Patent Policy with Information disclosure

Preliminary draft

By
Sarah Parlane
and
Han Nie

University College Dublin
Institute For the Study of Social Change

Abstract

This paper reexames patent policy under sequential innovation with information disclosure. When innovation is sequential the party which successfully developed the first innovation has advantage in the discovery of the second innovation. In this case, the timing of the following innovation being find out, not only depends on the amount of the investment in R&D, but also depends on the knowlege of the first innovation. Patent office has to adjust the policy under different level of information disclosure of the first innovator to reward the initial innovation and to encourage the sequential innovation. We find internal solution for the patent policy when there is information disclosure.

Keywords: Information disclosure, Sequential Innovation, Patent policy

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Introduction

Knowlege of the foundational technology is very important to the innovator for the development of the commercial application of this foundational innovation. The more details the innovators know about the foundational technology, the easier the discovery of the application innovation is. Most of the foundational technologies have no stand alone value. For example, pharmaceuticals develops with bioengineering techniquies do not make profit

by just holding the patents on those techniquies, until those techniqies apply into special drugs or applications and being sold to the public.

In this paper, we will exame optimal patnet policy with patent race for the application innovation under the situation that information disclosure has been taken into account . In the literature, patent policy is usually composing of breadth and length. The patent's length is the life time of a patent. The patent's breadth somehow characterizes the extend to which a subsequent innovation has to be different to be patented. Patent office gives the innovator exclusive right of use the new innovation for the life time of the patent. In these days, the speed of new innovation is very fast,new innovations come out everyday. When the new innovation comes out ,the actual life time of a patent is ended, although the life time of the patent are still valid. In this paper, we will introduce a new element which will affect patent policy and has not be studied in the literature–degree of information disclosure.When the foundational innovation is found in the industry, there possiblily will be an application innovation coming out from it, which will bring surplus to the socity. The problem comes from this phenomenon is that how could the social planner reward the party who discover the foundational innovation as its stand alone value is zero before the application innovation comes out? How could the social planner encourage development of the application innovation that based on this foundational innovation? The most important feature that patent officice can award the innovator is patent breadth footnote . But how much to reward to the owner of the foundational innovation? The only way to encourage further research based on this foundational innovation is to let public know it. But how much details to relase to the public ?So, In this paper we will examine how does the patent policy is affected by the information disclosure.

The concept of information disclose is particularly important when innovation is sequential. Because the application innovation based on it, and the owner of the foundational innovation has a strong advantage of finding the application. By mastering the whole detail of the foundational innovation, he can develop application innovations faster than his competitors. He could, in an extreme scenario, become the only innovator who be able to

develop further innovations.Without disclosure of information, the benefit of the foundational innovation will be mitigated with the delay of discovery of the application innovation. By allowing competitors to know somehow of the new idea, we preserves certain level of competition among them over R&D, thus to maximise the total return to the socity. What does inforation disclosure represent in the reality? It could be the decision of patent office as part of the patent policy. For example, whenever the patent office receive a new application for patent protection, it will examine the application to see if there is an existing application which has the same feature as this new application. In this case, they will public some details of the application for certain time. If one think his or her existing patent is infringed by this application, he should come forward to the patent office, and patent office will decide if it is ture. In this situation, we can interpreate how much details that the patent office is going to public is the level of information discolsure. It also could be firms decision. The holder of the foundational innovation has the right to diclose whatever detail it want to the public about its innovation to maximising its expecting profit. Just like Lunix, the company prefer to open up the source code to the public.

We are going to use forward protection to measure the award to the innovaot of the foundational innovation.. It is a way of define the breadth of the patent. In the literature, some authors define the breadth as forward protection, under the situation where the application innovation will dissipate the rent from the foundational innovation. The idea in this paper is that the application innovation creates value for the foundational innovation. If an foundational innovation inspires the research of the application innovation, patent office will gurantee that some revenue creates by the application innovation goes to the owner of the foundational innovation.How much that the value is created by the application innovation should go to the finder of the foundational innovation is what we mean by forward protection in this paper. This implicitly requires that the use of an application innovation is perfectly observable. Such an assumption is possibly acceptable in a context where this foundational innovation is necessary for the application innovation to be found out. Therefore where the existence of application innovations is a proof in itself of having used the foundational

innovation footnote . Asking how to award the discover of the foundational should be allowed goes back to questioning the need for strong or weak forward protection. This has received much attention in the literature. When innovations are build on some the initial innovation, or when an innovation can be used and comercialized through different applications, there is a risk of rent dissipation. The first innovator's profits may vanish as the second generation innovations appear or as applications develop. In Green and Scotchmer (1995), and Scotchmer (1996), the importance of a strong forward protection is well illustrated. In this paper, Green and Scotchmer argue that first-generation innovator should be given strong forward protection so that will encourage second-generation innovation. A strong forward protection can be achieved via broad patents (making further innovations difficult to patent). Alternatively, licencing agreements can substitute patents for second generation innovations. This is not the purpose of the forward protection in this case, as the foundational innovation has no value, it creates only value through the application innovation.Hence, there is no initial rent. Forward protection is only a tool of reward the discovery and indeed affect the innovation decision, how much award that the initial innovator will get depends on how good this foundational innovation is or how much value that the application innovation comes from it worthy. As demonstrated in Chang (1995) and Denicolo (2000), strong forward protection can also discourage investment for further innovations. In this case, the division of profits among initial innovator and the application innovator (initial innovator could also be application innovator) is not the way of spreading the foundational innovation in the economy and encourage innovation. As it is shown in the cited papers, it is impossible to get rid of investment distortions in both period at the same time.But under the situation in this paper, we don't have problem of this investment distortions according to forward proteciton. In this paper, we only focus on the patent policy when erhe is one stage patent race, race for the application innovation. We dont need to worry about the investment for the foundational innovation. The argument we can give here is , the foundational innovation could be a sudden discover. For example, a great idea come form a fun of computer. Or it could be a state funding project, or university funding project.

What we study here is how to use patent policy to encourage the application and reward the innvator of the foundational innovation. None of the papers cited above extend the patent's characteristics to the possibility of infromation disclosure. In this paper, we are going to extend the patent policy to where there is a foundational innovation and possiblity of information disclosure.

The information disclosure stimulates R&D effort in the whole industry, while the forward protection reward the innovator of the foundational innovation. In this paper, the more information disclosed to the public, the easier the public will found a new innovation based on this new idea. The other characterise is that the party who discovers the foundational innovation can not get any award unless there is someone (someone also inculding itself) turns this foundational innovation into an application innovation, in this case the more valuable the application innovation is the more rewards that the founder of the the foundational innovator will get.

The model considered is simple. There is an incumbent and free entrance. Incumbent owns the foundational innovation, what we mean by incumbent is that it is the incumbent in R&D. Firms (incumbent and free entrance) race to obtain patents for innovations which need the foundational innovation. On the market, asssumeed free entry drives the entrance's expecte profit is zero. Thus, without an application innovation, the foundational innovation brings no value to the firm and consumers. The model intends to corporate the following features. First, we assume that there is no stand along profit of the foundational innovation.. Second, the application innovation has to based on the foundational innovation. Third, incumbent has advantage in the R&D of the application innovation.

Despite the simplicity of the model, the resolution is tedious. The organization of the paper is the following. First, we present the model. Then, we characterize the optimal patent plicy. After that we discuss information disclsure and remark the conclusion.

The Model

We consider a simple model with one incumbent and free entrance (firm i and firm e). Incumbent has found out a foundational innovation which cannot be sold public and is of no

vaule except for the further innovation. Once the incumbent has this foundational innovation, patent office decides on the patent policy to reward the incumbent by encourage firms to use this new idea create further innovation which can brings commercial value to firm and social vaule to consumers. If other firms find this application innovation which is based on it, they should pay some portion of the value that the new innovation brings to them to the incumbent. Incumbent and entries no-cooperativly on the investment effort per period in R&D. Time (denoted by t) is continuous in each period. Let h_i $(i = i, e)$ represents the effort invested in R&D per unit of time. To fix ideas, you can consider that both firms decide on how much to spend monthly on R&D and spend the same amount per month until one finds an innovation.

The foundational idea is automatically patented (as the begining of the game). Then patent office decides on the patent policy which involves the forward protection $\beta \in [0, 1]$.The forward protection is how much that others have to pay for the incumbent in terms of the value that they can get from the innovation that is based on the foundational innovation. Information disclosure is how much detail information that patent office is going to publish to the public about the foundational innovation.You can treat β as a parameter that represent the license fee or breadth of the patent. As β increases, the patentee get more value from the further innovation that based on the foundational innovation. Information disclosure is the new parameter that have not been consider in the literature. The time at which an innovation is found is stochastic and depends on a firm's R&D effort. In the R&D race, incumbent has the idea and entrance only know some part of the idea which depends on how much information disclosed. So firms are asymmetric according to the information they have. We assume that the incumbent's distribution dominates in a first order stochastic sense the entry's distribution. And all entries distribution are iid. The incumbent's advantage depends on how open is the innovation. More precisely, if we call t_i (respectively t_e) the time at which the incumbent (respectively the entryr) finds the innovation, and h_i and *he* incumbent's and entryr's effort respectively. Both firms are symmetric and the probability that firm finds an innovation before $t = \tau$ is given by an exponential distribution

$$\Pr(t_w \leq \tau) = 1 - \exp(-h_w \tau),$$

$$\Pr(t_l \leq \tau) = 1 - \exp(-\alpha h_l \tau)$$

where $\alpha \in [0, 1]$ refers to the possibility of open source. Note that h_i gives the instantaneous conditional probability of a success at $t = \tau$.

Let c denotesthe cost of per unit of effort in R&D. This cost function is constant (does not change from one period to the other) and the same for both firms. The value that attached to theapplication innovation is v per unit of time. A product modified by innovation has a value of s for consumer. For a varitey of reasons the social returns from innovation may be greater than the private return, lets assume $S > 2V$ to make the furthe analyse simple.

Patent race

We solve this game by backward induction. Note however that the first period the patent policy has been decided. Which means at the second period,β are constant. The payoffs functions of the incument I and the entry E are the present value of expected profits net of the R&D costs.

$$I(h_i, h_e) = \frac{\beta \alpha H_e + h_i}{h_i + \alpha H_e + r} V - c h_i$$

and

$$E(h_i, h_e) = \frac{(1 - \beta)\alpha h_e}{h_i + \alpha H_e + r} V - c h_e$$

where H_e represents the sum of all entries's investment effort, r is the interest rate and $V = \frac{v}{r}$. β is the parameter for forward protection, which is the portion that incument will get from entryace if the entance find the further innovation. Incument choose the level of investment in R&D to maximise its own profit, knowing that free entry drives entrires's expected profit to zero, first order condition and zero profit condition gives us that in equilibrium

$$H_e = \frac{\alpha(1-\beta)V}{c} - \frac{r}{\alpha(1-\beta)}$$
$$h_i = \frac{V\alpha(1-\alpha)(1-\beta)}{c} + \frac{r\beta}{(1-\beta)}$$

Lemma 1:*In some cases, entrance will not invest in R&D and there will only be one firm in the market. When the value of the new innovation is too high or the cost of R&D effort is too low. When* $\alpha(1-\beta) > \sqrt{\frac{C}{V}}$ *, there is no entry.*

It includes the case that when there is no information disclose about the foundaional innovation to the public which is $\alpha = 0$. It also includes the case where there is extremly forward protection about this foundational innovation, which means that any profit, which comes from the application innovation, goes to the incumbent, $\beta = 1$. Given this foundational innovation has no stand alone value unless the application innovation be discovered by further innvation, the value attached to the application innovation has to be high enough to cover the cost of R&D. We assume that $V > rC$, where $C = rc$ to guarantee there is innovation of application innovation at all. If there is no entry invest, we have incument behaving as a monopolist in R&D, the profit maximising investment in equilibrium is

$$h_i^m = \sqrt{\frac{v}{c}} - r$$

In equilibrium, when there is entry, free entry drives entrance's expected profit to zero, and the incumbent's profit is the following.

$$I(\alpha,\beta) = V(1-\alpha(1-\beta)(2-\alpha)) - cr\frac{\beta}{1-\beta}$$

When other things are constant, incumbent's expect profit in equilibrium decreases with degree of information release α and increases with forward protection β. It tells that the more information be released to the public, the less the research advantage the incumbent has, indeed the less the expect profit for the incumbent. Also the more forward protection the incumbent get, the more profit it will gain, except the case where $\beta = 1$.

Proposition 1:*In equilibrim, it is easy to see that the probability of the innovation coming out under free entry is higher than it is under monoploy no matter of the level of forward protection and the information disclosure.*

In the case of only incumbent invest in R&D, the probability of the innovation coming out is $\frac{h_i^m}{r+h_i^m}$, and in the case of entry, probablity of the innovarion coming out is $\frac{h_i+\alpha H_e}{h_i+\alpha H_e+r}$. It is not certain that in which cases the incumbent invest more in R&D, as it is depends on the forward protection and the information disclose. Incumbent invest more under monoploy than it does under free entry,if the forward protection is weak and there is a big information disclosure.

Optimal patent policy

Definition *The social value of the innovation is the expected private return that this innovation bringings to firms and the probability of this innovation be discoved times the social value that this innovation brings to consumers, mins the cost of release information.*

The social welfare in this case is the following expression:

$$TS = I(\alpha, \beta) + \frac{h_i + \alpha H_e}{h_i + H_e + r} S$$

Where $S = rs$. The above total surplus equation is the total surplus when there are entrance in the industry. It is not the same when there is extremly forward protection and when there is no inforation disclose. I will talk about it later. In equilibrium, it is a function of forward protection (β)

$$TS = V + S - C\frac{\beta}{1-\beta} - \alpha(1-\beta)(2-\alpha)V - \frac{CS}{\alpha(1-\beta)V}$$

Patent office choose the levele of forward protection to maximising the above expected total surplus. As long as, entrance's investment is positive, total surplus is a concave function with respect to the forward protection β. $TS''(\beta) < 0$. The optimal forward protection is the following expression:

$$\beta = 1 - \sqrt{\frac{C(\alpha V + S)}{\alpha^2 V^2 (2-\alpha)}}$$

Proposition 2:*There is an internal solution of the forward protection, for each level of information disclosure, cost of innivation, private return and social return of the application innovation*

Now we can focus on how does this patent policy affect the R&D decision. In a pure strategy equilibrium, unless $H_e = 0$, when other things are constant, the sum of entry's effort in R&D decrease with the forward protection β, and the incumbent's investment increases with the forward portection β. It tells us that the greater the forward protection is, the more profit incumbent will get from the further innovation. Also, the early the innovation comes out, the more the profit it will get, indeed incument will increase the R&D effort. When $\beta = 1$, entry will not invest in R&D,so incument's investment jump to a very high level, otherwise it will not get any value from the foundational innovation that it finds in the first place. For entrance, strong forward protection will lower the marginal return of the investment for certain level of investment cost, indeed prevent the investment. For incumbent, the stronger the forward protection, the higher the marginal return of the investment, so investment increases with the forward protection. Overall investment in the socity decrease with the forward protection, which means the entrance investment dominate the incumbent investment, as there are free entry.Total welfare initially increases with the degree of forward protection, and then decreases as it keep increasing. As we know that investment decreases with the forward protection, so as the forward protection increases the overall investment in the socity moves from over-invest to the optimal investment and then to underinvestment.

How does the socail return and pricate return and the coat of innovation affect the optimal patent policy? Forward protection decreases with the socail return and the cost of innovation, and increases with the private return. When the social return and the cost of innovation is high, the earler the innovation comes out, the better off the social welfare is. To stimullate the investment, we need weak forward protection. When the private return is high, there is more value that attacehd to the innovation for firms, there is no need to use forward protection to stimulate investment, social planner should increrases the forward protection.

Lemma 3: *In equilibrim, the forward protection increase with the information disclosure. The more information that has been discloused, the more forward protection that we need to give to the inumbent.*

Information disclosure

Information disclosure hasn't been modle into the patent policy literature before. We can interpreted it in many ways. It could be part of the patent policy as we metioned before. Patent office can decide how much detail of the foundational innovation it will realease to the public, through the publication periode of the appliction proceed. Patent office can also give this to firm, firm choose the level of information disclosure to maximising its profit

Information disclosure as part of patent policy

If the information disclosure is patent office desicion, then there must include cost of relases information, in this section we will examine the patent policy when information disclosure is part of it. Let us assume that cost function $Z(\alpha)$.is increasing and convex with respect to α. .Patent office choose the levele of forward protection and the level of informaiton disclosure to maximising the above expected total surplus. The first derivative for the total surplus funtion are

$$\frac{dTS}{d\beta} = -\frac{C(\alpha V + S)}{\alpha V(1-\beta)^2} + \alpha(2-\alpha)V$$
$$\frac{dTS}{d\alpha} = 2V(1-\beta)(\alpha-1) + \frac{CS}{(1-\beta)V\alpha^2} - Z'(\alpha)$$

Lemma 4:*As long as*, *entrance's investment is positive*, *and the cost function is not too convex footnote* , *total surplus is a concave function with respect to the information disclose α and the forward protection* β. $TS''(\alpha) < 0$, *and* $TS''(\beta) < 0$. *To maximise the total surplus*, *the forward protection increases with the information disclosure*.

Patent office chooses the pair of forward protection and the disclosure of the information to maximising the total surplus. At certain level of private (V), social return (S), cost of innovation (C), there is a pair of forward protection and informatio disclose (α, β) to maximise total surplus. From the first order condition of the total surplus with respect to the level of forward protection , we have an explicite function of the forward protection with respect to the information disclosure For example if we have a special cost function as $Z(\alpha) = \lambda\alpha^2$. In equilibrium we can solve out the optimal patent policy

$$\alpha = (1 - \frac{S}{2V}) + \frac{\lambda(2V+S)\sqrt{(CV+4\lambda^2)}}{V(CV+4\lambda^2)}$$

$$\beta = 1 - \frac{2VC\sqrt{(CV+4\lambda^2)}}{2V^2C - VCS - 8S\lambda^2 + 4S\lambda\sqrt{(CV+4\lambda^2)}}$$

Lemma 5: *In a pure strategy equilibrium, unless* $H_e = 0$, $H_e'(\alpha) > 0$ *and* $h_i''(\alpha) < 0$. *The sum of entry's effort in R&D increases with the information disclose* α. *The incument's R&D effort initially increase with the information disclose* α, *when* $\alpha < 0.5$. *and then decreases with the information disclose* α, *when* $\alpha > 0.5$.

In other words, when other things are constant, the entrance's marginal benefit of the R&D effort increases with the degree of information disclosed. For the incumbent, when there is little information relasing to the public, incumbent itself's marginal benefit of R&D effort increase with information disclosure. But when there already is lots of information disclosed, the incument's marginal benefit of the R&D effort decreases, because entrance has more chance of getting the innovation, indeed they will reap some of the marginal benefit of R&D effort from the incumbent

Now we will study how does information disclosure's effect when taking the forward protection as constanct. Another thing need to be mentioned here is that all the comparative statice is in the case where we have entrance in the R&D race. When the forward protection is constant. The optimal information disclosure increases with the socail return and the cost of R&D effort, decreases with the private return. The optimal forward protection increases with the private return and decrease with the social return and the cost of R&D effort. When the socail return of the innovation is big and the cost of R&D effort is big, the earler the innovation comes out, the better it is from social point of view. To encourage R&D investment, patent office need to relases more information about the initial idea. When the private return of the innovation is big, firms will invest more in R&D, in this case, there is no need to use information disclose to encourage R&D investment.

Information disclosure is firm's decision

In this section we will focus on if information disclosure is firms decision. After firm find out this foundational innovation, it can decide on how much to relases to the public. In

this case, the model has to be changed a little bit. Up to now, we only focus on the patnet policy on teh sequential innovation without worry about the first period decision. When information disclosure is firm's decision, then after the discover of this foundationall innovation, firm has to decide on how much to relase to the public about this innovation. Firm will never want to relase any information to the public to maximising its own profit.

Special cases

All the analysis above is the situation where we have entrance in the market. The forward protection will never equal to one, in other words, it is not social desirable to have complete forward protection. If the total surplus when there is only incumbent invest in equilibrium is

$$TS\ |_{\alpha=0}\ = (V+S+C) - 2\sqrt{CV} - \sqrt{\frac{C}{V}}\,S$$

The total surplus when there is extremely disclose about the inital information in equilibrium is

$$TS\ |_{\alpha=1}\ = (V+S+C) - 2\sqrt{C(V+S)} - Z(1)$$

Proposition 3: *Socity is always better off under complete information disclose than there is no information being disclosed. As long as the cost of release informationis not greater than* $\frac{CS}{V}$.

When one new idea can potentially bring some value to the socity, it is always better off to spread this information to the public rather than keep it secretly. The new idea has no value when it stands along, so the socity is better off to turn this idea into a further novation. Which level of informtion disclose is the best for the socity depends on the exact value of social return and privat return.

Lemma 6:*When there is extremely disclosure about the information, the total surplus decreases with the forward protection.*

It tells us that if incumbent has no advantage in terms of R&D, the less forward protection is,the higher the total surplus is.Because there is no incentive for incumbent to invest in terms of R&D advantage, so social planner should give incumbent less forward protection to sitmulate incumbent's investment.

Conclusion

We have examed the issue of optimal patent design using a standard model of patent races with a Poisson discovery process. This model has well-know limites but allows we to analyze how the dynamic externality arising from the cumulative nature of innovation with the winner-takes-all effect and difference between the private and social return. This paper has applied this model into a new way of rewarding exploiter in the econmy, namely, ex-post profit through forward protection. We are trying to see how could patent policy, control the technology spread (information disclosure), indeed, affects the total welfare in the economy. We introduced a parameter which decribes the information disclosure into the model.We find a internal solution of the patent policy for the sequential innovation which has not been found in the literature.

References

GREEN,J,R AND SCOTCHMER,S. ”On the Division of Profit in Sequential Innovation Reconsidered.” RAND Journal of Economics, Vol 26 (1995), pp. 20-33.

SCOTHCMER,S. ” Protecting Early Innovators: Should Second-Generation Products be Patentable?” RAND Journal of Economics, Vol 27 (1996),pp 322-331.

BESSEN. J, MASKIN.E. ”Sequential Innovation, Patents and Imitation” MIT workind paper 2000

DENICOLO. V. ” Two-Stage patent Races And Patnet Policy” RAND Jouranly of Ecomonics,Vol 31,No 3,Autumn (2000) pp. 488-501