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Medicine Pricing, Optimal Patent Length and Social Welfare

Junlong CHEN[1], Jiali LIU[2], Yuncheng LONG[3], Jialing LUO[4]

Abstract

Social welfare, the ultimate pursuit of medicine patent protection, is affected by multiple market and government factors. This paper constructs a multi-stage dynamic sequential game model involving the government and medicine enterprises and integrates various market and government factors into account. Next, the social welfare of monopoly pricing and government pricing are compared, while the optimal length and its correlations with the influencing factors are determined for medicine patent. It is concluded that the optimization of medicine patent length is a complex decision-making process; the optimal patent length is affected by pricing mode, government subsidy, market demand elasticity, R&D investment, marginal cost, product lifecycle and discount rate. The government should determine medicine patent length according to local conditions, rationalize medicine pricing mechanism, and develop a competitive medicine market.

Keywords: monopoly pricing, government pricing, optimal patent length, social welfare, social innovation.

Introduction

Patent protection mainly guarantees the interests of inventors, promotes R&D among enterprises and advances technical innovation. The length of patent protection (patent length) refers to the maximum period during which a patent can be maintained in force. It is very important to optimize the patent length, which

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directly bears on the benefits of inventors and the overall social welfare. The optimization of patent length is particularly important for medicine, especially targeted medicines. This is because medicine protects basic human rights like the right to health and the right to life, and requires a long-lasting, costly and risky R&D process. If it is too long, the patent length will lead to market monopolies, despite bringing short-term profits to the inventors. In this case, the R&D of new medicine will be hindered in the long run, hurting the interests of consumers and the public health. If it is too short, the R&D innovation and public health will also be endangered, as the enterprises cannot acquire the expected profits from the huge investment in the early stage. Therefore, the patent length of medicines should strike a balance between enterprise profits and public health benefits, while pursuing the maximum social welfare. In other words, the optimal patent length of medicines ought to protect the profits of medicine R&D, externalities of medicines and interests of consumers. Mansfield (1981) and Lanjouw(1998) show that due to a large number of imitation behaviors, few patents can survive until the end of the protection period. What we examine in this papei is not the persistence of patents after the implementation of patent protection, but how to develop an optimal patent protection period under the premise of effective protection.

The study on optimal patent length is pioneered by Nordhaus (1969), who holds that the optimal patent length must balance the static distortion of markup pricing and the dynamic income from enhanced innovation. Some scholars believed that the optimal patent length should be unlimited. Based on a general equilibrium model, Judd (1985) argues that price distortions will disappear in an infinite cycle, for all commodities will be subjected to equal monopoly pricing. However, some other scholars suggest limiting the optimal patent length to promote enterprise performance. For instance, Klemperer (1990) constructs a partial equilibrium model to prove that the patent length should be very long or very short, depending on the preference structure. According to the quality-ladder model, Horowitz and Lai (1996) advocated limiting the patent length to maximize growth and social welfare. The same suggestion is put forward by Kwan and Lai (2003), as well as Futagami and Iwaisako (2007). Iwaisako and Futagami (2003) claim that a short patent length helps suppress additional distortion on the allocation of intermediate commodities. Chu (2010) suggests that flow-profit depreciation rate determines how much patent length affects R&D and consumption, concluding that a limited patent length can greatly reduce R&D and consumption while an extended patent length has no significant effect on the two issues, due to the high depreciation rate of US patents. The above studies provide key insights into the influencing factors of the optimal patent length. However, most of them do not consider the effect of the optimal patent length on overall social welfare, assuming that the design of patent length only aims to promote enterprise performance like R&D (Çevikarslan, 2017). In addition, there is few reports on the relationship between patent length and the interests of consumers, especially the consumers of medicines. In fact, the

blind pursuit of enterprise performance may damage consumer interests, which in turn dampens the overall social welfare.

To solve the above problems, not many scholars have integrated patent length and price regulation into the analytical framework for maximizing social welfare. For example, Zeng et al. (2014) explore the impacts of patent length and price regulation on R&D growth and social welfare, indicating that a short patent length and a low price of patented product contribute to innovation. Specifically, it is beneficial for R&D growth by extending the patent length and raising the price ceiling of patented product below the monopoly pricing level, but damaging for social welfare. This conclusion reflects the contradiction between enterprise profits and social welfare and implies that the medicine patent length should be optimized to maximize the social welfare. Nevertheless, these scholars have not taken account of the particularities of medicine patents like government subsidy and price elasticity.

In the context of economic globalization, the patent length for foreign targeted medicines needs to be optimized considering the cross-border protection of intellectual property rights. Chin and Grossman (1998), Diwan and Rodrik (1991) and Deardorff (1992) examine the patent protection problem under the North-South framework. The same framework is adopted by Kabiraj (2000) to analyze the optimal patent length. These studies advise non-innovative southern countries to set longer patent length than innovative northern countries, noting that an effective patent cooperation agreement can extend the patent length and enhance the social welfare of all countries. In other words, the relevant scholars agree that extending patent length is an effective way to protect cross-border intellectual property rights. While considering many incentives for patent protection, these studies fail to consider social welfare or pricing of medicines.

In summary, the optimal patent length has been studied extensively, shedding important light on our research. However, there is a severe lack of studies that optimize medicine patent length for the maximal social welfare, considering both market factors and government factors. To make up for this gap, this paper constructs a multi-stage dynamic game model between the government and medicine enterprises, which integrates various market factors (e.g. R&D investment, marginal cost, product lifecycle and market demand) and government factors (e.g. price regulation and subsidy policy). The proposed model is adopted to reveal the effects of patent length on social welfare, under the independent pricing or government pricing. On this basis, we determine the optimal patent length for medicines, identified its influencing factors, and describe its intrinsic mechanism. The research findings provide valuable references for government to formulate patent length policies.

Model

We construct a multi-stage dynamic game model between the government and medicine enterprises. The assumptions are as follows.

Assumption 1

It is assumed that a medicine enterprise plans to develop a new medicine whose patent will be valid for T years. The medicine will be replaced by a newer medicine after being in the market for T years. The R&D of the medicine requires an R&D investment and incurs a marginal cost, which are defined as m and d respectively. Note that T, m and d are all positive constants. The market demand of the medicine can be expressed as $p = a - \delta q$, where $a > 0$ and δ is the slope of the demand curve which is negatively correlated with the elasticity. Considering the particularity of medicines, especially targeted medicines, the value of δ must be greater than 1, that is, the consumers are not sensitive to price, and likely to be deprived of a part of consumer surplus. To secure the R&D investment, it is also assumed that the enterprise profits in the patent length can compensate for the R&D investment m, regardless of the pricing strategy.

During the patent length, the medicine market is completely monopolized by the enterprise. If there is no price regulation, the enterprise will implement monopoly pricing. When the patent length expires, the medicine will be imitated by other enterprises, triggering a Cournot competition between multiple enterprises. For simplicity, the marginal cost of each enterprise is defined as d.

Assumption 2

To reflect the impact of government factors on patent length, it is assumed that the government protects the patent of the medicine enterprise for t years to stimulate medicine R&D investment and gives the enterprise the concession to monopolize the market. In pursuit of the maximal profits, the enterprise only decides to produce the medicine when the marginal cost equals the marginal profit. Thus, the government must ensure that the patent length is long enough to let the enterprise recover its R&D investment. Otherwise, the enterprise will not have the incentive to develop the new medicine. Moreover, the government is assumed

to provide certain subsidy to maintain social fairness because medicines are not purely private products. Taking China for example, targeted medicines are covered by medical insurance. Therefore, the market demand function can be modified as $p = \beta(a - \delta q)$, where β is government subsidy and $\beta > 1$. Finally, it is further assumed that the government, as the designer of patent length, ensures that the patent length can enhance social welfare.

Assumption 3

Considering the time value of money, a discount factor $0 < \eta < 1$ is set up. The value of η is negatively correlated with the discount rate. Inspired by Jain (2010) and Fanti (2016), it is assumed that the social welfare $SW = PS + CS$, where PS is the producer surplus and CS is the consumer surplus. The value of PS equals the sum of enterprise profits, and that of CS can be calculated as $CS = \frac{\beta\delta Q^2}{2}$. The overall social welfare through the patent length T (SW_t) covers the present value of social welfare in the monopoly period (SW_m) and the social welfare in the competition period (SW_c), that is, $SW_t = \frac{1-\eta^t}{1-\eta} SW_m + \frac{1-\eta^{T-t}}{1-\eta} \eta^t SW_c$.

Under the above assumptions, we explore the optimal patent period t^*, and disclose the impacts of various factors on t^* and social welfare function.

Model Analysis

Monopoly pricing in patent length

Under the above hypotheses, this subsection studies the independent pricing of the enterprise in the patent length, that is, in the absence of price regulation. The first step is to examine the decision of the monopoly enterprise in patent length. Through the patent length, the enterprise implements monopoly pricing to pursue $MC = MR$. It can be further obtained that $\frac{\partial(PQ)}{\partial Q} = d$. Thus, the equilibrium output in the monopoly period can be expressed as

$$Q^* = \frac{\beta a - d}{2\beta\delta} \qquad (1)$$

Further, the social welfare in this period can be defined as

$$SW_m = \frac{3(a\beta - d)^2}{8\beta\delta^2} \qquad (2)$$

After the patent length expires in t years, the monopoly enterprise loses its monopoly position, and many enterprises enter the market through product imitation. In this case, the Cournot competition takes place around the output. Then, the equilibrium output can be derived from $\frac{\partial \pi_i}{\partial q_i} = 0$:

$$q_i = \frac{a\beta - d}{(n+1)\beta\delta} \qquad i = 1, 2, \cdots n \qquad (3)$$

At this time, the total social output can be described as $Q = \sum_{i=1}^{n} q_i = \frac{n}{n+1}\frac{a\beta - d}{\beta\delta}$. Hence, the social welfare in the competition period can be illustrated as:

$$SW_c = \frac{n(a\beta - d)^2(n+2)}{2\beta\delta(n+1)^2} \qquad (4)$$

Considering the discount rate, the overall social welfare in period T can be obtained from formulas (2) and (4) as

$$SW_t = \frac{3(1-\eta^t)(a\beta-d)^2}{8(1-\eta)\delta\beta} + \frac{(1-\eta^{T-t})\eta^t(a\beta-d)^2 n(n+2)}{2(1-\eta)\delta\beta(n+1)^2} \quad (5)$$

Finally, the impacts of various factors on social welfare can be depicted as follows.

$\frac{\partial SW_t}{\partial \delta} = -\frac{3(1-\eta^t)(a\beta-d)^2}{8(1-\eta)\delta^2\beta} - \frac{(1-\eta^{T-t})\eta^t n(n+2)(a\beta-d)^2}{2(1-\eta)\delta^2\beta(n+1)^2} < 0$: the overall social welfare is positively correlated with market demand elasticity *(Figure 1)*.

$$\frac{\partial SW_t}{\partial \beta} = \frac{3(1-\eta^t)(a\beta-d)}{4(1-\eta)\delta\beta}\left(\frac{a\beta+d}{2\beta}\right) + \frac{(1-\eta^{T-t})\eta^t n(n+2)(a\beta-d)}{(1-\eta)\delta\beta(n+1)^2}\left(\frac{a\beta+d}{2\beta}\right) > 0$$

: the overall social welfare is positively correlated with government subsidy *(Figure 2)*.

$$\frac{\partial SW_t}{\partial \eta} = -\frac{(a\beta-d)^2\{[(t-1)\eta^t - t\eta^{t-1}](n+3)(n-1) + 4(n+2)n[(T\eta^{T-1} - (T-1)\eta^T] - 3(n+1)^2\}}{8(\eta-1)^2\beta\delta(n+1)^2} > 0$$

: the overall social welfare is negatively correlated with the discount rate *(Figure 3)*.

$\frac{\partial SW_t}{\partial t} = \frac{\eta^t \ln(\eta)(a\beta-d)^2(n+3)(n-1)}{8(1-\eta)\beta\delta(n+1)^2} < 0$: the overall social welfare is negatively correlated with the patent length *(Figure 4)*.

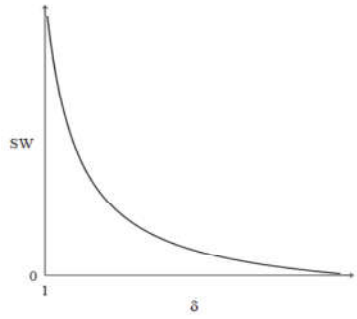

Figure 1: Relationship between δ and SW under monopoly pricing

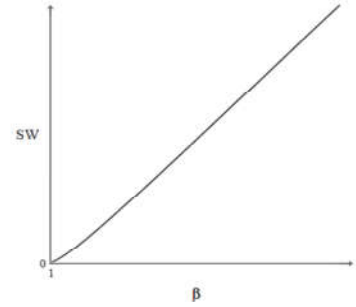

Figure 2: Relationship between β and SW under monopoly pricing

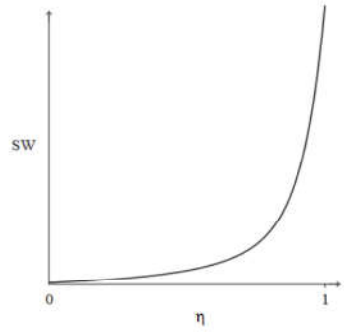

Figure 3: Relationship between η and SW under monopoly pricing

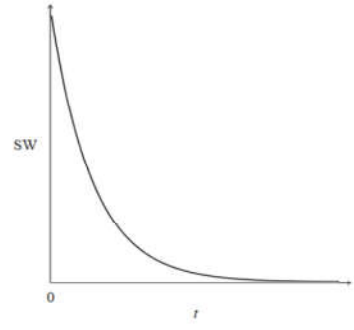

Figure 4: Relationship between t and SW under monopoly pricing

Proposition 1: During the patent length, if the enterprise implements monopoly pricing and the government subsidizes consumers, shortening patent length, reducing the discount rate, and increasing the market demand elasticity and government subsidy, will increase the social welfare.

It can be seen from Proposition 1 that, the government, pursuing the maximal social welfare, should minimize the patent length, enhance the medicine subsidy, and reduce consumer cost. The government should encourage more enterprises invest in R&D of alternative medicines to make the market demand less rigid. In

view of the externalities of the medicine, the government ought to adopt a low discount rate and implement social discount rate instead of single market interest rate.

The above analysis shows that the patent length should be minimized. Meanwhile, the enterprise enthusiasm must not be ignored to ensure the recovery of R&D investment expressed as $\frac{1-\eta^t}{1-\eta}(p^*-d)q^* \geq m$. Substituting this inequality into formulas (1) and (2), we can get

$$t \geq \frac{\ln(1-\frac{4m\beta\delta(1-\eta)}{(a\beta-d)^2})}{\ln(\eta)} \qquad (6)$$

Combined with Proposition 1, the optimal patent length can be determined as $t^* = \frac{\ln(1-\frac{4m\beta\delta(1-\eta)}{(a\beta-d)^2})}{\ln(\eta)}$.

Next, the author identified how influencing factors β, δ, d, and η affect the optimal length.

$\frac{\partial t^*}{\partial \beta} = \frac{4m\delta(1-\eta)(a\beta+d)}{\ln(\eta)(a\beta-d)((a\beta-d)^2-4m\beta\delta(1-\eta))} < 0$: the optimal patent length is negatively correlated with government subsidy (Figure 5).

$\frac{\partial t^*}{\partial \delta} = -\frac{4m\beta(1-\eta)}{\ln(\eta)((a\beta-d)^2-4m\beta\delta(1-\eta))} > 0$: the optimal patent length is negatively correlated with market demand elasticity (Figure 6).

$\frac{\partial t^*}{\partial d} = -\frac{8\beta\delta m(1-\eta)}{\ln(\eta)(a\beta-d)((a\beta-d)^2-4m\beta\delta(1-\eta))} > 0$: the optimal patent length is positively correlated with the marginal cost of the enterprise (Figure 7).

$$\frac{\partial t^*}{\partial \eta} = \frac{-((a\beta-d)^2-4m\beta\delta(1-\eta))\ln(1-\frac{4m\beta\delta(1-\eta)}{(a\beta-d)^2})+4m\beta\delta\ln(\eta)\eta}{\ln(\eta)^2\eta((a\beta-d)^2-4m\beta\delta(1-\eta))} < 0$$

: the optimal patent length is positively correlated with discount rate (Figure 8).

$\frac{\partial t^*}{\partial m} = -\frac{4\beta\delta(1-\eta)}{\ln(\eta)((a\beta-d)^2-4m\beta\delta(1-\eta))} > 0$: the optimal patent length is positively correlated with the R&D investment *(Figure 9)*.

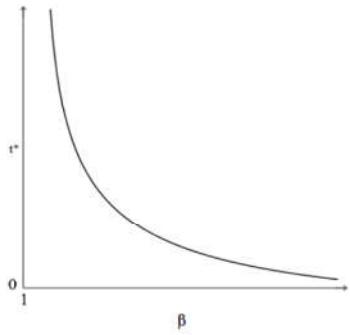

Figure 5: Relationship between β and t^* under monopoly pricing

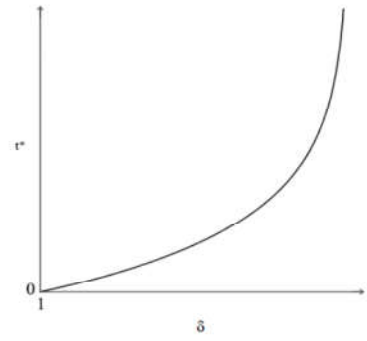

Figure 6: Relationship between δ and t^* under monopoly pricing

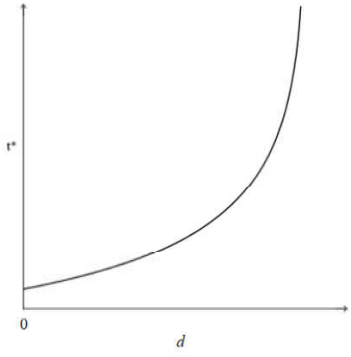

Figure 7: Relationship between d and t^* under monopoly pricing

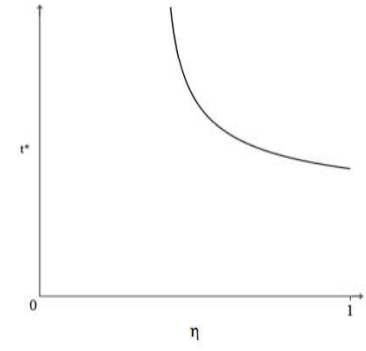

Figure 8: Relationship between η and t^* under monopoly pricing

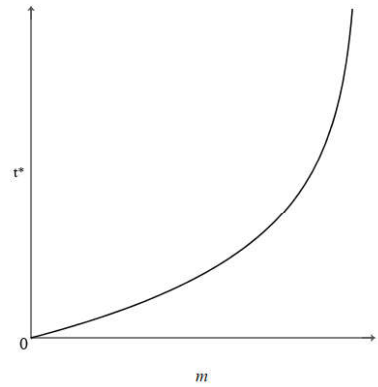

Figure 9: Relationship between m and t^* under monopoly pricing

Proposition 2: When the enterprise implements monopoly pricing, the optimal patent length of the medicine is affected by multiple factors. In this case, the patent length can be shortened by increasing government subsidy and market demand elasticity and reducing marginal cost, discount rate, and R&D investment.

According to the above proposition, the government should fully consider government subsidy, market demand elasticity, R&D investment, marginal cost and discount rate before setting out the policies on patent length for medicines.

Price regulation during the patent length

In addition to the null assumptions, it is assumed that the government regulates the price by not subsidizing consumers and taking the most efficient marginal cost pricing, i.e. $p = a - \delta q = d$. It is also assumed that the government subsidizes the enterprise at $L > 0$ per unit of output to ensure the enterprise to invest in R&D. The equilibrium output can be expressed as

$$q^* = \frac{a-d}{\delta} \tag{7}$$

At this time, the overall social welfare can be described as

$$SW_m = \frac{(a-d)(2L+a-d)}{2\delta} \tag{8}$$

Once the patent expires, the government will stop subsidizing the enterprise but consumers. Then, the market demand can be expressed as $p = \beta(a - \delta q)$. In this case, the equilibrium output of each enterprise under the Cournot competition can be calculated as

$$q_i^* = \frac{a\beta - d}{(n+1)\beta\delta} \qquad i = 1, 2, \cdots n \tag{9}$$

The total output of social equilibrium can be determined as $Q = \sum_{i=1}^{n} q_i = \frac{n}{n+1}\frac{a\beta - d}{\beta\delta}$, and the overall social welfare as $SW_c = \frac{n(a\beta - d)^2(n+2)}{2\beta\delta(n+1)^2}$. Next, the overall social welfare of the entire period T can be computed as

$$SW_t = \frac{(1-\eta^t)(a-d)(2L+a-d)}{2(1-\eta)\delta} + \frac{(1-\eta^{T-t})\eta^t n(a\beta - d)^2(n+2)}{2(1-\eta)\beta\delta(n+1)^2} \tag{10}$$

Through further analysis, the effects of the influencing factors on the overall social welfare during the T period can be obtained as

$$\frac{\partial SW_t}{\partial \delta} = -\frac{(1-\eta^t)(a-d)(2L+a-d)}{2(1-\eta)\delta^2} - \frac{n(n+2)(a\beta - d)^2(\eta^t - \eta^T)}{2\delta^2\beta(n+1)^2(1-\eta)} < 0;$$

$$\frac{\partial SW_t}{\partial \beta} = \frac{n(n+2)(\eta^t - \eta^T)(a^2\beta^2 - d^2)}{2\delta\beta^2(n+1)^2(1-\eta)} > 0;$$

$$\frac{\partial SW_t}{\partial \eta} = \frac{(a-d)(2L+a-d)}{2\eta\delta(\eta-1)}(t\eta^{t-1} - \frac{\eta^t - 1}{\eta - 1}) + \frac{n(a\beta - d)^2(n+2)}{2\beta\delta(n+1)^2(\eta-1)}(\frac{\eta^t - \eta^T}{\eta - 1} - (t\eta^{t-1} - T\eta^{T-1})) > 0$$

;

$$\frac{\partial SW_t}{\partial t} = [(a-d)(2L+a-d) - \frac{n(a\beta - d)^2(n+2)}{\beta(n+1)^2}]\frac{\eta^t \ln(\eta)}{2\delta(\eta-1)} < 0.$$

The relationships between these factors and overall social welfare are plotted as in Figures 10-13.

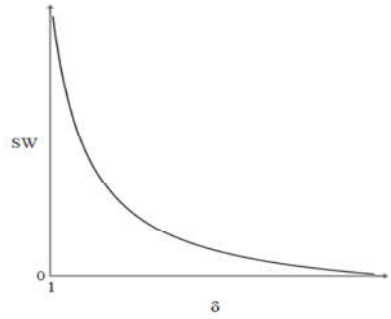

Figure 10: Relationship between δ and SW under government pricing

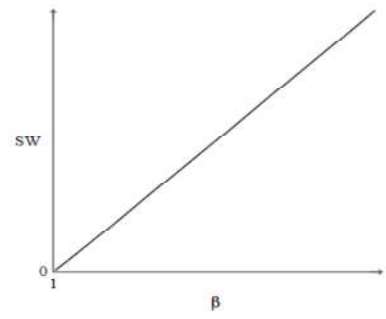

Figure 11: Relationship between β and SW under government pricing

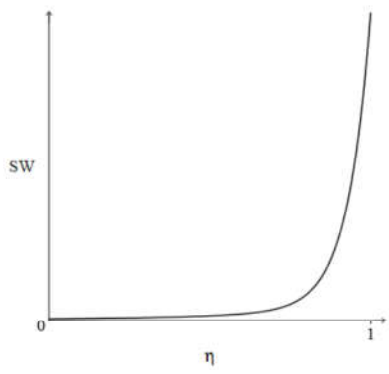

Figure 12: Relationship between η and SW under government pricing

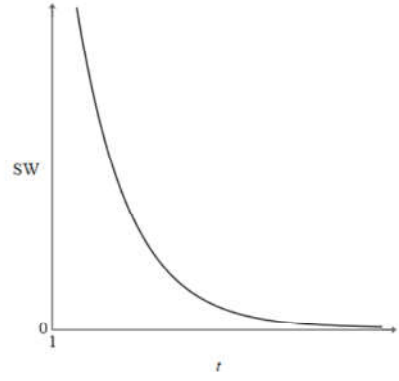

Figure 13: Relationship between t and SW under government pricing

Proposition 3: Under government pricing during the patent length, the overall social welfare is positively correlated with market demand elasticity, government subsidy, and negatively with the discount rate and patent length.

As the monopoly pricing changes to government pricing, the correlations of overall social welfare with market demand elasticity, government subsidy, discount rate and patent length remains the same, indicating that the social welfare can be

enhanced by increasing market demand elasticity and government subsidy and lowering the discount rate and patent length.

To recover the R&D investment in the patent length, the enterprise must satisfy the condition as $\frac{1-\eta^t}{1-\eta}\frac{a-d}{\delta}L \geq m$. Thus, we can deduce that $t \geq \frac{\ln(1-\frac{m\delta(1-\eta)}{(a-d)L})}{\ln(\eta)}$. Then, the optimal patent length $t^* = T$ can be obtained from Proposition 3.

Proposition 4: If monopoly pricing is adopted through the patent length, the optimal patent length must be , that is, all patent protection is implemented within the lifecycle of the medicine.

Comparison between the two pricing modes

This subsection compares the monopoly pricing mode with the government pricing mode, especially the social welfare under the two modes. Let

$SW_1 = \frac{3(1-\eta^t)(a\beta-d)^2}{8(1-\eta)\delta\beta} + \frac{(1-\eta^{T-t})\eta^t n(a\beta-d)^2(n+2)}{2(1-\eta)\delta\beta(n+1)^2}$ and

$SW_2 = \frac{(1-\eta^t)(a-d)(2L+a-d)}{2(1-\eta)\delta} + \frac{(1-\eta^{T-t})\eta^t n(a\beta-d)^2(n+2)}{2(1-\eta)\beta\delta(n+1)^2}$ be the

social welfare under monopoly pricing and government pricing, respectively. Then, the social welfare difference between the two pricing modes can be obtained as

$$SW_1 - SW_2 = \frac{3(1-\eta^t)(a\beta-d)^2}{8(1-\eta)\delta\beta} - \frac{(1-\eta^t)(a-d)(2L+a-d)}{2(1-\eta)\delta} \qquad (11)$$

If $L > L^* = \frac{3a^2\beta^2 - 6a\beta d - 4a^2 + 8ad - d^2}{8(a-d)}$, we can get $SW_1 < SW_2$. This means, if the government subsidy to the enterprise surpasses a threshold, the government should promote social welfare by regulating the price and subsidizing the enterprise.

If $L < L^* = \frac{3a^2\beta^2 - 6a\beta d - 4a^2 + 8ad - d^2}{8(a-d)}$, then $SW_1 > SW_2$. This means, if the government subsidy to the enterprise stays below the threshold, the government should not change monopoly pricing but subsidize consumers.

If $L = L^* = \frac{3a^2\beta^2 - 6a\beta d - 4a^2 + 8ad - d^2}{8(a-d)}$, then the government subsidy to the enterprise stands on the threshold. In this case, both pricing modes can be adopted *(Figure 14)*.

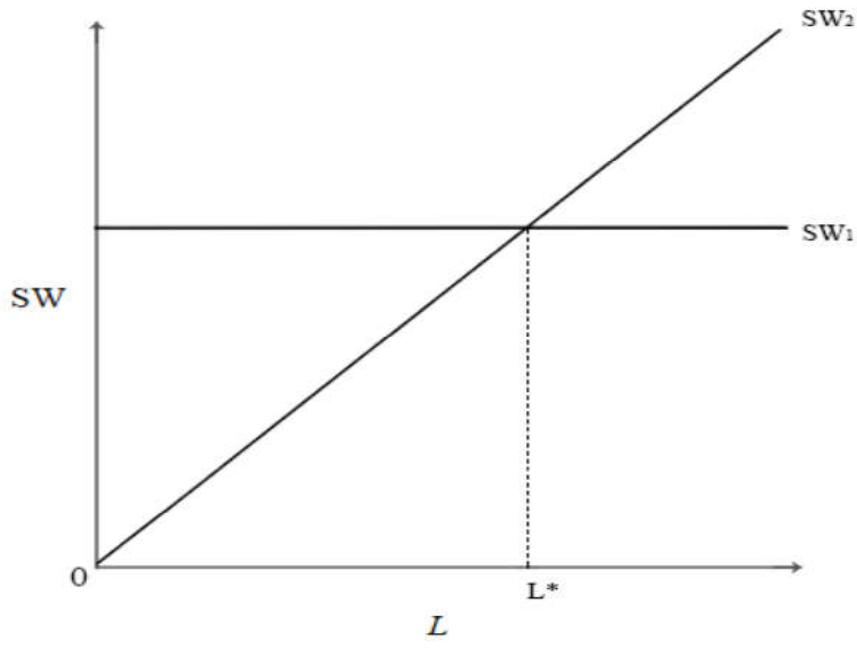

Figure 14: Relationships between L, SW_1 and SW_2 under government pricing

Proposition 5: The pricing mode greatly affects the social welfare. Monopoly pricing is better if $L < L^* = \frac{3a^2\beta^2 - 6a\beta d - 4a^2 + 8ad - d^2}{8(a-d)}$, government pricing is better if $L > L^* = \frac{3a^2\beta^2 - 6a\beta d - 4a^2 + 8ad - d^2}{8(a-d)}$, and both pricing modes are acceptable if $L = L^* = \frac{3a^2\beta^2 - 6a\beta d - 4a^2 + 8ad - d^2}{8(a-d)}$.

As a result, the government should fully consider various factors before regulating the price. Government pricing does not always bring more social welfare. The effect of this pricing mode depends on the patent length, market demand elasticity, as well as the direction and level of government subsidy.

Conclusions

In pursuit of the maximal social welfare, this paper analyzes the optimal patent length for medicine under monopoly pricing and government pricing. Through comparative analysis, the following conclusions are put forward:

First, the optimization of medicine patent length is a complex decision-making process. The optimal patent length is affected by various factors, including pricing mode, government subsidy, market demand elasticity, R&D investment, marginal cost, product lifecycle and discount rate.

Second, under monopoly pricing, if the government subsidizes the price, then the social welfare is negatively correlated with the discount rate and patent length, and positively correlated with market demand elasticity and government subsidy. The optimal patent length for medicine is negatively correlated with government subsidy and market demand elasticity, and positively correlated with marginal cost, R&D investment and discount rate.

Third, under government pricing, the overall social welfare increases with market demand elasticity, government subsidy, but decreases with the growth in discount rate and patent length. In this case, the medicine patent should be protected through the lifecycle of the product.

Fourth, the pricing mode greatly affects the social welfare. Monopoly pricing is better if the government subsidy to the enterprise is lower than the threshold ($L^* = \frac{3a^2\beta^2 - 6a\beta d - 4a^2 + 8ad - d^2}{8(a-d)}$), government pricing is better if the subsidy is above the threshold, and both pricing modes are acceptable if the subsidy equals the threshold.

According to the above conclusions, the medicine patent length should be determined according to local conditions and the features of the medicine (e.g. market demand elasticity, R&D investment, marginal cost), and aided with tools like government subsidy and price regulation. Moreover, the government should categorize the prices of different medicines, facilitating the selection of suitable pricing mode for each type of medicine, and follow market rules in the pricing of medicines, except for some foreign and public welfare medicines. For foreign medicines, especially targeted drug, the government must negotiate a favorable price for domestic consumers, develop a competitive medicine market, and roll out policies to encourage enterprise R&D activities.

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