Political Economy of Patent Protection and Economic Growth*

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Contents

Ⅰ Introduction

Intellectual property right (hereafter IPR) protection has been an important policy issue. For the last two decades, many developed countries such as the United States

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and Japan have strengthened IPRs. Additionally, since the Agreements on Trade-Related Aspects of Intellectual Property Rights (TRIPs) has been approved as part of the Final Act of the Uruguay Round, many developing countries also have strengthened their IPR protection. In developed countries, strong IPR policies enhance the returns to research and development and increase productivity and long-run growth rate. In developing countries, strong IPR policies attract foreign investment and technology, promoting economic growth.

The above discussion implies that firms that engage in research activity desire strong IPR protection. According to the Centre for Responsive Politics (2012), the amount of money spent on lobbying in the United States has been increasing from 2000, and reached $ 3.54 billion in 2010. In particular, the health-related industry, which includes pharmaceutical and medical companies, spends more than $ 524 million per year on lobbying activities[1]. Since we know that these industries strongly depend on domestic IPR policies, it is natural that IPR policies are affected by political activities such as lobbying or political donations.

Many researchers discuss how IPR policies affect development and economic growth. In terms of theoretical studies, Judd (1985) examined how patent length affects the market equilibrium path by using an exogenous growth model. However, a number of papers have investigated the relationship between IPR policies and economic growth after the development of endogenous growth theory by Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). In particular, Goh and Olivier (2002), Iwaisako and Futagami (2003), Kwan and Lai (2003), and O'Donoghue and Zweimüller (2004) examined the domestic effects of IPR policies on economic growth using an endogenous growth framework. In general, these studies found that strengthening IPR policies increases productivity and the long-run growth rate[2]. In terms of empirical studies, Gould and Gruben (1996) examined the relationship between IPR protection and per capita GDP growth for 95 countries in the period 1960-1998 by using an index of IPR protection constructed by Rapp and Rozek (1990). Gould and Gruben (1996) find that IPR policies affect economic growth significantly and this effect is relatively stronger in open economies.

Further, many researchers also have studied the determinants of IPR policies. In particular, Nordhaus (1969) and Scherer (1972) started a study of optimal patent duration. Klemperer (1990) and Gilbert and Shapiro (1990) examined optimal patent breadth. In general, strengthening IPR policies has two effects on the welfare. First of all, by strengthening IPR protection, the government can provide greater incentives for innovation, and this will lead to consumers enjoying better products. This is a marginal benefit of strengthening IPR protection. However, marginal cost of strengthening IPR protection is making consumers suffer from monopoly prices and dead-weight losses. The optimal patent policy balances the marginal benefits with marginal costs.

In a theoretical study, Iwaisako and Futagami (2003) used a variety-expansion growth model based on Romer (1990) to show that the optimal patent length that maximizes social welfare is finite. Lai and Qiu (2003) and Grossman and Lai (2004) also developed the North-South trade model to analyze international effects of IPR protection, and showed that the governments of developed countries chooses stronger IPR protection than those of developing countries. However, these studies assumed that the government is non-corrupt and maximizes household utility. Recently, Eicher and García-Penalõsa (2008) showed how private incentives to protect IPR affect economic growth. In particular, they have assumed that the private firms themselves protect their IPR and show that multiple equilibria can emerge.

In this paper, we construct an endogenous growth model that only incorporates

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1) The financial sector and communications/electronics sector also spend a lot of money on lobbying activities. For details, see the Centre for Responsive Politics (2012).

2) Some studies point out the possibility that strengthening IPR protection discourages economic growth. For example, Goh and Olivier (2002) developed a growth model with an upstream sector that produces differentiated inputs and a downstream sector that produces differentiated final goods. They showed that tightening IPR in the downstream sector weakens the incentive to innovate and decreases the rate of economic growth through the market size effect.

innovation as a source of economic growth. Using this model, we consider how political donations from firms to the government affect its IPR policy, innovation, and welfare. Our model is similar to that of Eicher and García-Penalõsa (2008) in that the firms make efforts to protect IPR. However, we assume that the government decides its IPR protection taking into account household utility and the amount of political donation. This assumption is different from that in other literature. In general, political donation is regarded as a rent-seeking activity. Many researchers have investigated the relationship between rent-seeking activities and economic development. One view in the literature is that rent-seeking activities lower the growth rate, because they distort the allocation of resources and weaken capital accumulation and research activity[3]. On the other hand, political donation aimed at strengthening IPR protection may enhance the incentives for research activity and promote economic growth. In this paper, we consider political efforts by firms and the importance of political donations in policy-making process.

This paper is organized as follows. In Section 2, we construct the base model without political donations. In this setting, we assume that the government chooses its IPR protection to maximize household utility. We show that welfare-maximizing IPR protection is weaker than growth-maximizing protection. In Section 3, we introduce political donations into the base model. In particular, we assume that the government pays attention not only to household's welfare but also to the amount of money offered by the firms. In this setting, we show that the amount of political donations distorts optimal patent policy. In Section 4, we provide concluding remarks.

3) For example, based on an empirical analysis, Mauro (1995) finds that rent-seeking activities have a negative effect on economic growth. Murphy, Shleifer, and Vishny (1991) argue that rent-seeking activities rewards talent more than entrepreneurship does. This implies that rent-seeking activities discourage economic development.

II A Simple Model of Innovation and IPR

1. Households

We consider a closed economy with a fixed number of identical households. We normalize the total number of households to unity. We assume that each household is endowed with L units of labor and supplies its labor inelastically. Households consume two kinds of goods, homogenous goods and a continuum of differentiated goods. The representative household maximizes lifetime utility over an infinite horizon. The lifetime utility U^h is given by:

$$U^h = \int_0^\infty e^{-\rho\tau}[\beta \log D(\tau) + (1-\beta)\log Y(\tau)]d\tau, \tag{1}$$

where ρ is a discount rate. $D(t)$ is a consumption index of differentiated goods at time t and $Y(t)$ is consumption of homogenous goods. $\beta \in (0, 1)$ is a parameter which determines the proportion expenditure on different goods. Many kinds of differentiated goods exist in this economy and $n(t)$ denotes a measure of differentiated products invented before time t. Each differentiated good is indexed by some real number $j \in [0, n(t)]$. $D(t)$ is represented by a Dixit and Stiglitz-type function:

$$D(t) = \left[\int_0^{n(t)} x(j,t)^\alpha dj\right]^{\frac{1}{\alpha}}, \tag{2}$$

where and $x(j, t)$ is consumption of the j^{th} variety of differentiated product at time t and $\alpha \in (0, 1)$ is a parameter which determines the price elasticity of demand.

Under these assumptions, the households' optimization problem can be broken down into two stages. In the first stage, the household chooses the optimal time path of expenditure in order to maximize (1) subject to the following lifetime budget constraint:

$$\int_0^\infty e^{-\int_0^\tau r(s)ds} E(\tau)d\tau = \int_0^\infty e^{-\int_0^\tau r(s)ds}[w(\tau)L - T(\tau)]d\tau + W(0), \tag{3}$$

where $E(t)$ is instantaneous expenditure, $r(t)$ is the interest rate, $w(t)$ is the wage,

$T(t)$ is lump-sum tax, and $W(0)$ is the initial asset holding. In the second stage, the household determines how to allocate a given expenditure across differentiated goods and homogenous goods. By solving the second optimization problem, the demand functions of differentiated goods and homogenous good are given by:

$$x(j,t) = \frac{\beta E(t)}{\int_0^{n(t)} p(j',t)^{-\frac{\alpha}{1-\alpha}} dj'} p(j,t)^{-\frac{1}{1-\alpha}}, \tag{4}$$

$$Y(t) = (1-\beta)E(t). \tag{5}$$

Next, we return to the first stage of households' optimization. To derive the time path of expenditure, we define the ideal price index of $D(t)$ as

$$P_D(t) = \left[\int_0^{n(t)} p(z,t)^{-\frac{\alpha}{1-\alpha}} dz\right]^{-\frac{1-\alpha}{\alpha}}. \tag{6}$$

Using this price index, we rewrite the flow of utility as $\log \beta^{\beta}(1-\beta)^{(1-\beta)} + \log E(t) - \beta \log P_D(t)$. Therefore, the solution of the above dynamic optimization problem is given by the following Euler equation:

$$\frac{\dot{E}(t)}{E(t)} = r(t) - \rho. \tag{7}$$

2. IPR Policy

In the literatures, there have been some ways to formulate intellectual property right in an economic model. For example, various features of intellectual property and patent legislation (namely, *patent duration, patent breadth, exogenous rate of imitation and cost of imitation*) are considered and analyzed. In this paper, we assume that the government chooses an effort of its enforcement policy, which is given by $\omega \in [0, 1]$. Precisely speaking, ω represents the probability that an invented good is protected from competition by the enforcement of a patent. Once a patent is enforced by the government, the patent holder can enjoy the exclusive right to produce and sell the good. For simplicity, we assume that the lifetime of a patent is infinite if the government decides to enforce a patent. Therefore, differentiated products protected by patents exist in the fraction of ω and those not protected in the fraction of $1-\omega$.

To enforce ω, the government must employ labor. A lump-sum tax collected from households is used to employ the labor forces. In particular, we assume $\gamma\omega^{\theta}$ units of labor are employed by the government in order to enforce ω. This represents social cost of patent enforcement. Moreover we assume $\theta > 1$, which implies that the marginal social cost of patent enforcement is increasing.

3. Producers

Labor is the only factor of production. We assume that one unit of labor is required to produce both differentiated and homogenous goods. The homogenous good is always produced in competitive markets. Since a homogenous good is the numeraire, a price of a homogenous good is equal to the unit costs of producing it. This implies that $w(t) = 1$, where $w(t)$ is the wage rate.

Firms in the differentiated goods sector produce their goods based on designs created by R&D activity. Prices of products protected by patents are given as $p_m = 1/\alpha$, from the demand (4), because the patent holders have the exclusive rights to produce and sell those goods. $x_m(t)$ denotes the demand for differentiated good which are protected by patents and $\pi(t)$ denotes patent profits. Therefore, the profit is given as

$$\pi(t) = \left(\frac{1-\alpha}{\alpha}\right) x_m(t). \tag{8}$$

On the other hand, a technology for producing a product is immediately imitated if a patent is not enforced for the product. Thus, the price of unpatented differentiated goods is $p_c = 1$, because such goods are produced in a competitive market. $x_c(t)$ denotes demand for an unpatented products. Obviously, unpatented products do not provide profits to producers.

4. R&D Sector

In this paper, new designs of differentiated goods are invented by research and development. We let $v(t)$ denote the value of a new design of differentiated good. This is equivalent to the sum of the discounted present value of the expected profits from time t. Therefore, we have

$$v(t) = \int_t^{\infty} \pi(s) e^{-\int_t^s r(s')ds'} ds. \tag{9}$$

By differentiating $v(t)$ with respect to t, we derive the no-arbitrage condition as

$$\dot{v}(t) + \pi(t) = r(t)v(t). \tag{10}$$

Next, we consider the technology of product development. If a firm engaging in R&D activity employs $L_n(t)$ units of labor, it can produce $\dot{n}(t)$ units of new designs of differentiated goods, according to the following knowledge creation function:

$$\dot{n}(t) = \frac{n(t)}{a} L_n(t). \tag{11}$$

where a represents a parameter which determines the productivity of product development. We assume that firms can enter into R&D activity freely. Firms finance the costs of product development by issuing equities. Once a firm succeeds in developing a new design of a differentiated product, this design creates a value of $v(t)$ when it is protected by a patent. Since ω is the probability that an invented good is protected by the enforcement of a patent, the expected value of a new design is given by $\omega v(t)$. However, $a/n(t)$ units of labor are required to invent a new blueprint. Since the free-entry condition requires that the value of patent must not exceed the cost of producing it, we obtain

$$\omega v(t) \leq \frac{w(t)a}{n(t)} = \frac{a}{n(t)}, \quad \text{with equality whenever } \dot{n}(t) > 0. \tag{12}$$

5. National Income

The final equilibrium condition equates savings with investment. The total income of this economy consists of wage from the labor supply and dividends from equities. As mentioned before, the measure of products protected by patents is $\omega n(t)$. The aggregate income is given as $w(t)L + \omega n(t)\pi(t)$. In this paper we assume that the government collects taxes from households in order to enforce its patent policy. Therefore, disposable income is $w(t)L + \omega n(t)\pi(t) - w(t)\gamma\omega^{\theta}$. Saving is given by the difference between disposable income and aggregate expenditure, $E(t)$. Moreover, saving finances research investment through the financial market. Thus, we derive the equilibrium condition as follows:

$$w(t)L + \omega n(t)\pi(t) = E(t) + \frac{w(t)a\dot{n}(t)}{n(t)} + w(t)\gamma\omega^{\theta}. \tag{13}$$

6. The Equilibrium Path

In this section we derive the equilibrium path of the economy. Dividing the both sides of (10) by $v(t)$ gives

$$\frac{\pi(t)}{v(t)} + \frac{\dot{v}(t)}{v(t)} = r(t). \tag{14}$$

Next, we consider the demands of differentiated goods. Using $p_c = 1$ and $p_m = 1/\alpha$, the demand function of differentiated goods protected by patents is

$$x_m(t) = \frac{\alpha\beta E(t)}{[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]n(t)}. \tag{15}$$

Similarly, the demand function of unpatented differentiated goods is

$$x_c(t) = \frac{\alpha^{-\frac{\alpha}{1-\alpha}}\beta E(t)}{[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]n(t)}. \tag{16}$$

By substituting (15) into (8), the profit $\pi(t)$ is expressed as follows:

$$\pi(t) = \frac{(1-\alpha)\beta E(t)}{[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]n(t)}. \tag{17}$$

Using this expression, we can rewrite the no-arbitrage condition into (14) as follows:

$$\frac{(1-\alpha)\beta E(t)}{[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]n(t)v(t)} + \frac{\dot{v}(t)}{v(t)} = r(t). \tag{18}$$

Here we define $z(t) \equiv E(t)/(n(t)v(t))$. By using (7) and (18), the change in $z(t)$ is expressed by the following differential equation:

$$\frac{\dot{z}(t)}{z(t)} = \frac{(1-\alpha)\beta z(t)}{[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]} - \frac{\dot{n}(t)}{n(t)} - \rho. \tag{19}$$

On the other hand, dividing (13) by $n(t)v(t)$ and using $w(t) = 1$ and (12) yields

$$\frac{\dot{n}(t)}{n(t)} = \frac{L - \gamma\omega^{\theta}}{a} + \frac{(1-\alpha)\beta z(t)}{[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]} - \frac{1}{\omega}z(t). \tag{20}$$

Substituting (20) into (19), we have

$$\frac{\dot{z}(t)}{z(t)} = \frac{1}{\omega}z(t) - \frac{L - \gamma\omega^{\theta}}{a} - \rho. \tag{21}$$

The steady state of the economy is determined so that $\dot{z} = 0$. We let z^* denote the value of $z(t)$ in the steady state. Therefore, we can derive z^* as follows:

$$z^* = \frac{\omega(L - \gamma\omega^{\theta} + a\rho)}{a}. \tag{22}$$

The phase diagram of this model is shown in **Fig.1**. We can easily see that the unique steady state, z^*, is unstable because $1/\omega$ is positive. Since we can interpret $z(t)$ as the inverse of total assets measured by utility, $z(t)$ is a variable that can jump. Therefore, $z(t)$ jumps to the steady state value z^* in this economy. This implies that our model has no transitional dynamics and the equilibrium path jumps to the steady state instantaneously[4].

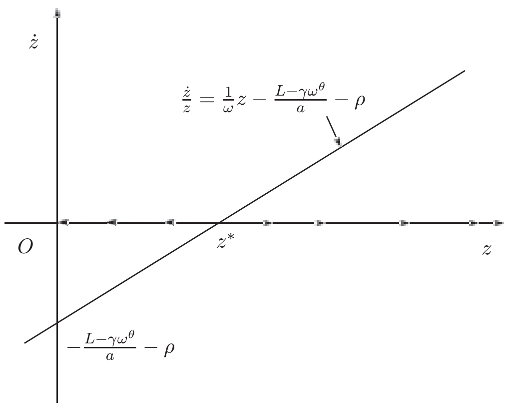

Fig.1. The phase diagram

Next, we derive the growth rate of *n(t)* in the steady state, *g*. Substituting (12) into the expression of *z** given by (22), we derive *E(t)* in the steady state. Since we can show that the expenditure *E(t)* is constant and depends on ω, the steady-state value of expenditure is expressed as follows:

$$E(\omega) = L - \gamma\omega^{\theta} + a\rho. \tag{23}$$

Obviously, the expenditure $E(\omega)$ is a decreasing function of ω. If the government would like to strengthen patent protection, it has to collect more tax. This tax collection reduces household' disposable income and expenditure.

Substituting (22) into (20) yields the growth rate of *n(t)* in the steady state as follows:

$$g = \frac{(1-\alpha)\omega\beta(L - \gamma\omega^{\theta} + a\rho)}{[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]a} - \rho. \tag{24}$$

We call *g* the rate of innovation in the steady state. We are now ready to analyze how the strength of IPRs protection affects innovation and welfare. Since the rate of innovation *g* is a function of the effort of patent enforcement ω, we can express $g = g(\omega)$. Differentiating *g* with respect to ω yields

$$\frac{dg(\omega)}{d\omega} = \frac{\beta(1-\alpha)}{a}\frac{\alpha^{-\frac{\alpha}{1-\alpha}}(L - \gamma\omega^{\theta} + a\rho) - \theta\gamma\omega^{\theta}[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]}{[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]^2}. \tag{25}$$

Let ω^g denote the patent protection that maximizes the rate of innovation. From (25), ω^g must satisfy the following relationship.

$$\alpha^{-\frac{\alpha}{1-\alpha}}(L - \gamma\omega^{\theta} + a\rho) = \theta\gamma\omega^{\theta}[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]. \tag{26}$$

Fig. 2 shows the relationship between the rate of innovation and patent protection. From **Fig. 2**(a), we find that there is an unique interior solution of ω^g when the cost of enforcing the patent policy (γ and θ) is sufficiently large. Moreover, we easily find that the growth-maximizing level of patent protection is larger when the

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4) In other words, the equilibrium path which is not in the steady state cannot satisfy rational expectations. For details, see Grossman and Helpman (1991).

economy has a larger population (L), higher productivity of research activity and manufacturing (a) and lower cost of patent protection (γ)[5].

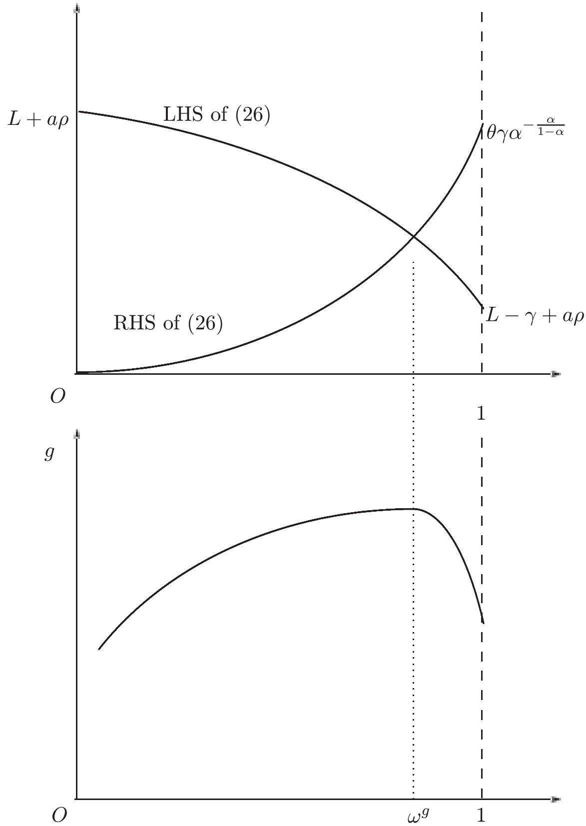

Fig. 2. The growth-maximizing patent protection

5) On the other hand, the rate of innovation becomes zero when the level of patent protection is too weak. We can derive an infimum in which the rate of innovation is positive from (24). Here, we focus on the case where the rate of innovation is positive because we are interested in an equilibrium path where research and development is conducted.

7. Government without Political Donation

We now analyze the government policy of patent protection. Here we consider the case where the government is non-corrupt and maximizes household utility U^h. In other words, the government's objective function W is given by

$$W = U^h. \tag{27}$$

For simplicity, we assume that the government sets ω at time 0 and does not change this patent policy after time 0.

Next, we derive the household utility as a function of the patent policy. Combining $D(t) = \beta E(\omega)/P_D(t)$, (6), $p_c = 1$, and $p_m = 1/\alpha$ yields

$$D(t) = \alpha\beta E(\omega) n(t)^{\frac{1-\alpha}{\alpha}} [\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]^{\frac{1-\alpha}{\alpha}}. \tag{28}$$

Substituting (28) and $Y(t) = (1-\beta)E(\omega)$ into $\beta \log D(t) + (1-\beta)Y(t)$ yields

$$\beta^\beta(1-\beta)^{(1-\beta)} + \beta\left(\frac{1-\alpha}{\alpha}\right)\log n(t) + \log E(t) + \beta\left(\frac{1-\alpha}{\alpha}\right)\log[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]. \tag{29}$$

By integrating (29) from 0 to ∞ with $n(t) = n(0)e^{g(\omega)t}$, we can derive U^h as follows:

$$U^h(\omega) = \frac{\beta}{\rho}\left(\frac{1}{\alpha} - 1\right)\left\{\frac{g(\omega)}{\rho} + \log[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]\right\} + \frac{1}{\rho}\log E(\omega) + \Lambda_0. \tag{30}$$

where Λ_0 is constant and independent from ω.

Let ω^b denote the level of patent protection that maximizes the welfare represented by (30). We find the condition that ω^b must satisfy by solving $dW(\omega)/d\omega = 0$ as follows:

$$\begin{aligned}\alpha^{-\frac{\alpha}{1-\alpha}}(L - \gamma\omega^\theta + a\rho) &= \theta\gamma\omega^\theta[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}] \\ &+ \frac{\rho a}{\beta(1-\alpha)}(\alpha^{-\frac{\alpha}{1-\alpha}} - 1)[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}] \\ &+ \frac{\rho^2 a\alpha}{\beta^2(1-\alpha)^2}\frac{\theta\gamma\omega^{\theta-1}[\omega + (1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]^2}{L - \gamma\omega^\theta + a\rho}.\end{aligned} \tag{31}$$

The second term of (31) shows that dead weight loss increases with the patent protection. The third term implies that the expenditure is a decreasing function of ω because more resources are needed to strengthen the patent protection. Obviously, the second and third terms of (31) are positive. Therefore, we can state the following proposition.

proposition 1 *The welfare-maximizing patent protection is weaker than the growth maximizing patent protection*.

Fig. 3 shows the relationship between IPR protection and welfare. When the economy is larger (larger L), the cost of enforcing patent protection is smaller (smaller γ), and the consumer has a greater preference for differentiated goods (larger β), the welfare-maximizing level of patent protection is higher.

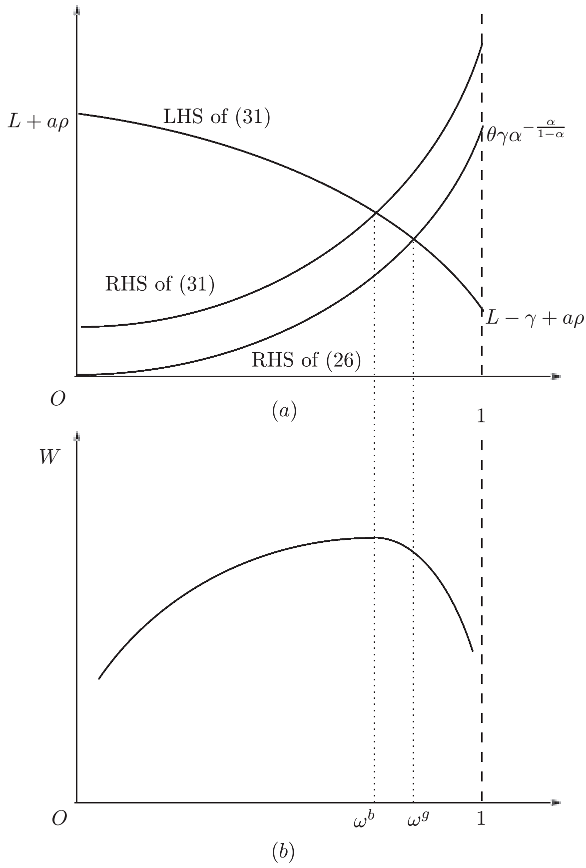

Fig. 3. The welfare-maximizing patent protection

Ⅲ The Effects of Political Donation

1. Introducing Political Donation

Next, we consider the possibility of lobbying and political donations. We assume that firms which produce differentiated goods protected by patents engage in lobbying activities in order to strengthen their monopolistic power. In particular, firms offer a fraction of their profits to the government as lobbying activities. When the government is corrupt and willing to receive money, lobbying activities may distort IPR policy.

In this paper, each firm which produces differentiated goods protected by patents gains a constant fraction of profit, ϕ. Therefore, the firm offers a fraction $(1-\phi)$ of profit to the government. In this case, the market value of a new design of a differentiated good, (9), is modified as

$$v(t) = \int_t^{\infty} \phi\pi(s)e^{-\int_t^s r(s')ds'} ds. \tag{32}$$

From (32), it turns out that the value of new design is smaller as compared with the case where there is no political donation. By differentiating $v(t)$ with respect to t, we derive the no-arbitrage condition as

$$\dot{v}(t) + \phi\pi(t) = r(t)v(t). \tag{33}$$

Next, the equilibrium condition of national income, (13) must be changed. In this section, we have assumed that a constant fraction of profits is sent to the government. Therefore, households receive $\omega\phi n(t)\pi(t)$ as a dividend and (13) is modified as follows:

$$w(t)L + \omega\phi n(t)\pi(t) = E(t) + \frac{w(t)a\dot{n}(t)}{n(t)} + w(t)\gamma\omega^{\theta}. \tag{34}$$

Next, we analyze the equilibrium path of the economy. Since we can derive the equilibrium path in the same way as in Section 2, we omit the derivation of the equilibrium path. As in Section 2, this economy has no transitional dynamics, and jumps to the steady state. We can show that the expenditure $E(\omega)$ is same as (23).

On the other hand, the rate of innovation in the steady state is given by

$$g = \frac{\phi(1-\alpha)\omega\beta(L-\gamma\omega^{\theta}+a\rho)}{[\omega+(1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]a} - \rho. \tag{35}$$

Since the rate of innovation g is a function of the effort of patent enforcement ω and ϕ, we can express $g = g(\omega, \phi)$. Differentiating g with respect to ω yields

$$\frac{\partial g(\omega,\phi)}{\partial \omega} = \frac{\phi\beta(1-\alpha)}{a}\frac{\alpha^{-\frac{\alpha}{1-\alpha}}(L-\gamma\omega^{\theta}+a\rho)-\theta\gamma\omega^{\theta}[\omega+(1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]}{[\omega+(1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]^2}. \tag{36}$$

Similarly, differentiating g with respect to ω yields

$$\frac{\partial g(\omega,\phi)}{\partial \phi} = \frac{(1-\alpha)\omega\beta(L-\gamma\omega^{\theta}+a\rho)}{[\omega+(1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]a}. \tag{37}$$

(36) implies that the growth-maximizing patent protection ω^g is the same as the case without lobbying. In other words, ϕ does not affect the growth-maximizing patent protection. On the other hand, (37) is positive. When the fraction of political donation of profits is smaller, the incentive to engage in research activity becomes higher. This effect stimulates innovation in the economy.

2. Government with Political Donation

Next, we examine how the government chooses its patent policy when political donation exists. The government decides patent protection considering not only household utility but also the gains from political donations. In this section, the utility function of the government is given as the average of household utility and the sum of the discounted value of political donations.

$$W = \zeta U^h + (1-\zeta)U^g. \tag{38}$$

where ζ is a parameter which determines the extent of government corruption. When ζ is small, the government values the amount of political donation. We define U^g as follows:

$$U^g = \int_0^{\infty} e^{-\int_0^{\tau} r(s)ds}(1-\phi)\omega n(\tau)\pi(\tau)d\tau. \tag{39}$$

By using (35), the total amount of political donation is expressed as follows:

$$
\begin{aligned}
(1-\phi)\omega n(t)v(t) &= \frac{(1-\phi)\omega(1-\alpha)\beta E(\omega)}{[\omega+(1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]} \\
&= \frac{1-\phi}{\phi}a(g+\rho).
\end{aligned}
\tag{40}
$$

Substituting (40) into (39) and using $r(t) = \rho$ on the equilibrium path reveals that U^g is simplified as

$$
U^g = \frac{1-\phi}{\rho\phi}a(g+\rho). \tag{41}
$$

(30) and (40) imply that (38) is represented as a function of ω. Let ω^d denote the level of patent protection that maximizes the welfare represented by (38). We find the condition that ω^d must satisfy by solving $dW(\omega)/d\omega = 0$ as follows:

$$
\begin{aligned}
\alpha^{-\frac{\alpha}{1-\alpha}}(L-\gamma\omega^\theta+a\rho) &= \theta\gamma\omega^\theta[\omega+(1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}] \\
&+\rho a\Gamma(\zeta,\phi)(\alpha^{-\frac{\alpha}{1-\alpha}}-1)[\omega+(1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}] \\
&+\frac{\rho a\alpha\Gamma(\zeta,\phi)}{\beta(1-\alpha)}\frac{\theta\gamma\omega^{\theta-1}[\omega+(1-\omega)\alpha^{-\frac{\alpha}{1-\alpha}}]^2}{L-\gamma\omega^\theta+a\rho}.
\end{aligned}
\tag{42}
$$

where $\Gamma(\zeta, \phi)$ is defined as

$$
\Gamma(\zeta,\phi) = \frac{\zeta}{\beta(1-\alpha)\zeta\phi+\rho a(1-\zeta)(1-\phi)}. \tag{43}
$$

Using (42) and (43), we can examine how political donation affects patent policy. First, we focus on the effect of ζ. ζ is a parameter that determines the preference of government. A larger ζ implies that the government gives much attention to household utility. Differentiating (43) with respect to ζ yields

$$
\frac{\partial\Gamma(\zeta,\phi)}{\partial\zeta} = \frac{\rho a(1-\phi)}{[\beta(1-\alpha)\zeta\phi+\rho a(1-\zeta)(1-\phi)]^2}. \tag{44}
$$

(44) is positive. This shows that when ζ is large, the second and third terms of (42) becomes large and ω^d become smaller (See **Fig.4**). This implies that if the government is not corrupt and pays much attention to household utility, it chooses weaker patent protection. On the other hand, a corrupt government chooses higher patent protection. In particular, we can show that for any ϕ, $\Gamma(0, \phi) = 0$. This implies that the second and third terms of (42) vanish and (42) corresponds to (26). Intuitively, when the government is corrupt and pays much attention to political

donations, it tends to have too much incentive to strengthen patent protection in order to receive a lot of money from firms. Therefore, we obtain the following proposition.

proposition 2 *If the government is corrupt and pays much attention to political donations, the government strengthens patent protection and increases innovation.*

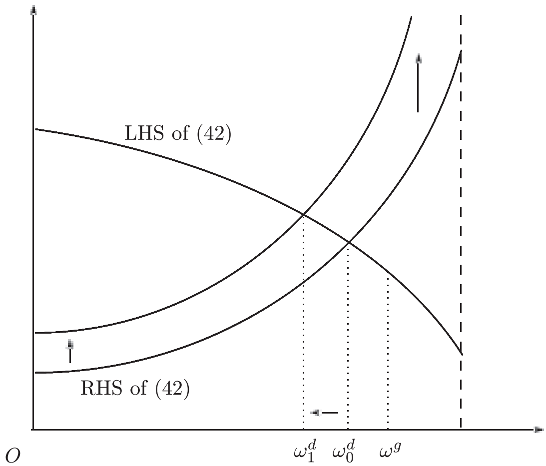

Fig. 4. An increase in ζ

Next, we examine the effect of ϕ. The parameter ϕ represents the fraction of profits that is paid as political donations. A larger ϕ implies that firms make efforts to offer a lot of money to the government. Differentiating (43) with respect to ϕ yields

$$\frac{\partial \Gamma(\zeta,\phi)}{\partial \phi} = -\frac{\zeta[\beta(1-\alpha)\zeta - \rho a(1-\zeta)]}{[\beta(1-\alpha)\zeta\phi + \rho a(1-\zeta)(1-\phi)]^2}. \tag{45}$$

Therefore, the sign of (45) depends on the relationship between ζ and ζ^*, defined as

$$\zeta^* = \frac{\rho a}{\beta(1-\alpha)+\rho a}. \tag{46}$$

This shows that $\partial\Gamma(\zeta, \phi)/\partial\phi < 0$ if $\zeta > \zeta^*$. In this case, an increase in ϕ reduces the second and third terms of (42), and the government chooses higher patent protection (See **Fig. 5**). On the other hand, $\partial\Gamma(\zeta, \phi)/\partial\phi > 0$ if $\zeta < \zeta^*$. In this case, an increase in ϕ increases the second and third terms of (42), and the government chooses weaker patent protection (See **Fig. 6**). Intuitively, we can find two effects when ϕ increases. Firstly, when ϕ is higher, an increase in ω raises the rate of innovation $g(\omega)$ more sharply. The higher rate of innovation increases household utility and political donation. In other words, an increase in ϕ raises the marginal benefit of strengthening patent protection. Secondly, an increase in ϕ directly reduces the amount of political donation. This effect decreases the marginal benefit of strengthening patent protection. When $\zeta > \zeta^*$, the first effect dominates and the marginal benefit of strengthening patent protection increases because the non-corrupt government considers the household utility seriously. This implies that when $\zeta > \zeta^*$, an decrease in ϕ, which corresponds to higher profit fraction allocated to political donation, only discourages innovation and the government chooses weaker patent protection. On the other hand, when $\zeta < \zeta^*$, the second effect dominates, and the marginal benefit of strengthening patent protection decreases because the government pays much attention to political donations. As a consequence, this implies that when $\zeta < \zeta^*$, an decrease in ϕ raises the amount of political donation and a corrupt government chooses stronger patent protection. Hence, we derive the following proposition.

proposition 3 *If the government is non-corrupt and pays much attention to house hold utility ($\zeta > \zeta^*$), a higher fraction of political donations discou rages innovation and the government chooses weaker patent protection. On the other hand, If the government is corrupt and pays much attention to political donation ($\zeta < \zeta^*$), a higher fraction of political donations encourages innovation and the government chooses stronger patent protection.*

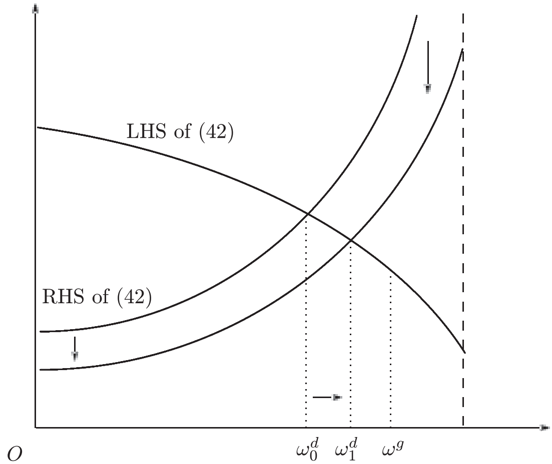

Fig. 5. An increase in ϕ when $\zeta > \zeta^*$

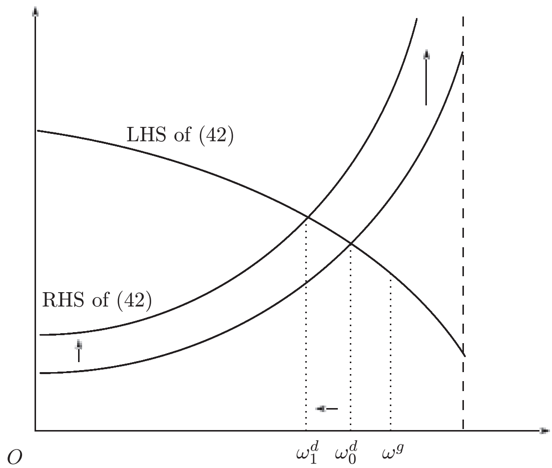

Fig. 6. An increase in ϕ when $\zeta < \zeta^*$

Ⅳ Concluding Remarks

Using an endogenous growth model that only incorporates innovation as a source of economic growth, this paper has examined how political donations from firms to the government affect its IPR policy, innovation, and welfare. Firstly, as a benchmark, we have assumed that the government is non-corrupt and pays attention only to household utility and that there are no political donations. In this model, we have shown that welfare-maximizing patent protection is weaker than growth-maximizing protection because strengthening patent protection damages households by increasing dead weight loss and decreasing expenditure level.

Next, we have considered the case of political donations. In this case, when the government is corrupt and pays much attention to political donations, it tends to have too much of an incentive to strengthen patent protection in order to receive a lot of money from the firms. Therefore, the government strengthens patent protection and increases innovation. This explains the patent policies tend to be strengthened in countries where political donation is important for politicians, such as in the United States.

On the other hand, we have observed two different effects when the fraction of profits allocated to political donations is higher. When the government is noncorrupt and pays much attention to household utility, a higher fraction of profits allocated to political donations discourages innovation and the government chooses weaker patent protection. This is because a higher fraction of profits allocated to political donations weakens the incentive to engage in research and development. As a consequence, this effect decreases the marginal benefit of strengthening patent protection. On the other hand, when the government is corrupt and pays much attention to political donations, a higher fraction of profits allocated to political donations encourages innovation and the government chooses stronger patent protection. This is because a higher fraction of profits allocated to political donations raises the amount of political donation. This effect enhances the marginal benefit of strengthening patent protection. In particular, the latter result is interesting because a higher fraction of political donation leads to a strong IPR policy and a higher rate of economic growth in countries where political donation is important for politicians. However, IPR policy in this case may be too high when we consider the household utility. In other words, when political donation is important for policymaking, the government tends to have an incentive to choose an excessive level of patent protection.

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