Wirtschaftswissenschaftliche Fakultät
der Eberhard-Karls-Universität Tübingen

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Patents and the Disclosure Requirement

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Tübinger Diskussionsbeitrag Nr. 296
August 2005

Wirtschaftswissenschaftliches Seminar
Mohlstraße 36, D-72074 Tübingen

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Abstract

This paper analyzes the patenting decision of a successful inventor in a model of dynamic technology adoption with asymmetric firms. We show that the extent of the inventor's technological headstart is decisive for his patenting behavior. The overall patenting effect consists of two parts, a protective and a disclosure effect. If the technological headstart is high the negative disclosure effect may overcompensate the positive protective effect of a patent. In this case the inventor prefers secrecy. Welfare considerations show that a patent may be socially desirable even though it delays the first adoption of a new technology.

Keywords: Patenting decision, Secrecy, Disclosure requirement, Technology adoption, Patent height

JEL Classifications: L13, O14, O33, O34

*I wish to thank Jörn Kleinert, Tobias Schüle, Barbara Sender, Manfred Stadler and the participants of the PhD Seminar of the University of Tübingen in July 2005, Blaubeuren, for valuable comments. Any remaining errors are naturally mine.

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1 Introduction

In the last decades changes in patent law, a growing number of knowledge based enterprises and the rise of new technologies have led to the appraisal of patents as necessary and sufficient instruments to appropriate the returns of investments in research. But the rise of this *pro patent era* (*Arundel* (2001)) is opposed by strong empirical evidence based on various innovation surveys.[1] These surveys consistently find that manufacturing firms rate secrecy higher than patents as appropriation mechanism for product and process research and development (R&D). The relative effectiveness of patents and secrecy for appropriation was explicitly analyzed by *Arundel* (2001) with data from the 1993 European Community Innovation Survey (CIS). His findings support other surveys that consider various appropriation mechanisms of R&D: a higher percentage of firms in all size classes rates secrecy as more valuable than patents. According to *Cohen et al.* (2000) a major reason for this appropriation behavior of firms is the disclosure requirement linked to a patent.

In the economic literature a more differentiated view on the patenting decision itself evolves only recently: *Denicolò*, *Franzoni* (2004) interpret a patent as a contract between an inventor and society: An exclusive property right is granted in exchange for the disclosure of all technological information concerning the protected invention. This leads to the question whether the monopoly benefits from patent protection are large enough to outweigh the disutilities that arise from the disclosure requirement so that a patent is profitable for the inventor. Understanding a patent as a contract leaves room for secrecy as an alternative appropriation mechanism that comes to call whenever a patent would be disadvantageous.

The aim of this paper is to analyze the strategic choice of an inventor between a patent and secrecy to appropriate returns from research. In contrast to recent work by *Denicolò*, *Franzoni* (2004) and *Bessen* (2005) we explicitly incorporate the disclosure requirement as the loss of a technological headstart. This loss affects a patentee from the moment the patent is granted by boosting his rival's research. In a recent paper *Erkal* (2005) also considers this effect of the disclosure requirement. To capture the idea of cumulative innovation she assumes that firms compete in two consecutive R&D races. The winner of the first race has a higher probability of winning the second race than his rivals. Yet if he decides to patent his invention he loses his

[1]See for example *Cohen et al.* (2000) for a survey of manufacturing firms in the United States and *Arundel et al.* (1995) for a European survey.

headstart and as a consequence all firms face the same probability of success subsequently. Whereas *Erkal* (2005) focusses on the optimal policy in the context of cumulative innovation our paper attempts to find the driving forces behind the patenting decision itself.
To analyze the strategic patenting decision we introduce the possibility of patenting into a dynamic model of technology adoption as provided by *Dutta et al.* (1995). In their model, *Dutta et al.* (1995) consider continuous improvements of a basic invention: after a technological breakthrough a new technology has to be further developed and adapted to market conditions. So firms have to decide when, i. e. at which quality level to adopt a new technology. *Dutta et al.* (1995) model the strategic adoption decisions of two rival firms as a process of dynamic vertical product differentiation without considering the possibility of patenting. One firm adopts early and markets a low quality good as the other waits for the basic invention to mature further and markets a high quality good later. The quality of the basic invention, once discovered, is assumed to rise costlessly over time. Therefore the strategic adoption decisions have to balance the trade-off between being temporary monopolist as first adopter and realizing higher duopoly profits as second adopter.
In contrast to *Dutta et al.* (1995) we do not assume that a new technology arrives exogenously but consider the basic invention as the outcome of a duopolistic invention race. The successful inventor possesses the complete technological knowledge needed to manufacture the basic invention and has the possibility to patent this know-how. To participate in the invention race the competing firm has also invested in research and therefore it can profit from own research findings. Yet in the subsequent improvement competition it has a technological disadvantage compared to the inventor. As our analysis will show it is this knowledge asymmetry between the inventor and the non-inventor that drives the patenting decision.

The idea of introducing the possibility to patent into a model of vertical product differentiation goes back to *van Dijk* (1996). In his model one of two symmetric firms holds a patent on the basic invention without facing any negative effect due to the disclosure requirement. The patenting decision itself is not considered. The non-patentee may only enter the market with a quality that is sufficiently high compared to the basic invention, namely a quality that exceeds the exogenously given patent height. His two-stage model setting leads *van Dijk* (1996) to the conclusion that the patentee faces a „patent trap“ since the patent commits the non-patentee to developing a higher quality than he would have without a patent. In equilibrium the non-patentee will be offering the high quality product so the commitment effect of a patent results in higher profits for the non-patentee compared to the patent holder. This „patent trap“ results due to the high-quality advantage that prevails in two-stage models of vertical product differentiation.[2] As the subsequent analysis will show in a dynamic setting with asymmetric firms the patent trap vanishes and a patent may even be profitable for the inventor.

The rest of the paper is organized as follows. Section 2 introduces the dynamic model of technology adoption with asymmetric firms and analyzes possible equilibria. In Section 3 we consider the decision between patenting and secrecy. Section 4 investigates patent height as a possible policy measure. Section 5 concludes.

2 A Model of Dynamic Quality Competition

After an initial technological breakthrough a successful inventor, i, and his rival, the non-inventor j, compete in quality improvements of a basic invention. As further research improves the quality over time the firms have to make the strategic decision of when to adopt and market the new technology.[3]
We assume, as in *Dutta et al.* (1995) and *Hoppe*, *Lehmann-Grube* (2001), that the level of quality, x, costlessly rises over time and without further loss of generality that the quality level increases by one unit in every subsequent period. The inventor's quality improvement function is given by

$$t_i(x) = x \tag{1}$$

which states that in order to reach a certain quality level $\bar{x}$ the inventor has to invest $t_i(\bar{x})$ periods of time. To capture the fact that the non-inventor has a technological disadvantage compared to the inventor his quality improvement function is specified by

$$t_j(x) = x + \gamma \tag{2}$$

with $\gamma \geq 0$ as the extent of the technological headstart of the inventor. In words, to reach a certain quality the non-inventor has to wait γ periods longer than the inventor.
The first adopter of the new technology earns temporary monopoly profits as his product of relatively low quality is the only version of the new technology

[2] For a detailed analysis of the persistence of the high-quality advantage see *Lehmann-Grube* (1997).

[3] The inventor has the possibility to patent the new technology. His patenting decision is analyzed in Section 3.

available so far. The subsequent adoption of the rival firm constitutes an asymmetric duopoly where the former monopolist realizes lower profits since his rival now offers a higher quality. At the beginning of the game, $t = 0$, both firms decide when, i. e. at which quality level, to adopt the new technology. Each firm can only adopt once.

The underlying demand structure follows *Shaked*, *Sutton* (1982). Consumers differ in their tastes θ for improvements of the basic invention. Quality preference, $\theta \in [a, b]$ with $b > 2a > 0$, is assumed to be uniformly distributed. Each consumer will buy one unit of the product in every period as long as his net utility, $U = \theta x - p$, is greater than zero.

The early adopter offers a low quality x_l. All consumers with a quality preference $\theta \geq p_l/x_l$ will buy one unit of the product with quality x_l from the temporary monopolist in every period until the rival firm adopts a higher quality x_h. Straightforward computation yields the monopoly profit of the early adopter in every period

$$\pi_m = A_m x_l$$

with $A_m \equiv b^2/4$. The adoption of the high quality x_h by the rival firm constitutes an asymmetric duopoly. By definition $x_h > x_l$. Then the consumer indifferent between buying high or low quality is situated at $\theta^0 = (p_h - p_l)/(x_h - x_l)$, $h,\, l = i,\, j\,;\, i \neq j$. The market share for the firm offering the low quality is $[a, \theta^0]$ and the high quality offered by the late adopter has a market share of $[\theta^0, b]$. Production costs are symmetric and are assumed to be zero.

Standard computation yields the duopoly prices

$$\begin{aligned} p_l &= (x_h - x_l)(b - 2a)/3 \\ p_h &= (x_h - x_l)(2b - a)/3 \end{aligned} \quad (3)$$

and the corresponding profits per period

$$\begin{aligned} \pi_h &= A_h(x_h - x_l) \\ \pi_l &= A_l(x_h - x_l) \end{aligned}$$

with $A_h \equiv (2b - a)^2/9$ and $A_l \equiv (b - 2a)^2/9$.

2.1 The Late Adopter's Problem

A late adopter has to decide when to adopt the new technology after his rival has already adopted a low quality x_l in t_l. All future profits are discounted with the interest rate $r > 0$. Since with his entry into the market in t_h with a high quality x_h the late adopter earns duopoly profits π_h per period he realizes lifetime profits

$$F(x_h, x_l) = \int_{t_h(x_h)}^{\infty} e^{-rt} \pi_h dt. \tag{4}$$

Optimization with respect to the quality level x_h yields the optimum differentiation strategy given the early adopter's quality decision, x_l,

$$x_h^* = x_l + \frac{1}{r \frac{\partial t_h(x_h)}{\partial x_h}}. \tag{5}$$

As stated above the non-inventor will need γ additional periods to reach a quality of level x_h so that his entry date as late adopter would be $t_j^h(x_h) = x_h + \gamma$. Due to his technological headstart the inventor would be able to adopt this quality earlier, namely at $t_i^h(x_h) = x_h$. Obviously in both cases the derivative of the quality improvement function with respect to the level of quality equals one, $\partial t_j^h(x_h)/\partial x_h = \partial t_i^h(x_h)/\partial x_h = 1$. Thus the profit maximizing differentiation strategy as defined in equation (5) is $x_h^* = x_l + 1/r$. Consequently the optimum level of differentiation is $\Delta_x^* = x_h^* - x_l = 1/r$, independent of the order of adoption. The adoption date for the non-inventor as late adopter would be $t_j^h(x_h^*) = x_l + 1/r + \gamma$ due to his technological disadvantage. By inserting these results into the above profit function (4) and solving the integrals the overall profits of the non-inventor as second adopter can be derived as

$$F_j(x_l) = e^{-1-r(x_l+\gamma)} \pi_h / r.$$

If the inventor is the late adopter he would optimally adopt at $t_i^h(x_h^*) = x_l + 1/r$ so his overall profits would amount to

$$F_i(x_l) = e^{-1-rx_l} \pi_h / r.$$

Note that if the inventor loses his technological headstart due to a patent, $\gamma = 0$, both firms are symmetric and thus would realize identical profits as second adopter, $F_i(x_l)\big|_{\gamma=0} = F_j(x_l)\big|_{\gamma=0}$.

2.2 The Early Adopter's Problem

The early adopter anticipates the optimum differentiation strategy of his rival, x_h^*. His overall profit consists of two parts: the monopoly profits he realizes from his adoption in t_l until the second firm enters in t_h and the subsequent duopoly profits,

$$L(x_l) = \int_{t_l(x_l)}^{t_h(x_h^*)} e^{-rt}\pi_m \, dt + \int_{t_h(x_h^*)}^{\infty} e^{-rt}\pi_l \, dt. \tag{6}$$

Taking into account the optimum level of differentiation, $\Delta_x^* = 1/r$ and $\partial t_h(x_h^*)/\partial x_l = 1$, optimization with respect to x_l yields the profit maximizing adoption quality for the first adopter

$$x_l^* = \frac{1 - e^{-r(t_h(x_h^*)-t_l)}(1 + A_l/A_m)}{r(1 - e^{-r(t_h(x_h^*)-t_l)})}. \tag{7}$$

Two different cases may occur: the inventor or the non-inventor can be the early adopter. Suppose that the non-inventor j adopts first. Due to his technological disadvantage he needs more time to reach the quality level x_l. Thus as early adopter he would enter the market in $t_j^l(x_l) = x_l + \gamma$ and the inventor as second adopter would follow in $t_i^h(x_l) = x_l + 1/r$. To assure that $t_j^l(x_l) < t_i^h(x_l)$ let $\gamma < 1/r$. Inserting these adoption dates into equation (6) and solving the integrals yields the overall profits of the non-inventor as early adopter

$$L_j(x_l) = \frac{(e^{-r\gamma} - e^{-1})\,\pi_m + e^{-1}\,\pi_l}{e^{rx_l} r}.$$

Since the non-inventor faces a technological disadvantage he is able to realize positive profits only after γ periods of time have elapsed so that $L_j(x_l) > 0 \; \forall \; t > \gamma$ and $L_j(x_l) = 0 \; \forall \; x_l \leq \gamma$. If the non-inventor is the early adopter his profit maximizing early adoption quality x_{lj}^* can be derived by inserting $t_i^h(x_h^*)$ and $t_j^l(x_l)$ into equation (7),

$$x_{lj}^* = \frac{1 - e^{-1+r\gamma}(1 + A_l/A_m)}{r(1 - e^{-1+r\gamma})}. \tag{8}$$

The case is different if the inventor is the first adopter. He would optimally adopt the basic invention in $t_i^l(x_l) = x_l$ and the non-inventor as second adopter would follow in $t_j^h(x_l) = x_l + 1/r + \gamma$. Inserting these relations into the profit function (6) and solving the integrals yields the overall profit of the inventor as early adopter

$$L_i(x_l) = \frac{(1 - e^{-1-r\gamma})\,\pi_m + e^{-1-r\gamma}\,\pi_l}{e^{rx_l}\, r} \tag{9}$$

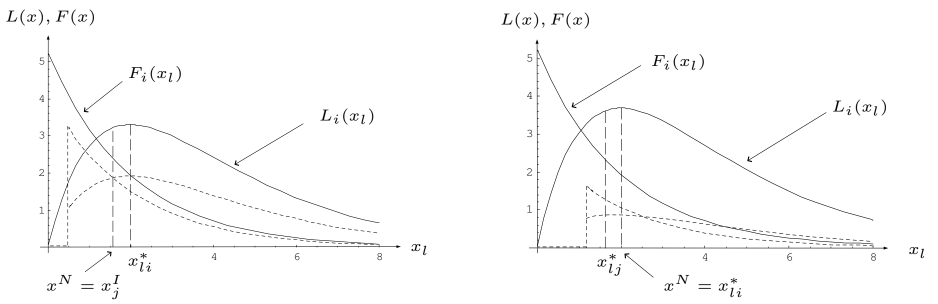
with the corresponding profit maximizing quality level

$$x^*_{li} = \frac{1 - e^{-1-r\gamma}(1 + A_l/A_m)}{r(1 - e^{-1-r\gamma})}. \tag{10}$$

Note that again firms are symmetric if $\gamma = 0$ due to a patent and thus as early adopters they would choose similar quality levels, $x^*_{li}\big|_{\gamma=0} = x^*_{lj}\big|_{\gamma=0}$ and realize identical profits, $L_i(x_l)\big|_{\gamma=0} = L_j(x_l)\big|_{\gamma=0}$. For all $\gamma > 0$ the profit maximizing quality level of the inventor exceeds that of the non-inventor, $x^*_{li} > x^*_{lj}$, as obviously $\partial x^*_{li}/\partial\gamma > 0$ and $\partial x^*_{lj}/\partial\gamma < 0$.

2.3 Equilibria

In the previous section the overall profit functions solely depending on the adoption quality of the first adopter, $L_i(x_l)$, $L_j(x_l)$, $F_i(x_l)$ and $F_j(x_l)$ were derived. Note that the asymmetric adoption capabilities of the firms were taken into account by inserting the specific quality improvement functions $t_i(x)$ and $t_j(x)$ as specified in equations (1) and (2). Therefore the quality level, x_l, that the profits are now dependent on, is equivalent to time, $x_l = t$. Figure 1 depicts these profit functions for two alternative values of the technological headstart where the solid lines are the overall profits of the inventor and the dotted lines represent the non-inventor's alternative profits.



(a) Preemption, $\gamma = 1/2$ (b) Maturation, $\gamma = 6/5$

Figure 1: Nash Equilibria for different values of the technological headstart, x^N depicts the equilibrium low quality, with $a = 2$, $b = 5$, $r = 0.5$

If the headstart of the inventor is small, as in Figure 1(a), both firms prefer to be the first adopter with quality x^*_{lk}, $k = i, j$, as this would maximize their overall profits $L_k(x^*_{lk})$, $k = i, j$. Since both anticipate that the other will follow this adoption strategy no one is able to realize his profit maximizing

quality level. Suppose the inventor i intends to adopt quality x^*_{li} then the non-inventor, j, anticipating this, would adopt at $x^*_{li} - \epsilon$ since this yields higher profits, $L_j(x^*_{li} - \epsilon) > F_j(x^*_{li})$. Now the inventor in turn has an incentive to preempt and so on. Following this argument preemption is the dominant strategy for both firms as long as $L_k(x^*_{lk}) > F_k(x^*_{lk})$, $k = i, j$.
Evidently either firm will stop preempting as soon as it reaches the adoption quality at which early and late adoption yield the same profits, the intersection point x^I_k with $L_k(x^I_k) = F_k(x^I_k)$, $k = i, j$. Therefore the loser of a preemption race will be the firm that reaches its intersection point first when moving backwards from x^*_{lk}, $k = i, j$.

Lemma 1 *The inventor will always be the first adopter if both firms follow a preemption strategy.*

Proof: The intersection point for the non-inventor can be derived by equating his alternative profits, $F_j(x^I_j) = L_j(x^I_j)$. Rearranging terms yields

$$x^I_j = \frac{e^{-r\gamma}A_h - A_l}{erA_m(e^{-r\gamma} - e^{-1})}. \tag{11}$$

Analogously the intersection point for the inventor can be derived as $x^I_i = (A_h - e^{-r\gamma}A_l)/(erA_m(1 - e^{-1-r\gamma}))$. As both firms are symmetric whenever $\gamma = 0$, x^I_i has to be equal to x^I_j if there is no technological headstart. As obviously $\partial x^I_j/\partial\gamma > 0$ and $\partial x^I_i/\partial\gamma < 0$ it is always true that $x^I_i < x^I_j$ for $\gamma > 0$. Consequently if both firms follow a preemptive strategy the non-inventor reaches his intersection point first and thus always loses the preemption race. ■

Thus if the technological headstart is low as in Figure 1(a) the inventor will always win the preemption race by adopting the quality x^I_j. The non-inventor has no incentive to preempt this quality as in this case he realizes higher profits as second adopter, $L_j(x^I_j - \epsilon) < F_j(x^I_j)$.

In the case of a high technological headstart as depicted in Figure 1(b) the non-inventor has no incentive to preempt his rival at all since $F_j(x^*_{lj}) \geq L_j(x^*_{lj})$. It can be shown that opposing to the change of strategies of the non-inventor from preemption to maturation the inventor's dominant adoption strategy does not change as the technological headstart rises.

Lemma 2 *If the technological headstart rises the non-inventor's dominant strategy changes from preemption to maturation while the inventor's dominant strategy always is preemption.*

Proof: The preemption-conditions for the firms can be derived by inserting their profit maximizing quality levels x_{lk}^*, $k = i, j$ as stated in equations (8) and (10) into $L_k(x_{lk}^*) > F_k(x_{lk}^*)$, $k = i, j$. Solving for γ yields the critical condition for the technological headstart. For the non-inventor it is

$$\gamma < \frac{1}{r} \ln \left[e - \frac{A_h}{A_m} \right] \equiv \gamma^p. \tag{12}$$

If and only if $\gamma^p > 0$ both strategies, preemption and maturation, exist for the non-inventor. Preemption prevails whenever $\gamma < \gamma^p$ and as the technological headstart rises above γ^p the dominant adoption strategy of the non-inventor changes to maturation. Rearranging $\gamma^p > 0$ yields a critical condition for consumer diversity[4]

$$\frac{a}{b} > 2 - \frac{3}{2}\sqrt{e-1}. \tag{13}$$

Solving the preemption condition for the inventor, $L_i(x_{li}^*) > F_i(x_{li}^*)$, for γ results in $\gamma > \ln[e - \frac{4}{9}(2 - \frac{a}{b})^2]/(-r)$. Due to condition (13), the right hand side of this inequality is always negative so the preemption-condition for the inventor is fulfilled for all $\gamma \geq 0$. ■

According to *Lemma 2* whenever $\gamma \geq \gamma^p$ maturation is the dominant strategy of the non-inventor while the inventor follows a preemptive strategy trying to realize x_{li}^*. Following his dominant strategy the non-inventor either lets the quality of the basic invention mature up to the point in time where he can reach his profit maximizing quality, x_{lj}^*, realizing overall profits $L_j(x_{lj}^*)$ or he waits until the inventor enters with his profit maximizing quality x_{li}^*. By entering as second adopter he then would realize overall profits $F_j(x_{li}^*)$. The actual maturation strategy of the non-inventor thus depends on the respective height of the profits that he can realize.

Lemma 3 *If the technological headstart is very high, the non-inventor prefers to be second adopter and waits until the inventor adopts his profit maximizing quality* x_{li}^*.

Proof: Rearranging $F_j(x_{li}^*) \geq L_j(x_{lj}^*)$ yields the implicit solution for the critical height of the technological headstart γ,

$$\gamma \geq \frac{1}{r} \ln \left[e - \frac{A_h}{A_m} \, e^{-r(x_{li}^* - x_{lj}^*)} \right] \equiv \gamma^m. \tag{14}$$

[4]Note that this condition corresponds to the preemption-condition for symmetric firms as stated by *Dutta et al.* (1995).

As $e^{-r(x^*_{li}-x^*_{lj})} < 1$ it is always true that $\gamma^m > \gamma^p$. Since for all $\gamma > \gamma^p$ the non-inventor follows a maturation strategy he will choose between the two possible strategies *wait until* x^*_{lj} if $\gamma < \gamma^m$ since then $F_j(x^*_{li}) < L_j(x^*_{lj})$ and *wait until* x^*_{li} if $\gamma \geq \gamma^m$ since then $F_j(x^*_{li}) \geq L_j(x^*_{lj})$. ■

Obviously Figure 1(b) depicts a situation where the non-inventor realizes higher profits by leaving the first move to the inventor than by adopting first himself as here evidently $F_j(x^*_{li}) \geq L_j(x^*_{lj})$ holds.
With the results stated in *Lemmata 1* to *3* the unique and stable subgame perfect Nash equilibria of this game of dynamic quality competition can be derived. An equilibrium in which both firms preempt each other is defined as a *preemption equilibrium* while an equilibrium where at least one firm lets the basic invention mature up to a certain quality is defined as a *maturation equilibrium.* Note that these Nash equilibria exist if and only if the market is completely covered.

Proposition 1 *This dynamic game of quality competition with asymmetric firms has three unique subgame perfect Nash Equilibria given that consumer diversity is sufficiently wide:*

i) *a* preemption *equilibrium with* $x^p_i = x^I_j$ *and* $x^p_j = x^I_j + \frac{1}{r}$ *whenever* $\gamma < \gamma^p$*,*

ii) *a* maturation I *equilibrium with* $x^{mI}_i = x^*_{lj} - \epsilon$ *and* $x^{mI}_j = x^*_{lj} - \epsilon + \frac{1}{r}$ *whenever* $\gamma^p \leq \gamma < \gamma^m$*,*

iii) *a* maturation II *equilibrium with* $x^{mII}_i = x^*_{li}$ *and* $x^{mII}_j = x^*_{li} + \frac{1}{r}$ *whenever* $\gamma^m \leq \gamma$

with $\gamma^p = \frac{1}{r}\ln\left[e - \frac{A_h}{A_m}\right]$ *and* $\gamma^m = \frac{1}{r}\ln\left[e - \frac{A_h}{A_m}\, e^{-r(x^*_{li}-x^*_{lj})}\right]$.

Proof: *i) preemption equilibrium* - From *Lemmata 1* and *2* we know that if $\gamma < \gamma^p$ both firms follow a preemption strategy and that in this case the inventor will always win the preemption race. Thus in equilibrium the inventor markets the quality $x^p_i = x^I_j$ whereas the non-inventor optimally differentiates as stated in equation (5) and adopts the quality $x^p_j = x^I_j + 1/r$.

ii) maturation I equilibrium - As stated in *Lemma 3* the non-inventor's adoption strategy changes from preemption to maturation for $\gamma \geq \gamma^p$. Then two possible strategies may prevail as analyzed in *Lemma 3.* Whenever $\gamma < \gamma^m$ the non-inventor aims at being the first adopter with the quality x^*_{lj}. The inventor anticipates this behavior and, as he always follows a preemption strategy, he preempts his rival by adopting a quality just marginally below, $x_i^{mI} = x_{lj}^* - \epsilon$. The non-inventor has no incentive to deviate from his optimum differentiation level as second adopter, $x_j^{mI} = x_{lj}^* - \epsilon + 1/r$, since preempting the inventor would yield lower profits, $L_j(x_{lj}^* - 2\epsilon) < F_j(x_{lj}^* - \epsilon)$, as well as adopting a slightly higher quality would yield lower profits, $L_j(x_{lj}^*) < F_j(x_{lj}^* - \epsilon)$.

iii) maturation II equilibrium - According to *Lemma 3* whenever $\gamma \geq \gamma^m$ the non-inventor aims at being the second adopter and waits until the inventor adopts his profit maximizing quality x_{li}^* since $F_j(x_{li}^*) \geq L_j(x_{lj}^*)$. In this case the inventor is able to reach his profit maximizing quality level $x_i^{mII} = x_{li}^*$ and the non-inventor optimally differentiates by choosing $x_j^{mII} = x_{li}^* + 1/r$. ■

To assure that the market for differentiated quality goods is completely covered for these equilibria the consumer with the lowest taste parameter has to realize a positive net utility from buying the low quality good, $ax_l - p_l \geq 0$. Inserting p_l as stated in equation (3) and rearranging yields

$$x_l \geq \frac{1-2c}{3cr} \tag{15}$$

with $c \equiv a/b$. In the respective equilibria the low quality takes the values $x_l = \{x_j^I, x_{lj}^* - \epsilon, x_{li}^*\}$. As $\partial x_j^I / \partial \gamma > 0$ and $\partial x_{li}^* / \partial \gamma > 0$ if the market coverage condition holds for the respective minimum values $x_j^I\big|_{\gamma=0}$ and $x_{li}^*\big|_{\gamma=0}$ it is always fulfilled for all values with $\gamma > 0$. Substituting $x_j^I\big|_{\gamma=0}$ into the critical condition (15) and rearranging terms leads to the restriction that consumer diversity has to exceed a critical level, $c \geq 0.2382$, for the market to be covered. Substituting $x_{li}^*\big|_{\gamma=0}$ into the market coverage condition as stated in equation (15) yields the critical level for consumer diversity, $c > 0.2108$.
The case is different for $x_l = x_{lj}^* - \epsilon$ since $\partial x_{lj}^* / \partial \gamma < 0$. Inserting $x_l = x_{lj}^* - \epsilon$ into equation (15) solving for γ and letting $\epsilon \rightarrow 0$ yields

$$\gamma < \frac{1}{r} ln \left[\frac{3e(5c-1)}{19c - 3 - 16c^2(1-c)} \right] \equiv \tilde{\gamma}.$$

Note that for $c > 0.2108$ it is always true that $\tilde{\gamma} > \gamma^p$. Thus a *maturation I* equilibrium with $x_l = x_{lj}^* - \epsilon$ can exist whenever the market coverage condition for a *maturation II* equilibrium is fulfilled. Consequently, if $c > 0.2382$ all three unique Nash equilibria exist.

3 The patenting decision

An incentive to patent exists in every situation where the inventor is not able to adopt his profit maximizing quality level, x^*_{li}. As the precedent analysis showed this is the case in a *preemption* equilibrium and in a *maturation I* equilibrium. Thus $x_i^S = \{x_i^p, x_i^{mI}\}$ describes all secrecy equilibrium qualities that induce an incentive to patent. If the inventor patents his basic invention the non-inventor is deterred from adopting the new technology up to a certain quality level that is characterized by the height of the patent[5], $\phi \in]x_i^S, x^*_{li}]$. Consequently a patent enables the inventor to choose a higher quality level than with secrecy, $\phi > x_i^S$. As $\partial L_i / \partial x_i > 0$ for $x < x^*_{li}$, the inventor will always profit from this *protective effect* of a patent. Note that in case of a patent the choice variables of the firms carry the superscript ϕ. With a patent the inventor will adopt the quality that corresponds to the height of the patent, $x_i^\phi = \phi$ since this maximizes his profits.

The *protective effect* of a patent is determined by the increase of the inventor's profit resulting from the possibility of adopting a higher quality than without a patent, $\phi > x_i^S$,

$$\Delta^+ = L_i(\phi)|_{\gamma>0} - L_i(x_i^S)|_{\gamma>0}. \tag{16}$$

This positive *protective effect* is opposed by the negative effect arising from the disclosure requirement of a patent. Understanding a patent in the sense of *Denicolò*, *Franzoni* (2004) as a contract between the inventor and society, the inventor is granted an exclusive property right in exchange for the disclosure of all technological information concerning the protected invention. By the required disclosure the inventor loses his initial technological headstart, $\gamma = 0$. Consequently, as the non-inventor is now able to enter at an earlier point in time, $t_j^\phi(x) = x$, instead of $t_j^S(x) = x + \gamma$, the duration of the monopoly of the patent holder is narrowed. This negative patenting effect corresponds to the difference between the profit of the inventor when a positive technological headstart exists, $\gamma > 0$, and his profit when both firms face symmetric adoption abilities[6], $\gamma = 0$,

$$\Delta^- = L_i(\phi)|_{\gamma>0} - L_i(\phi)|_{\gamma=0}. \tag{17}$$

[5]To my knowledge *van Dijk* (1996) was the first to use this term to describe the quality range that is protected by a patent. Note that patent height does not necessarily correspond to the length of a patent. To isolate the strategic effect of patent height the length of a patent, τ_ϕ, is assumed to be greater than the time that is necessary to develop a quality that lies outside the protected quality range, $\tau_\phi > t(\phi + \epsilon)$.

[6]Changing this assumption to capture the fact that a patent might not lead to a total disclosure does not change the qualitative results of the subsequent analysis. Actually $\gamma > 0$ in spite of a patent would lead to a higher critical level of the technological headstart as defined in Proposition 2.

Combining the *protective* and the *disclosure effect* yields the overall effect that patenting has on the profit of the inventor, $\Delta_\phi = \Delta^+ - \Delta^-$. Inserting equations (16) and (17) this patent effect can be derived as

$$\Delta_\phi = L_i(\phi)|_{\gamma=0} - L_i(x_i^S)|_{\gamma>0}.$$

Whenever Δ_ϕ is positive the *protective effect* overcompensates the *disclosure effect* so that the inventor has an incentive to patent since this increases his overall profits. Inserting the profit function $L_i(\cdot)$ as defined in equation (9) and taking into account that Δ_ϕ is additively separable into the alternation a patent causes in the temporary monopoly and the alternation it causes in the subsequent duopoly yields

$$\Delta_\phi = \Delta_M + \Delta_D \tag{18}$$

with

$$\Delta_M \equiv A_m((e^{-rt_i^\phi} - e^{-rt_j^\phi})\phi - (e^{-rt_i^S} - e^{-rt_j^S})x_i^S)/r \tag{19}$$

$$\Delta_D \equiv A_l(e^{-rt_j^\phi} - e^{-rt_j^S})/r^2. \tag{20}$$

While the adoption date of the non-inventor in an equilibrium with secrecy, t_j^S, is dependent on the extent of the technological headstart, in case of a patent it is dependent on patent height with $\partial t_j^\phi/\partial\phi > 0$. Obviously, if patent height is chosen so that the adoption date of the non-inventor is the same with and without a patent $t_j^\phi = t_j^S$, namely $\phi = x_i^S + \gamma$, the overall patent effect solely consists of the patent effect in monopoly, $\Delta_\phi = \Delta_M$. Additionally using the established equilibrium interrelations $t_j^\phi = t_i^\phi + 1/r$ and $t_j^S = t_i^S + 1/r + \gamma$ equation (18) can be rewritten as

$$\Delta_\phi\big|_{t_j^\phi = t_j^S} = \frac{A_m\left((e-1)\,\phi - (e^{1+r\gamma} - 1)\,x_i^S\right)}{e^{rt_j^S}\,r}. \tag{21}$$

With this functional form of the overall patent effect it is possible to derive a critical level for the technological headstart that determines whether the inventor patents his basic invention or not. Recall that this dynamic game of technology adoption has three unique equilibria if patents are absent: a *preemption* equilibrium and two *maturation* equilibria. As one would expect the patenting behavior is different in the respective cases.

Proposition 2 *In this dynamic game of technology adoption the decision between patenting and keeping the basic invention secret crucially depends on the extent of the technological headstart of the inventor:*

i) in a preemption equilibrium the inventor will patent his basic invention whenever $\gamma \leq \gamma^p_\phi$.

ii) in a maturation I equilibrium the inventor will patent his basic invention whenever $\gamma > \gamma^m_\phi$.

iii) in a maturation II equilibrium the inventor will never patent.

Where

$$\gamma^p_\phi \equiv \frac{1}{r} \ln \left[\frac{1}{2eA_l} (\alpha_0 - \sqrt{\alpha_0^2 - 4eA_l(A_h + A_m(e-1)re\phi)}) \right] \quad (22)$$

$$\gamma^m_\phi \equiv \frac{1}{r} \ln \left[\frac{1}{2e\alpha_2} (\alpha_1 + \sqrt{\alpha_1^2 - 4e^2\alpha_2 A_m(1 + (e-1)r\phi)}) \right] \quad (23)$$

with $\alpha_0 \equiv A_l + eA_h + A_m(e-1)r\phi$, $\alpha_1 \equiv A_l + A_m(1 + e^2 + (e-1)r\phi)$ *and* $\alpha_2 \equiv A_l + A_m$.

Proof: *i) preemption equilibrium* - The inventor will patent whenever $\Delta_\phi\big|_{t^\phi_j = t^S_j} \geq 0$. Solving for γ and rearranging terms yields $\gamma \leq \gamma^p_\phi$ as stated in equation (22). A *preemption* equilibrium requires $\gamma < \gamma^p$ (*Proposition 1*) so that if $\gamma^p_\phi < \gamma^p$ holds, patenting and secrecy may occur. Obviously $\partial\Delta_\phi\big|_{t^\phi_j = t^S_j}/\partial\phi > 0$ and consequently $\partial\gamma^p_\phi/\partial\phi > 0$. Then a function $\Omega^p \equiv \gamma^p - \gamma^p_\phi > 0$ must be monotonically decreasing in ϕ reaching its minimum when patent height ϕ reaches its maximum. Inserting $\phi = x^*_{li}$ into $\Omega^p(\cdot) > 0$ and rearranging terms yields

$$\frac{a}{b} > 2 - \frac{3}{2}\sqrt{e-1}$$

which is equal to the necessary condition for a preemption equilibrium as stated in equation (13). So for all $\phi < x^*_{li}$ it is true that $\gamma^p_\phi < \gamma^p$.

If $t^\phi_j > t^S_j$ ($t^\phi_j < t^S_j$) the inventor patents more (less) whenever $\phi > A_l/(A_m r)$ since then $\partial\Delta_\phi/\partial t^\phi_j > 0$. If $\phi < A_l/(A_m r)$ the inventor patents less (more) if $t^\phi_j > t^S_j$ ($t^\phi_j < t^S_j$) since in this case $\partial\Delta_\phi/\partial t^\phi_j < 0$.

ii) maturation I equilibrium - Solving $\Delta_\phi\big|_{t^\phi_j = t^S_j} > 0$ for γ and rearranging terms yields $\gamma > \gamma^m_\phi$ as stated in equation (23). A *maturation I* equilibrium

requires $\gamma^m > \gamma \geq \gamma^p$ (*Proposition 1*) so that if $\gamma_\phi^m \lesseqgtr \gamma^m$ and $\gamma_\phi^m > \gamma^p$ hold, patenting and secrecy may occur. Note that $\partial\gamma^m/\partial\gamma > 0$ so that γ^m reaches its maximum as γ approaches its upper limit, $\lim_{\gamma\to 1/r}\gamma^m = 1/r$, while $\gamma_\phi^m < 1/r$ remains unchanged. Thus $\gamma^m\big|_{\gamma\to 1/r} \geq \gamma_\phi^m$ must be true for large values of the technological headstart. In this case patenting ($\gamma > \gamma_\phi^m$) and secrecy ($\gamma \leq \gamma_\phi^m$) may occur in a *maturation I* equilibrium. If on the other hand γ approaches its lower bound, $\lim_{\gamma\to 0}\gamma^m = \gamma^p$ so that it is sufficient to show that $\gamma_\phi^m > \gamma^p$. In this case secrecy prevails in a *maturation I* equilibrium. Define $\Omega^m \equiv \gamma_\phi^m - \gamma^p$. As $\partial\Omega^m/\partial\phi = \partial\gamma_\phi^m/\partial\phi > 0$ the minimum of the function $\Omega^m(\cdot)$ is reached when $\phi = 0$. It can be shown that $\Omega^m\big|_{\phi=0} > 0$ so that for all $\phi > 0$ it must be true that $\Omega^m > 0$ and thus $\gamma_\phi^m > \gamma^p\ (= \gamma^m\big|_{\gamma\to 0})$. In this case the inventor will never patent in a *maturation I* equilibrium.
For $t_j^\phi \neq t_j^S$ patenting behavior varies in the same way as stated for the preemption case *i)* above.

iii) maturation II equilibrium - In a *maturation II* equilibrium the inventor realizes $x_i^{mII} = x_{li}^*$ so that the *protective effect* of a patent as stated in equation (16) is smaller than or equal to zero. Consequently, the overall patenting effect can never be positive so the inventor never patents in a *maturation II* equilibrium. ■

Figures 2 and 3 illustrate[7] these results for $\phi = x_{li}^*$ and $t_j^\phi = t_j^S$. As stated in *Proposition 1* this game of technology adoption has a *preemption* equilibrium whenever $\gamma < \gamma^p$ which means that all parameter constellations below the γ^p-curve in Figure 2 lead to an adoption quality $x_i^p = x_j^I$ of the inventor if the basic invention is not patented. As $\Delta_\phi\big|_{t_j^\phi=t_j^S} = \Delta_M$ the γ_ϕ^p-curve defines all combinations of a/b and γ for which the *protective* and the *disclosure effect* compensate each other and thus the patent effect equals zero. Clearly this curve lies within the area that constitutes a *preemption* equilibrium so that the patenting decision depends on the extent of the technological headstart. If the technological headstart is small the *protective effect* dominates the *disclosure effect* and the inventor profits from patenting his basic invention. This is the case in the hatched area of Figure 2. In the extreme case of $\gamma = 0$ the inventor will always patent his invention in a *preemption* equilibrium since this protects him from a preemptive adoption by his competitor with the *disclosure effect* being absent. If the technological headstart exceeds the critical value γ_ϕ^p, as is the case between the γ_ϕ^p-curve and the γ^p-curve,

[7] Note that for figures 2 and 3 the range of consumer diversity, a/b, is chosen such that market coverage and thus the existence of all three unique Nash equilibria is ensured.

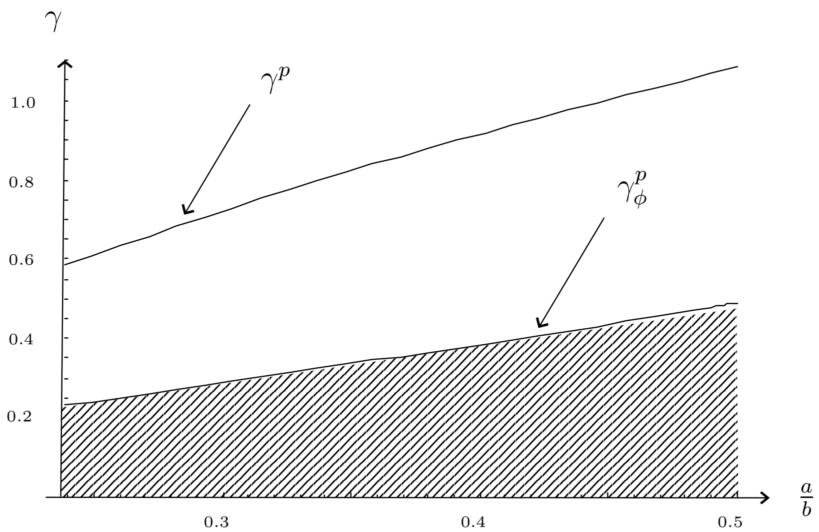


Figure 2: Patenting behavior in a preemption equilibrium, $r = 0.5$

the *disclosure effect* outweighs the *protective effect* and the inventor prefers to keep his invention secret.

Figure 3 shows the critical values of the technological headstart concerning the patenting decision in the *maturation* equilibria. Recall that γ^m represents an implicit solution to the maturation condition $F_j(x_{li}^*) \geq L_j(x_{lj}^*)$ (*Lemma 3*) so naturally the appearance of the γ^m-curve varies with different $\gamma-$values: Each γ^m-curve is only valid for one particular value of the technological headstart which is represented by a horizontal dotted line in Figure 3. The two values $\underline{\gamma} = 0.85$ and $\bar{\gamma} = 1.95$ are chosen to illustrate all possible cases stated in *Proposition 2 ii)* and *iii)*. If the technological headstart is rather small, $\underline{\gamma} = 0.85$, and consumer diversity is relatively large (areas I and II) then $\underline{\gamma}$ is greater than $\gamma^m\big|_{\underline{\gamma}}$ so that a *maturation II* equilibrium prevails in which the inventor never patents. As consumer diversity becomes smaller (a/b rises) $\gamma^m\big|_{\underline{\gamma}}$ rises so that $\underline{\gamma}$ is now smaller than the critical value $\gamma^m\big|_{\underline{\gamma}}$. Consequently in area III the necessary condition for a *maturation I* equilibrium, $\gamma^m\big|_{\underline{\gamma}} > \underline{\gamma} \geq \gamma^p$, holds. Recall that the γ_ϕ^m-curve represents all parameter values for which the *protective* and the *disclosure effect* exactly compensate each other so that the patent effect is zero. If γ moves below (above) the γ_ϕ^m-curve the *protective effect* decreases (increases) more than the *disclosure effect* as $\partial\Delta^+/\partial\gamma > \partial\Delta^-/\partial\gamma$. Consequently, as $\underline{\gamma} < \gamma_\phi^m$ the

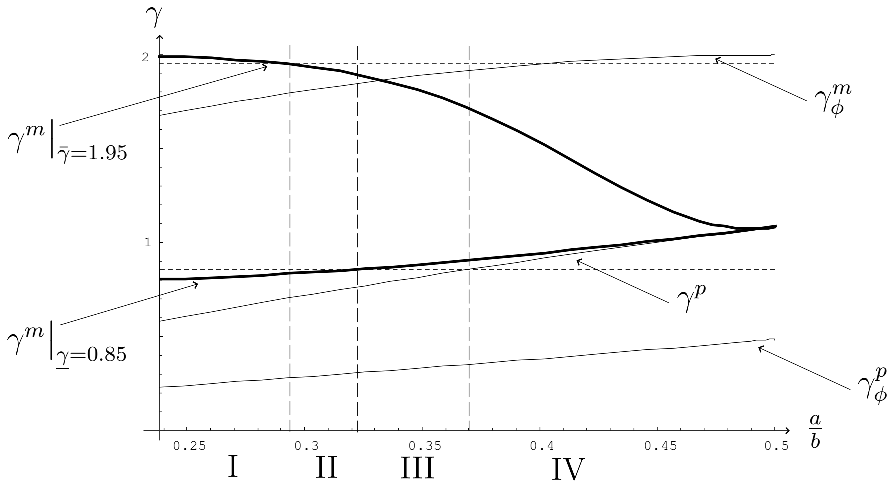


Figure 3: Patenting behavior in the maturation equilibria, $r = 0.5$

inventor refrains from patenting in the *maturation I* equilibrium in area III since the *protective effect* is outweighed by the *disclosure effect.* For a very narrow diversity of consumers (area IV) $\underline{\gamma}$ is even smaller than γ^p so that a *preemption* equilibrium prevails.

The case is different if the technological headstart is high. As $\bar\gamma = 1.95$, represented by the upper dotted horizontal line, is greater than γ^p for all values of consumer diversity, a/b, a *preemption* equilibrium never occurs. If consumer diversity is large (area I) $\bar\gamma$ fulfills the condition for a *maturation I* equilibrium as $\gamma^m > \bar\gamma \geq \gamma^p$. Since additionally $\bar\gamma$ lies in the parameter area where the *protective effect* of a patent exceeds its *disclosure effect*, $\bar\gamma > \gamma^m_\phi$, the inventor will patent his basic invention in area I. As consumer diversity becomes smaller (areas II-IV) the critical height of the technological headstart $\gamma^m\big|_{\bar\gamma}$ decreases so that the condition for a *maturation II* equilibrium, $\bar\gamma > \gamma^m\big|_{\bar\gamma}$, is fulfilled. Since in this case the inventor can realize his profit maximizing quality x^*_{li} he will not patent his basic invention in areas II-IV.

As the preceding observations show, the technological headstart as well as the diversity of consumers are decisive for the strategic decision between a patent and secrecy. The central results are twofold: if secrecy leads to a *preemption* equilibrium then a higher technological headstart leads to an intensive increase of the *disclosure effect* so that the inventor refrains from patenting for high values of γ. If secrecy leads to a *maturation I* equilibrium then a higher technological advantage leads to a boost of the *protective effect* so that it even overcompensates a relatively high *disclosure effect*. In this case the inventor patents his basic invention for high values of γ.

4 Patenting and Welfare

The analysis of the patenting decision of an inventor leaves the question whether a patent is socially desirable or not. As the height of a patent is left to policy decisions, investigating this question might lead to careful implications on the design of this parameter. Naturally, a first step has to be the determination of a social welfare function in the underlying model of dynamic technology adoption. In the subsequent welfare considerations only the preemption case with the inventor as early adopter will be considered. Recall that this means that the inventor will enter the market as monopolist in t_l adopting the product at a low quality whereas the non-inventor enters at t_h adopting a high quality. This unambiguousness allows us to drop the subscripts i and j. Consumers thus face monopoly and subsequently duopoly so that consumer surplus amounts to

$$\begin{aligned}\mathrm{CS} &= \int_{t_l}^{t_h} e^{-rt} \int_{p_m/x_l}^{b} (\theta x_l - p_m)\, d\theta\, dt \\ &+ \int_{t_h}^{\infty} e^{-rt} \left(\int_{a}^{\theta^0} (\theta x_l - p_l)\, d\theta + \int_{\theta^0}^{b} (\theta x_h - p_h)\, d\theta \right) dt\end{aligned}$$

where the first summand depicts the consumer's surplus during monopoly and the second summand their surplus during duopoly. The producer's surplus consisting of the overall profits of the two firms over time equals

$$\mathrm{PS} = \int_{t_l}^{t_h} e^{-rt} \pi_m dt + \int_{t_h}^{\infty} e^{-rt} (\pi_l + \pi_h)\, dt.$$

Inserting equilibrium prices, quality levels and profits derived in the previous sections, solving the integrals, summing up and collecting terms yields the social welfare function

$$\mathrm{W} = \frac{1}{8\,r} \left[3\, b^2\, e^{-rt_l} + (b^2 - 4a^2)\, e^{-rt_h} \right]. \tag{24}$$

The derivatives of this function with respect to the adoption dates t_h and t_l are both negative so that an early date of the first technology adoption as well as a small level of differentiation are socially desirable. As stated in the following Proposition a patent may be welfare enhancing although it delays the date of the first adoption.

Proposition 3 *Patenting the basic invention increases (decreases) social welfare if a technological headstart exists, $\gamma > 0$, and $\phi < \phi^W$ ($\phi \geq \phi^W$). Where*

$$\phi^W = x^I + \gamma - \frac{1}{r}\, ln \left[\frac{4a^2 - b^2(1+3e^{1+r\gamma})}{4a^2 - b^2(1+3e)}\right].$$

In the absence of a technological headstart, $\gamma = 0$, a patent is welfare decreasing.

Proof: If the inventor decides to patent, his date of adoption depends on the height of the patent, $t_i^\phi = \phi$, as does the adoption date of the non-inventor, $t_j^\phi = \phi + 1/r$. Substituting these adoption dates into equation (24) yields $\mathrm{W}^\phi = [\,3\,b^2\,e^{-r\phi} + (b^2 - 4a^2)\,e^{-r(\phi+1/r)}]/(8\,r)$. If the inventor refrains from patenting his adoption strategy is $t_i^S = x^I$ and the non-inventor reacts by adopting in $t_j^S = x^I + 1/r + \gamma$. Substituting these adoption times into equation (24) results in the welfare realized when the basic invention is not patented, $\mathrm{W}^S = [\,3\,b^2\,e^{-rx^I} + (b^2 - 4a^2)\,e^{-r(x^I+1/r+\gamma)}]/(8\,r)$. Then the effect patenting has on social welfare amounts to $\Delta_\phi^W = W^\phi - W^S$. Inserting W^ϕ and W^S as derived above and rearranging terms yields

$$\Delta_\phi^{\mathrm{W}} = 3\,b^2(e^{-r\phi} - e^{-rx^I}) + (b^2 - 4a^2)(e^{-1-r\phi} - e^{-r(x^I+1/r+\gamma)}). \qquad (25)$$

This patent effect on welfare is zero, $\Delta_\phi^{\mathrm{W}} = 0$, for a patent height of ϕ^{W} as stated in the above Proposition. In the absence of a technological headstart, $\gamma = 0$, this critical patent height is $\phi^{\mathrm{W}} = x^I$. A patent of this height would have no *protective effect* at all so the inventor would never patent. Therefore minimum patent height must be $\phi^{min} = x^I + \epsilon$. Since $\partial\Delta_\phi^{\mathrm{W}}/\partial\phi < 0$ the patent effect on social welfare will be positive for all patent heights with $\phi < \phi^{\mathrm{W}}$. As $\partial\phi^{\mathrm{W}}/\partial\gamma > 0$, an increase of the technological headstart would raise the critical level of the patent height that induces a welfare effect of zero, ϕ^{W}. Thus for all $\gamma > 0$ there is a multitude of possible patent heights $\phi \in [x^I + \epsilon, \phi^{\mathrm{W}}[$ that offer a *protective effect* and enhance social welfare. ∎

Recalling *Proposition 2* and the fact that the inventor may refrain from patenting if his technological headstart exceeds a critical level γ_ϕ^p, it is crucial to investigate whether patents actually occur for patent heights that are welfare enhancing. Note that ϕ^{W} as stated in the above *Proposition 3* always exceeds $x^I + \gamma$ since the term in square brackets is smaller than one so that the logarithm always has a negative value. Then $\bar{\phi} = x^I + \gamma < \phi^{\mathrm{W}}$ is a welfare enhancing patent height. As stated in Section 3 the inventor will patent as long as the overall effect of patenting, Δ_ϕ, as stated in equation (18), is positive. Note that $\bar{\phi} = x^I + \gamma$ may lead to both cases, patenting and secrecy, depending on the extent of the technological headstart (see *Proposition 2*). Consequently patent height is indeed a tractable measure to induce a welfare enhancement. But adjusting patent height for welfare reasons is a very complex matter - not only the counter effects of a patent on social welfare have to be considered but also the effects on the inventor's patenting decision: The attempt to enhance social welfare by decreasing patent height may lead to a situation where the inventor completely refrains from patenting.

5 Conclusions

This paper has examined the patenting decision of a successful inventor. In understanding a patent as a contract between an inventor and society (*Denicolò*, *Franzoni* (2004)) we divided the effect a patent has on the profits of an inventor into two parts, a protective and a disclosure effect. The literature so far mostly assumes that a disclosure effect applies only after a patent expires. Before this date the disclosure requirement has no negative consequences for the patentee. We extend this view to include the realistic case that the disclosure requirement affects the patentee from the moment a patent is granted as he loses a technological headstart.
The main contribution of this paper is that we derive a critical level of asymmetry between the firms, i. e. extent of a technological headstart, as the decisive factor concerning the patenting behavior of a successful inventor. Building on *Dutta et al.* (1995) the patenting decision was endogenized in a dynamic model of technology adoption. This game has three unique Nash equilibria, *preemption* and *maturation I* and *II*. The patenting behavior differs in all cases. If both firms follow preemptive strategies in improving the basic invention, a patent will only benefit the inventor if his headstart does not exceed a critical level. If the technological headstart is higher, the *disclosure effect* of a patent absorbs its positive *protective effect* completely - a patent would decrease the profits of the patentee so that he prefers secrecy. In a *maturation II* equilibrium this is always the case. If secrecy leads to a *maturation I* equilibrium then a higher technological headstart leads to such an increase of the *protective effect* that it even overcompensates a relatively high *disclosure effect*. In this case the inventor patents his basic innovation if γ *exceeds* a critical value.

Weakening patent protection by decreasing a patent's height may have positive welfare effects. But possibly a decrease of patent height may have a negative influence on the patenting decision of the inventor. If he refrains from patenting due to the lower patent height a policy attempt would be in vain. Thus any policy implications have to be considered with great care cautiously taking into account specific market conditions.

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