big) \tag{13}$$

$$s.t. \Sigma P_i X_i + C = I \tag{14}$$

We obtain the demand function $X_i(P_1, P_2, ..., P_n)$ for drug i.

Next, we consider the pharmacy's behaviour. It should be noticed that under the R2 rule, pharmacies are no longer the price makers, but the price takers. When W_i is determined by the firms, P_i is automatically determined by the R2 rule (12). Given the retail prices (P_i) and the wholesale prices (W_i), the pharmacies buy the drugs from the firms and sell them to the consumers to maximise the profit. Their profit is written as

$$P_i X_i\Big(P_1, P_2, ..., P_n\Big) - W_i X_i\Big(P_1, P_2, ..., P_n\Big). \tag{15}$$

The amount of the pharmacy ' s purchase is equal to the amount of the pharmacy ' s sales for each i. For the pharmacies, W_i, P_i, and hence X_i are determined exogenously. Then, the factor demand of the pharmacies can be written as

$$X_i = X_i\Big(P_1, P_2, ..., \frac{W_i}{0.98}, ..., P_n\Big). \tag{16}$$

Finally, the firms are the price makers. Given the R2 rule (12) and the factor demand functions, the pharmaceutical firm i produces drugs i, and monopolistically sell them to the pharmacies to maximise the profit. Then, the pharmaceutical firm i's maximisation problem is

$$\max_{W_i} W_i X_i\Big(P_1, P_2, ..., \frac{W_i}{0.98}, ..., P_n\Big) - c_i\Big[X_i(P_1, P_2, ..., \frac{W_i}{0.98}, ..., P_n)\Big] \tag{17}$$

Solving this problem, we obtain the equilibrium W_i, P_i, and X_i.

It is important that, in this economy, the firms decide all prices (W_i and P_i) in effect. This feature reflects the actual behaviour of the firms in the market. It is often reported in the newspapers, magazines, and their statements that the firms are concerned about the government's price revisions when they determine the W_i. Consider the situation in which the firms are planning to decrease the wholesale price to sell a large amount of the drug i to the pharmacies. However, the firms expect that it would make the government revise the retail price lower. If this price revision would decrease the profit, the firms would give up decreasing the wholesale price. In short, taking into account the governmental price revision (the R2 rule) on the retail price, the firms determine the wholesale price in reality. In other words, the firms affect not only the wholesale price, but also the retail price.

3.3 Comparison

In the previous section, we model both Hypothetical unregulated market and Japanese regulated market. What is the difference in terms of economic welfare? Which is more efficient system? The answer is that the Japanese regulated market is equivalent to the hypothetical unregulated market when $(1 + m_i) = \frac{1}{0.98}$. This section presents this result.

Note that we solve the model backward. The order is, (i) the consumers' problem, (ii) the pharmacies' problem, and then (iii) the firms' problem. What determines the equilibrium in the end is, therefore, the firms' problem. We focus on the firms' problem. Let us rewrite the maximisation problem (11) of the firms in the hypothetical unregulated market.

$$\max_{W_i} W_i X_i\Big[P_1, P_2, ..., (1 + m_i)W_i, ..., P_n\Big] - c_i\Big\{X_i[P_1, P_2, ..., (1 + m_i)W_i, ..., P_n]\Big\}.$$

On the other hand, the maximisation problem (17) of the firms in Japanese regulate market under the R2 rule is .

$$\max_{W_i} W_i X_i\Big(P_1, P_2, ..., \frac{W_i}{0.98}, ..., P_n\Big) - c_i\Big[X_i(P_1, P_2, ..., \frac{W_i}{0.98}, ..., P_n)\Big].$$

We can easily confirm that the Japanese market under the R2 rule is equivalent to the hypothetical unregulated market, when

$$(1 + m_i) = \frac{1}{0.98}. \tag{18}$$

We can say that the Japanese fixed rate rule (the R2 rule) cause the same social inefficiency as the well-known double marginalisation problem. The drug price is higher, and hence the consumers' surplus is lower than the single monopoly. Regardless of the high price, the social profit is lower, and hence the produces' surplus is lower than the single monopoly.

We can derive some important implications for the two discussions that we introduce in the section 1. The discussions are as follows.

1. Are the drug prices in Japan high or low?
2. Is there enough incentives for pharmaceutical innovations in Japan?

Here, we can answer these questions. For the first question, the R2 rule raises the drug price too high. For the second question, the R2 rule reduces the incentives for innovations because the R2 rule reduces the social profit from the new drug.

4 The Answer: Margin Rate Rule

4.1 Derivation of the Margin Rate Rule

We see that the R2 rule leads to the social inefficiency. We ask whether there is an alternative more efficient rule than the R2 rule. In this section, we suggest one alternative pricing rule that we name “Margin Rate Rule”. To derive this new rule, we suppose that the government replace the R2 rule (12) by the new rule,

$$P_i = \alpha_i(W_i), \tag{19}$$

where α_i denotes a pricing rule that depends on W_i. In other words, by monitoring the wholesale price W_i, the government sets the retail price P_i. Note that the R2 rule also depends on W_i, as seen in (12). The other environments are the same as in the Japanese regulated market in the subsection 3.2. Under this new rule, the pharmaceutical firm solves

$$\max_{W_i} W_i X_i\Big[P_1, P_2, ..., \alpha_i(W_i), ..., P_n\Big] - c_i\Big[X_i(P_1, P_2, ..., \alpha_i(W_i), ..., P_n)\Big]. \tag{20}$$

We want to find a new rule $P_i = \alpha_i(W_i)$ that yields the same allocation and profit as the single monopoly. My suggestion, margin rate rule, is the answer.

Proposition (Margin Rate Rule)**.** *Margin rate rule, $\alpha(W_i) = A_i(W_i - c_i) + c_i$ where A_i is an arbitrary constant and c_i is the marginal cost of production, is the pricing rule that yields the same allocations as the single monopoly.*

Proof. Under the pricing rule $P_i = \alpha(W_i)$, the firms solve

$$\max_{W_i} W_i X_i\Big[\alpha_i(W_i)\Big] - c_i\Big(X_i(\alpha_i(W_i))\Big). \tag{21}$$

The first order condition is

$$X_i\Big[\alpha_i(W_i)\Big] + W_i\alpha_i'(W_i)X_i'\Big[\alpha_i(W_i)\Big] - c_i'\Big[X_i(\alpha_i(W_i))\Big]X_i'\Big[\alpha_i(W_i)\Big]\alpha_i'(W_i) = 0. \tag{22}$$

On the other hand, the single monopoly faces the following first order condition.

$$X_i\Big(\alpha_i(W_i)\Big) + \alpha_i(W_i)X_i'\Big[\alpha_i(W_i)\Big] - c_i'\Big[X_i(\alpha_i(W_i))\Big]X_i'\Big[\alpha_i(W_i)\Big] = 0. \tag{23}$$

If both (22) and (23) take the same form, the allocations under the rule are the same as the single monopoly. Then, we obtain the following first order difference equation with respect to $\alpha(W_i)$.

$$W_i \alpha_i'(W_i) - c_i'\Big[X_i(\alpha_i(W_i))\Big]\alpha_i'(W_i) = \alpha_i(W_i) - c_i'\Big[X_i(\alpha_i(W_i))\Big] \tag{24}$$

Solving this first order difference equation yields

$$\alpha_i(W_i) - c_i = A_i(W_i - c_i), \tag{25}$$

where A_i is an arbitrary constant and c_i is the marginal cost of production, which we assume constant for simplicity. We call this rule as the "margin rate rule". □

Under this margin rate rule, the economy achieves the same allocations as the single monopoly. Because the single monopoly is Pareto efficient to the double marginalisation, applying the margin rate rule is better than the R2 rule in the sense of economic efficiency. However, we additionally have to discuss whether the single monopoly is the better than any other allocations or not. In the standard price theory, the economy is the most efficient when the price is equal to the marginal cost, i.e. in the perfect competition. However, in the pharmaceutical market, it is not true that the perfect competition is best, because we have to take into account the incentives for innovations. We can say that, at least, moderate monopolistic profit is necessary to invent new drugs. In this sense, whether the lower price than the single monopoly is more efficient or not is still an open question in economics. Therefore, our suggestion targets the single monopoly where the allocations are at least Pareto efficient to the double marginalisation.

4.2 Why do we name our rule as "Margin Rate Rule"

Here, we see why we name our rule as margin rate rule. The Japanese drug pricing rule controls the retail price based on the wholesale price. From the pharmacies' point of view, it controls the pharmacies' mark-up rate that is defined by $\frac{P_i - W_i}{W_i} = \frac{\alpha_i(W_i) - W_i}{W_i}$. First, the R2 rule sets the mark-up rate as

$$\frac{\alpha_i(W_i) - W_i}{W_i} = \frac{W_i/0.98 - W_i}{W_i} \approx 0.02. \tag{26}$$

In words, the R2 rule adjust the pharmacies' mark-up rate to 2%. Next, the margin rate rule sets the mark-up rate as

$$\frac{\alpha_i(W_i) - W_i}{W_i} = \frac{[A_i(W_i - c_i) + c_i] - W_i}{W_i} \tag{27}$$

$$= (A_i - 1)\frac{W_i - c_i}{W_i}. \tag{28}$$

In words, the margin rate rule sets the pharmacies' mark-up rate proportional to *the firms' margin rate*. Here, the margin rate means the same as the learner index. This is the reason why we call our rule as margin rate rule.

5 Why is the Margin Rate Rule efficient?

In the previous section, we derive an alternative pharmaceutical pricing rule, "margin rate rule". In this section, we see the intuitions for why "margin rate rule" yields more efficient allocations than the R2 rule.

5.1 Individual Firms' Margin vs Social Margin

As we see in the section 3, the R2 rule leads to the higher drug price than the single monopoly. Then, the R2 rule leads to the lower social profit than the single monopoly, because the social profit (=the firms' profit + the pharmacies' profit) is maximised under the single monopoly. This is because, under the R2 rule, maximising the firms' profit is not equivalent to maximising the social profit. As is seen in the section 3, both the double marginalisation and R2 rule cause this problem.

On the other hand, the margin rate rule leads to the same drug price and the same social profit as the single monopoly. This is because, under the margin rate rule, maximising the firms' profit is equivalent to maximising the social profit. To confirm this claim, we transform the margin rate rule to the following.

$$\alpha(W_i) - c_i = A_i(W_i - c_i). \tag{29}$$

The left hand side represents the margin of the firms for selling one drug. The right hand side represents the constant multiplication of the social margin (= the firms' margin + the pharmacies margin) for selling one drug. To sum up, the margin rate rule controls the retail price P=alpha so that the firms' margin is proportional to the social margin. Therefore, the firms set their margin that maximises the social margin and profit. The margin rate rule leads to the same drug price and the same social profit as the single monopoly. This is one explanation why the margin rate rule guides to the single monopoly.

5.2 Margin Rate Rule as Variable Rate Rule

The R2 rule sets the retail price by adding 2% to the wholesale price. The added percentage, 2 %, is fixed whatever the wholesale price level is. On the other hand, under the margin rate rule, the added percentage is variable according to the wholesale price level. In this sense, the margin rate rule is regarded as the variable rate rule, while the R2 rule is regarded as the fixed rate rule. Figure 3 shows the relationship between the wholesale price and the added percentage for both the R2 rule and the margin rate rule.

First, the R2 rule adds the fixed percentage, 2%. Second, the higher the wholesale price is, the higher percentage the margin rate rule adds to the wholesale price. What does it mean for the firms? Note that, under the R2 rule, the firms raises the wholesale price and hence the retail price above the single monopoly level. However, under the margin rate rule, the firms have lower incentives to raise the wholesale price. Suppose that the firms raised the wholesale price

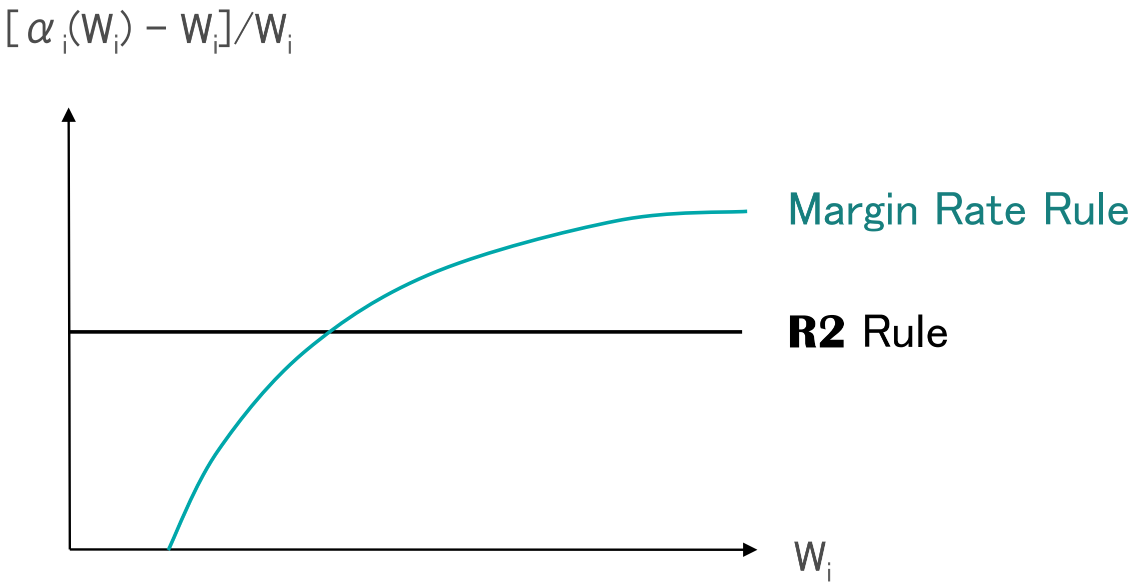

Figure 3: R2 Rule vs Margin Rate Rule

significantly. Then, as seen in Figure 5, the margin rate rule would add the higher percentage and hence set the higher retail price than the R2 rule. The consumers' demand for the drugs would become lower. As a result, the firms would gain less profit. In contrast, if the firms lowered the wholesale price significantly, then the margin rate rule would add lower percentage and the firms would gain more profit. In summary, under the margin rate rule, the firms lower the wholesale price to avoid government's high-percentage adding to the wholesale price. This is another explanation why the margin rate rule leads to lower drug prices than the R2 rule.

6 Advantages of Margin Rate Rule

Besides the result that margin rate rule is more efficient than the R2 rule, there are additionally three advantages in the margin rate rule. First, applying the margin rate rule does not require the demand information of the consumers, though the monopoly pricing normally requires it. Second, margin rate rule can divide the profit arbitrarily between the firms and pharmacies. The government can encourage innovation in new drugs. Third, the government can achieve the "unbiased meditations". Applying the margin rate rule requires only cost information. In this section, we study both advantages in detail.

6.1 No Need for Demand Estimation

The first advantage is that the margin rate rule does not require demand information including drug efficacy, competition, and price elasticity of demand. Consider an alternative method for the government to set the single monopoly price: at the time of price revision, the government estimates the hypothetical single monopoly prices and arbitrarily sets them for all drugs. What kinds of information would the government need for such estimations? To estimate the single monopoly price, the government would need to estimate the demand function and the marginal cost. It requires the drug efficacy, the competition level among firms, price elasticity of demand, and the production cost of the drugs. In short, the government would need both the demand and cost information. However, for the estimations the government would pay a large amount of time and money, and the accuracy of them would be unclear.

On the other hand, managing the margin rate rule does not require the demand information. The reason is that, under the margin rate rule, not the government, but the firms themselves calculate the drug efficacy, the competition level, and the price elasticity of demand to maximise the profit. Not the government, but the firms face the demand curves and set the price. The government only adjusts the relative margin: it adjusts the margin of the firms proportional to the social margin as seen above. In this sense, the margin rate rule can be regarded as a decentralised pricing rule. It implies that the market (i.e. the firms) is superior to the government in pricing the drugs.

Managing the margin rate rule only requires the cost information, the marginal cost to produce a drug as seen in $\alpha(W_i) = A_i(W_i - c_i) + c_i$. Of course, the government has to put effort into this estimation. However, as seen in the next section, the Japanese governement is currently estimating the production cost for some kinds of new drugs. Therefore, we can say that the government do not need to pay a large amount of additional time and money to manage the margin rate rule. We discuss this point in the next section.

6.2 Arbitrary Distribution of the Social Profit and Encouragement of Innovation

We show that the margin rate rule works to stimulate pharmaceutical Innovation by dividing the social profit arbitrarily between the firms and pharmacies. At the beginning, we should notice that A_i in margin rate rule $\alpha(W_i) = A_i(W_i - c_i) + c_i$ is an arbitrary constant. This is because we solve the first order differential equation when we derive the margin rate rule. What would happen when the government controls A_i? In principle, controlling A_i does not affect the size of the social profit. Whatever value A_i takes, the margin rate rule guides to the single monopoly, and hence, it does not affect the equilibrium value of X_i, P_i, and the size of the social profit.

However, it affects the distribution of the social profit between the firms and pharmacies. This is because the value of A_i clearly affects the equilibrium value of the remaining variable, W_i. If the government announces higher A_i than before, then the equilibrium value of P_i remains the same, but W_i becomes lower. Here, it should be noted that (i) the margin of the firms is $W_i - c_i$, and the margin of the pharmacies is $P_i - W_i$, and (ii) The margin determines the share of the social profit that they gain when X_i is unchanged. Then, we can restate our claim as follows.

- The higher A_i the government announces, the higher share of the social profit pharmacies gain, and the lower share of the social profit the firms gain.
- The lower A_i the government announces, the lower share of the social profit pharmacies gain, and the higher share of the social profit the firms gain.

Note that controlling A_i does not reduce the size of the social profit.

Why does the government take into account the distribution of the social profit? There are two answers to this question. First, there is a positive relationship between the pharmacies' share of the social profit and pharmaceutical innovation. The more share of the social profit the firms gain, the more incentives for inventing new drugs they have. This is because high share of the social profit means high reward of inventing new drugs. Inventing new drugs stimulate the economy in the end. Therefore, increasing the share of the firms would encourage R&D and innovation, and hence economic growth. Second, the Japanese government cares about the biased meditations. By controlling A_i, the government can also solve "biased" meditations problem. This is explained in the following.

6.3 Unbiased Meditations

As we discuss in the section 2, the Japanese government is concerned about the biased meditations: if the margin would vary across drugs, hospitals and pharmacies would tend to prescribe drugs with high margin. For the similar reason above, the margin rate rule solves this concern, by the appropriate control and announcements on A_i.

As we see above, high A_i makes low margin of the firms $(W_i - c_i)$ and high margin of the pharmacies $(P_i - W_i)$. In contrast, low A_i makes high margin of the firms $(W_i - c_i)$ and low margin of the pharmacies $(P_i - W_i)$. Here, we should notice that the value A_i can vary across drugs i. For the drug i the government can announce A_i, while for the drug j the government can announce $A_j \neq A_i$. Therefore, by controlling A_i and A_j, the government can set the pharmacies' margin of the drug i and j at the same level, i.e. $W_i - c_i = W_j - c_j$. Then, the hospitals and pharmacies gain the same margin whatever drugs they prescribe. Note that controlling A_i does not affect the size of the social profit. As a result, the government can achieve both the efficient allocations and unbiased meditations.

7 Data Feasibility of the Margin Rate Rule

Managing the margin rate rule only requires the production cost. Then, is it possible to obtain the cost information and manage the rule? The answer is positive because currently the Japanese government is collecting the production cost data to set the initial price for some kinds of new drugs.

As we overview in the section 2, if a pharmaceutical firm invents a new drug and it is listed in the National Health Insurance (NHI) Drug Price List ("NHI Price List"), the initial retail price is determined by the government. There are two methods to determine the initial retail price.

1. comparison (with drugs of similar efficacy) based price setting , and
2. cost-based price setting.

If the efficacy of the new drug is comparable to that of the existing one in the market, the first comparison-based method is applied. The government compares the efficacy of both drugs and sets appropriate price to the new one. On the other hand, if there is no comparable drugs in the market, the government applies the second cost-based price setting. The government estimates the cost of manufacturing, sales, administration, operating, distribution, marketing and VAT. Then, the government adds some margin to the cost for the firm to gain appropriate profit.

We put emphasis on the second pricing method. In short, currently the government is estimating the production cost for initial pricing of new drugs. Our margin rate rule requires cost information. If the government collected cost data more broadly, then the margin rate rule could be applied to the overall market. We conclude that the margin rate rule is feasible to manage in terms of data.

8 Concluding Remarks and Extension to the Model under Health Insurance

We evaluate the drug pricing sheme (R2 rule) in Japan, and find social inefficiency that is similar to well-known double marginalisation problem. Then we suggest an alternative rule that we name "margin rate rule". Applying margin rate rule is Pareto improving because the drug price is lower and the total profit of firms are larger than applying R2 rule. In addition, there are three notable advantages in the margin rate rule. First, the government does not have to estimate drug efficacy, competition, and other demand information in pricing drugs. The government only has to estimate the cost of drug production. In this sense, the margin rate rule is regarded as a decentralised rule. Therefore, we can say that the margin rate rule is feasible and easy to manage. Second, the government can control the margin share between the firms and pharmacies in order to encourage pharmaceutical innovation. Third, the government can also control the retail price and margin share so that meditations are not biased.

Finally, we refer to the health insurance. In this paper, the effect of the health insurance is not analysed. However, the existence of the health insurance would not change the functional form and advantages of the margin rate rule. Under the health insurance, there still exists the similar problem to the double marginalisation. Then, applying the margin rate rule is Pareto improving. To build a more realistic model, we are going to analyse the economy with the health insurance in the future study.

References

Canton, Erik, Westerhout, Ed., Model for the Dutch Pharmaceutical Market. Health Economics, Vol. 1999, Issue 5, pp391-402, 1999.

Bhattacharya, Jayanta, Vogt, William, B., A Simple Model of Pharmaceutical Price Dynamics. Journal of Law and Economics, Vol. 46, No. 2, pp. 599-626, 2003.

Tanno, Tadanobu, Hayashi, Yukinari, Current Status and Economic Analysis in Japanese Wholesalers of Prescription Drugs. Atomi University Department of Management Annals, No. 15, 2013.