The Research Use Exemption from Patent Infringement and the Propensity to Patent

Alexandra K. Zaby* and Diana Heger†

this version: March 20, 2013 – preliminary, please do not quote –

Abstract

A research use exemption excludes specific uses of patented know-how for research purposes from infringement claims, such that the input of patented knowledge in the research process of third parties is legalized. This article explores the effects of the research use exemption on R&D expenditures and on the propensity to patent. We distinguish between two alternative regimes following the legal implementation of a research use exemption in the U.S. and in Europe, respectively. For this we endogenize the patenting decision of early inventors in the context of cumulative innovation. Unlike earlier approaches concerned with the patenting decision, we take into account that the existence of a research use exemption possibly increases legal certainty, meaning that the probability to get prosecuted decreases. We find that strengthening the research use exemption increases R&D investments but decreases the propensity to patent.

Keywords: cumulative innovation, research use exemption, patenting decision, patent race

JEL Classifications: O31, O24, L24, D21

*University of Tuebingen, Faculty of Economics, Mohlstraße 36, D-72074 Tuebingen, Germany. E-mail: alexandra.zaby@uni-tuebingen.de

†Centre for European Economic Research, L7, 1, D-68165 Mannheim, Germany. E-mail: heger@zew.de

1 Introduction

The protective effect of patenting stems from a legal prohibitive right against third parties (see e.g. 35 U.S.C. §271 a). A patent protects newly generated knowledge from expropriation by others as it forbids making, using, offering, selling or importing the patented matter.
But besides protecting intellectual property, patents have the function of disclosing proprietary knowledge. For the sake of technological progress, many countries enhance this disclosure effect of patents by explicitly or implicitly exempting the input of patented knowledge in third parties' research processes. This is referred to as the research use exemption (RUE) from patent infringement. We take a distinguished look at the legal aspects of the RUE in Section 2. The motivation behind the implementation of a RUE is that building on existing, patented knowledge enhances the creation of new knowledge about the patented matter, possibly spurring the discovery of follow-on technologies. The RUE dates back to the case Whittemore v. Cutter in the year 1813[1] where it is stated that it would have been the intention of legislature to exempt actions of the ones

> *"...who constructed such a machine merely for philosophical experiments, or for the purpose of ascertaining the sufficiency of the machine to produce its described effect."*

This paper is motivated by the ongoing discussion in many countries about statutorily implementing a research exemption and about the effects thereof. From an economic perspective they are manifold. For example, one main criticism against a narrow implementation of a research use exemption is that it hinders technological progress by impeding competitors' access to patented knowledge. In this article, we additionally take into account that early inventors may even *refrain* from patenting when they are confronted with a broadly defined, strong research use exemption, as then competitors may legally use the patented knowledge as input in their own research activities. For the purpose of this paper, we distinguish two different types of infringement in order to better capture the impacts of a research exemption: *input* and *output* infringement. Typically, infringements are associated with imitations or too closely related variations of a product on the product market. We denote this type of infringement as *output-infringement*. In this paper, we want to examine the effects of a research use exemption on the propensity to patent and the technological progress. Hence, we need to take into account a different type of infringement which we denote *input-infringement*. This

[1]See 29 F.Cas. 1120, 1121 (C.C.D. Mass. 1813).

infringement takes place on the market for ideas and captures infringements which are the basis (or input) of a research process. Depending on the extent of the implemented research use exemption input infringements are exempted from infringement claims.

Following empirical evidence, we assume that the mandatory disclosure of knowledge, inherent to every patent system, has a negative impact on the patenting decision (see e.g. Cohen et al. (2000), Heger and Zaby (2009)). Our understanding is that, contingent on the existence of a research exemption, the use of this disclosed information as an essential input in the research activities of follow-up inventors is found to be legal or not. Whenever a research exemption does not exist or its effectiveness is insecure, inventors building upon previous, patented inventions face the risk of being sued by the patents' owners. Naturally, this risk affects their investment choices. To be able to analyze these issues we introduce the effects of a RUE into a stylized model of cumulative innovation in a patent race setting, in which the possibility of output-infringement is ruled out:

Ex-ante asymmetric firms compete in achieving a cumulative inventions in a R&D race with free entry. The leader holds an invention which gives him a technological headstart implying a higher probability to win the race compared to his competitors. Before the race, the leader decides whether to patent his invention or to keep it secret. Only with a patent the leader may earn positive profits until a follow-up innovation replaces his product. With secrecy, reverse engineering leads to immediate market entry of rivals driving profits to zero. Besides the height of his own R&D investment, the followers' probability to win the race depends on the leader's headstart and the strength of the research use exemption. This strength is determined by two parameters: The legal certainty that an input-infringement will not be prosecuted, and the enhancement of technology diffusion which is subject to innovation- and industry-specific characteristics. For the analysis, we compare two regimes:

(*i*) Probabilistic RUE, where the legal certainty concerning the RUE varies, and

(*ii*) Dependable RUE, where legal certainty is given.

Our main finding is that strengthening the RUE in both regimes leads to an increase of overall R&D investments but at the same time leads to a decrease of the propensity to patent.

To our best knowledge, besides own previous work, no theoretical literature and only very sparse empirical literature exists which analyzes the impact of a research use exemption on patenting activity.

In two related papers, Nagaoka and Aoki (2006, 2007), building on Scotchmer (2004) analyze the effect of a research use exemption on the R&D activities of firms, whereas the patenting decision itself is not considered. They find that a research exemption spurs technological progress but disregard the impact of the research exemption on the propensity to patent. Thumm (2003) provides the only empirical survey which explicitly includes an investigation of the research use exemption. For the Swiss biotechnology sector, he finds that participants consider the introduction of a broad research use exemption relatively beneficial. He finds two main reasons as substantial for this positive assessment: a broad research use exemption increases the access to genetic inventions, and it promotes the dissemination of technology.
Most of the economic literature implicitly assumes that a research use exemption does not exist (or has a very low impact), as the disclosure effect of a patent is disregarded. Our work relates to several contributions which also consider that patenting has a disclosure effect, but disregard the legal implementation of a research use exemption (see e.g. Scotchmer and Green (1990), Bhattacharya and Guriev (2006), Aoki and Spiegel (2009)). Our model setting is related to that presented in Erkal (2005) and Denicolò (2000). Both analyze the welfare aspects of alternative patent regimes in a setting of two consecutive R&D races.
Our analysis proceeds as follows. In the following Section 2 we lay out the legal differences regarding the implementation of a RUE in Europe and the U. S. and relate them to our theoretical set up. Section 3 introduces the theoretical model, beginning with the analysis of the R&D race in Section 3.1 and proceeding with the analysis of the patenting decision in Section 3.2. Section 4 concludes. All proofs can be found in the Appendix.

2 Legal implementation and theoretical approach

Most countries have implemented a research use exemption, its extent, however, depends on the respective juridical system. A central difference is whether a research exemption is implemented in common law jurisdiction, or whether it is part of a country's statutory law. Two major representatives of the alternative regimes are the U.S. and Germany. In the U.S. a specific statutory exemption was introduced in 1984 by the Patent Term Restoration and Drug Price Competition Act (Hatch-Waxman Act) by implementing 35

U.S.C. § 271 (e) (1)[2]:

> *"It shall not be an act of infringement to make, use, offer to sell or sell within the United States or import into the United States a patented invention ... solely for uses reasonably related to the development and submission of information under a Federal law which regulates the manufacture, use, or sale of drugs or veterinary biological products".*

This act allows generic drug companies to conduct research on and test patented compounds for clinical trials before the end of the patent term. Since the clinical trial phase usually takes several years, a denial of the exemption would lead to a de facto prolongation of the patent term and may assure the patent holder with an expanded monopoly period beyond the patent term. This allows generic drug producers to enter the market at the time of the compound patent's expiry. For all other fields, the research use exemption is part of common law jurisdiction where the definition of its extent depends on the courts and may differ from case to case. This naturally creates uncertainty for the firms using patented knowledge as input in their research activities.
In Germany § 11 PatG defines one of the broadest research use exemptions. This exemption includes all non-commercial research and trial activities as well as the research *on* the patented subject. Research *with* the patented matter remains an infringing action.[3] Furthermore, § 11 PatG was extended by the Supreme Court's decisions "Clinical Trials I" and "Clinical Trials II" which exempted the research use of patented compounds for equivalency tests, the provision of information and data for the admission procedures etc. This corresponds to the Hatch Waxman Act in the U.S.[4] These varying extents of a research use exemption are introduced in our theoretical model. The research use exemption legalizes the usage of the disclosed information. How severely this disclosure hurts an innovator is not specified by the research use exemption itself though, but is subject to innovation- and industry-specific characteristics.[5] The second alley through which the implemented research use exemption affects firm behavior is its reliability. Firms

[2]It was introduced after the Roche v. Bolar decision (See 733 F.2d 858, 865 (Fed. Cir. 1984).) in which it was found that "Bolar's intended 'experimental' use is solely for business reasons and not for amusement, to satisfy idle curiosity, or for strictly philosophical inquiry".

[3]Consequently, the use of research tools is not exempted as they are used in the research process as tool and not as knowledge input (see e.g. Holzapfel (2004)).

[4]For a thorough judicial investigation of the research use exemption in Germany and an examination of the court decisions "Clinical Trials I" and "Clinical Trials II" see Holzapfel (2004).

[5]For a discussion of these heterogeneous costs of disclosure see Heger and Zaby (2013).

using patented knowledge as input in their research face the risk of being sued for damages due to this behavior. Given the lack of a legal research exemption, the mere use of patented knowledge by rival firms already constitutes a patent infringement that may be prosecuted by an exogenously given probability, $1 - p$. In the case of prosecution, a firm has to pay a fine to the first innovator.
The strength of the research use exemption is thus driven by two parameters: (i) the legal certainty p that an input-infringement will not be prosecuted, i.e. the research exemption will not be challenged in court, and (ii) the enhancement of technology diffusion.

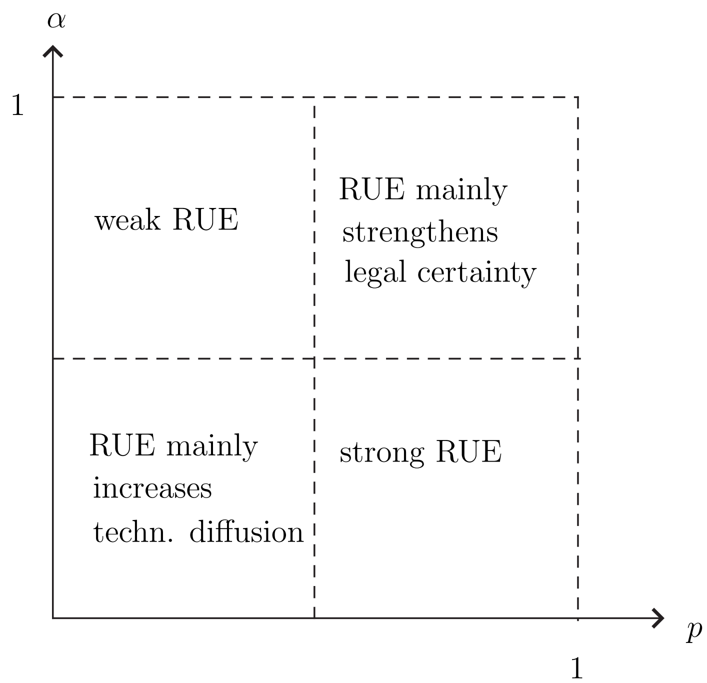

Figure 1: The dimensions of a research use exemption

Figure 1 visualizes the proposed dimensions of a research use exemption. Relating these theoretical definitions to the alternative legal situations described above, the dependable research use exemption as implemented throughout Europe is located at $p = 1$, whereas the rather probabilistic definition implemented in U. S. case law is depicted by the parameter space for $p < 1$. Note that the policy dimension of a research exemption, i.e. the modifiable parameter, is the legal certainty of the use of patented knowledge, whereas the extent of technology diffusion itself is subject to innovation- and industry-specific characteristics. In the following we will denote the U.S. setting a regime of a probabilistic RUE and the European setting a regime of a dependable RUE. On a theoretical basis we analyse how these alternative legal situations influence the propensity to patent and the R&D investments of firms.

3 Model

Propose a research environment where ex-ante asymmetric firms have free entry into a R&D race. One of the firms, the *leader* ℓ, already owns an invention which gives him a technological headstart such that he has a higher probability of winning the race (i.e. a higher hazard rate) than the other firms, the *followers* f. Before the R&D race starts the leader decides how to protect his invention: Only if he patents it, he can earn a positive flow of profits until a follow-up innovation replaces his product (we assume production at zero marginal cost). If he relies on a non-legal protective measure such as secrecy, reverse engineering leads to the immediate entry of rival firms driving profits to null. Hence, with secrecy the innovator cannot realize positive profits from selling the first innovation. As generally assumed in innovation race models, the value of the (follow-up) invention is exogenous and commonly known, while its timing follows a Poisson discovery process (Loury (1979), Lee and Wilde (1980)). Once, before the beginning of the race every participant i decides how much to invest. His R&D investment on the one hand increases his probability of success, on the other hand it creates one-time lump-sum costs of height cx_i where c is the per-unit R&D cost and x_i, denotes the chosen R&D effort level (see Loury (1979)). The common social and private discount rate is given by r. Thus the time structure of the model is as follows: 1. inventor's patenting decision concerning the first innovation, 2. all firms' R&D investment decisions and 3. the R&D race starts.

To keep the model tractable we assume linear hazard functions $h_i(x_i)$. They depend on the chosen intellectual property protection strategy of the leader ℓ, and on the implemented research use exemption. The leader's hazard function is $h_\ell(x_\ell) = x_\ell$ while his rivals by assumption have a lower probability of winning the race with $h_f(x_f) = (1 - \alpha\gamma)x_f$, where γ, $0 < \gamma < 1$, defines the extent of the leader's headstart and α, $0 < \alpha < 1$, captures that a research use exemption allows technology diffusion. Thus, the hazard functions of the leader and his rivals become more similar, the lower the technological headstart of the leader is, or the higher technology diffusion is (i.e. the lower α

is). Our focal interest is the effect of the RUE on R&D investments and on the propensity to patent.
Referring to the regimes introduced in Section 2, we distinguish

- Regime I: probabilistic RUE, ($\alpha < 1$, $p < 1$),
- Regime II: dependable RUE, ($\alpha < 1$, $p = 1$).

We compare these regimes to the situation where the inventor decides to keep his invention secret. This case corresponds to a situation where $\alpha = p = 1$ as a RUE plays no role, and the inventor collects no profits from selling the first innovation.
Whenever the inventor *patents*, potentially two types of infringement could occur: *(i)* An *output-infringement* may take place on the product market, such that a rival firm markets a follow-up product which incorporates some features of the patented innovation. This *output-infringement* needs to be distinguished from *(ii)* an *input-infringement*. Given the lack of a legal research exemption, the mere use of patented knowledge as research input by rival firms constitutes an (input-)infringement. As this analysis focusses on the latter, we rule out the occurrence of illegal output-infringements by assumption. This means that whenever the first innovation is patented and a follower wins the R&D race, its innovation by assumption is independent of the first and thus never infringes the patent.[6] Thus only input-infringements occur and may be prosecuted by an exogenously given probability, $1-p$. The probability of not being prosecuted for the use of patented knowledge, p, is higher, the stronger the legal implementation of a research use exemption is. In the case of prosecution the infringer has to pay a fraction s of his profits as a fine to the initial innovator.

To summarize, we distinguish the two potential protection strategies of the leader:

(a) Secrecy –

  (pro) the inventor maintains his technological headstart, ($\alpha = 1$)

  (con) whenever a rival firm wins the R&D race the first inventor earns null.

(b) Patent –

[6] In the case of an output-infringement the second innovation's characteristics would only differ to a minor extent from the first innovation. Launching such a dependent innovation would require the second innovator to pay a licensing fee to the patentee.

(pro) the innovator earns a positive profit flow from the first innovation; whenever a rival firm wins the race, with probability $1-p$ he has to pay a fine to the initial innovator due to his *input-infringement*[7]

(con) the inventor loses part of his technological headstart ($0 \leq \alpha \leq 1$).

With a patent the followers profit from enhanced technology diffusion whenever a research use exemption is implemented.

3.1 R&D race

The leader's expected profit function at the beginning of the R&D race generally is given by

$$\begin{aligned} \Pi_\ell &= \int_0^\infty e^{-(h_\ell+\sum_f h_f+r)t}(h_\ell v_w + \sum_f h_f v_l + v_1)dt - cx_\ell \\ &= \frac{h_\ell v_w + \sum_f h_f v_l + v_1}{h_\ell + \sum_f h_f + r} - cx_\ell \end{aligned} \tag{1}$$

where $\sum_f h_f$ represents the aggregate hazard functions of the followers, v_w is the profit from winning the race, v_l the profit if the race is lost and v_1 are the (potential) profit flows from the first innovation.

(a) no patent

In the case that the leader refrains from patenting and chooses secrecy to protect his innovation, the RUE plays no role so we have $\alpha = p = 1$ and the hazard functions of the followers are given by $h_f^s(x_f^s) = (1-\gamma)x_f^s$ and for the leader we have $h_\ell(x_\ell) = x_\ell$. Further, the leader receives neither profits from the initial innovation ($v_1 = 0$) nor when a follower wins the race ($v_l = 0$). Inserting these parameter values in equation (1) the expected payoff function of the leader at the beginning of the R&D race is given by

$$\Pi_\ell^s = \frac{x_\ell^s v_w}{x_\ell^s + (1-\gamma)X_f^s + r} - cx_\ell^s, \tag{2}$$

where $X_f^s \equiv \sum_f x_f^s$ represents the aggregate investment of f rival firms participating in the R&D race.

[7]We deliberately narrow down the incentive to patent by disregarding the merits of licensing payments. If we would include dependent follow-on inventions (see Footnote 6), patenting would be more profitable as the patentee would additionally collect licensing income. We disregard this as possible input-infringements would never be prosecuted, because they are already compensated for by paying the licensing fee.

The innovator maximizes Π_ℓ^s with respect to x_ℓ^s. His first order condition yields

$$\frac{v_2}{c_2}\left[(1-\gamma)X_f^s + r\right] = \left[x_\ell^s + (1-\gamma)X_f^s + r\right]^2. \tag{3}$$

The expected profit of a generic rival firm in the R&D race is given by

$$\Pi_f^s = \frac{(1-\gamma)x_f^s v_w}{x_\ell^s + (1-\gamma)X_f^s + r} + cx_f^s. \tag{4}$$

Concerning the followers, due to free entry into the race we can set $\Pi_f^s = 0$.[8] Inserting the leader's first order condition (3) in the zero-profit condition we calculate the aggregate investment of the f participating rival firms as

$$X_f^{s*} = (1-\gamma)\frac{v_w}{c} - \frac{r}{(1-\gamma)}. \tag{5}$$

In line with economic intuition the followers' aggregate investment decreases when the headstart of the innovator, γ, increases.[9] Given this aggregate investment we can easily derive the innovator's investment decision in the R&D race. Inserting X_f^{s*} in equation (3) yields

$$x_\ell^{s*} = \gamma(1-\gamma)\frac{v_w}{c}. \tag{6}$$

Simple comparative statics show that an increase of headstart γ leads to an increase of the optimum investment level of the innovator, if and only if his headstart is sufficiently small, i.e. $\gamma < 1/2$. If his headstart is high, $\gamma \geq 1/2$, the relatively lower hazard rates of the participating rivals give him the opportunity to lower his R&D expenses without significantly decreasing his probability to win the innovation race.
Inserting the aggregate investment X_f^{s*} and the innovator's individual investment x_ℓ^{s*} into equation (2) yields the expected profit of the innovator given that he has not patented,

$$\Pi_\ell^{s*} = \gamma^2 v_w. \tag{7}$$

With secrecy, the inventor's expected profit is increasing in his technological headstart γ.

[8] Denicolò (2000) and Erkal (2005) use this modeling approach in a setting of two consecutive R&D races.

[9] To narrow down the complexity of our analysis allowing us a thorough investigation of our focal issue, the effect of the RUE on R&D investments and the propensity to patent, we only consider cases where leader and followers participate in the R&D race, i.e. $x_\ell > 0$ and $X_f > 0$.

(b) patent

In the case that the first inventor chooses to patent, the followers are able to use the information disclosed in the patent specification as input in their own research, such that the technology leader will lose part of his headstart.[10]

Regime I Given the probabilistic implementation of the RUE, the hazard functions of the followers decrease to $h_f^I(x_f^I) = (1-\alpha\gamma)x_f^I$. The profit of the leader in case that he loses the race, v_l^I, depends on the probability that the winner is prosecuted for an input-infringement, $1-p$, and on the height of the fine he needs to pay in order to compensate the leader, sv_w. Therefore we have $v_l^I = p \cdot 0 + (1-p)sv_w$, such that whenever a successful follower is not prosecuted, the leader receives null, and whenever he is prosecuted the leader receives part of the winner's profits, sv_w.
Thus the leader's expected profit with Regime I is given by

$$\Pi_\ell^I = \frac{x_\ell^I v_2 + (1-\alpha\gamma)X_f^I((1-p)sv_w) + v_1}{x_\ell^I + (1-\alpha\gamma)X_f^I + r} - cx_\ell^I. \tag{8}$$

Due to the assumption that all rival firms use the patent specification describing the leader's innovation, followers commit input-infringements and thus face the threat of prosecution (see footnote 10): If a rival firm wins the R&D race, with risk $1-p$ the research exemption will not hold and it will be prosecuted for its input-infringement. In this case the successful rival has to pay a fine sv_w to the early innovator to reimburse him for his losses. With probability p the input-infringement is found legal due to the research use exemption and the second innovator will not be prosecuted. In this case he receives monopoly profits from selling the second innovation. The expected profit of a generic follower firm with Regime I thus amounts to

$$\Pi_f^I = \frac{(1-\alpha\gamma)x_f^I(pv_w + (1-p)(1-s)v_w)}{x_\ell^I + (1-\alpha\gamma)X_f^I + r} - cx_f^I.$$

Defining $\sigma \equiv 1-(1-p)s$ and $\beta \equiv (1-\alpha\gamma)$ this payoff function simplifies to

$$\Pi_f^I = \frac{\beta x_f^I \sigma v_w}{x_\ell^I + \beta X_f^I + r} - cx_f^I, \tag{9}$$

[10]We assume that followers always take the opportunity and use the patented knowledge as input in their research. This behavior can be derived endogenously: Comparing the ex-ante expected profits of the followers in the cases that they use the patented knowledge or not (i.e. $\alpha < 1$ or $\alpha = 1$), the usage of patented knowledge yields higher profits as long as the fine in case of prosecution is not too high, $s < 1/(1-p)$. We rule out this case by assumption, see the definition of σ below.

where σ can be interpreted as the *threat of punishment*: If at the same time the probability to be prosecuted for an input-infringement and the fine in the case of prosecution, s, are small, the threat of punishment is small. This is the case when parameter σ is high. With a high probability of prosecution $(1-p)\uparrow$ and a high fine s the threat of punishment is high. This case is reflected by a small value of the parameter σ. To exclude cases of extremely high punishment fines greater than 1 we assume $0 \leq \sigma \leq 1$. While the threat of prosecution can be influenced by policy measures, the parameter β reflecting technology diffusion can only be influenced indirectly. Taking the level of the technological headstart of a leader as given, a high parameter β results from a high level of technology diffusion whereas a low value of β reflects low technology diffusion.

Again, due to free entry into the race, we set $\Pi_f^I = 0$ and insert the leader's first order condition which gives us the aggregate investment of the followers as

$$X_f^{I*} = \frac{c(v_1 - rv_w) + \sigma^2\beta^2 v_w^2}{cv_w\sigma\beta}. \tag{10}$$

Given X_f^{I*} the leader's optimal investment in the R&D race yields

$$x_\ell^{I*} = \frac{(1-\beta)\sigma\beta v_w}{c} - \frac{v_1 - (1-\sigma)rv_w}{\sigma v_w}. \tag{11}$$

Inserting x_ℓ^{I*} and X_f^{I*} into Π_ℓ^I gives the leader's expected profit in the R&D race in Regime I

$$\Pi_\ell^{I*} = \frac{\sigma[(1-\sigma) + \sigma(1-\beta)^2]v_w^2 + c(v_1 - (1-\sigma)rv_w)}{\sigma v_w}. \tag{12}$$

Obviously the leader's profit decreases as the level of technology diffusion increases ($\frac{\partial \Pi_\ell^{I*}}{\partial \beta} < 0$). Assuming $v_1/r > v_w$ the expected profit is further positively influenced by an increase of the threat of punishment ($\frac{\partial \Pi_\ell^{I*}}{\partial \sigma} < 0$), meaning that the leader profits from the expectation of high compensation payments in the case that a rival firm wins the race.

One of our focal interests is on the effect that the RUE has on the R&D investments of firms. We set off analysing separately the investment levels of the leader and the followers respectively, before turning to the effect on aggregate investment. The leader's investment level is obviously increasing with a decreasing threat of punishment, σ. The more probable the compensation through a prosecution fine becomes ($\sigma \downarrow$), the lower is the investment of the leader in R&D, as he can expect a positive payoff even in the case that he loses the race. Whereas this result is independent of the level of technology diffusion, the effect of σ on the aggregate investments of the followers depends on β. With a strong RUE, such that the threat of punishment is weak and the level of technology diffusion is high, further decreasing the threat of punishment increases the aggregate R&D investments of followers. This is in line with economic intuition and displays the desirable effect the implementation of a RUE should have. Contrasting this, if technology diffusion is low, decreasing the threat of punishment can also lead to decreasing investments of followers. This is due to the fact that the probability of winning the race decreases for the followers, because on the one hand the leader's investments increase with a decreasing threat of punishment and on the other hand their hazard rates are low due to the low level of technology diffusion. Hence, the overall effect of enhancing legal certainty by decreasing the threat of punishment on R&D investments can only be positive, if the possibly negative effect on followers' aggregate investments is overcompensated by the positive effect on the leader's investment level. Computing the overall effect we find that this is the case so we formulate

Lemma 1 *In a regime with a probabilistic RUE, decreasing the threat of punishment increases aggregate R&D investments.*

The second dimension of the RUE is the extent of technology diffusion. As discussed earlier this measure can only be influenced indirectly by policy attempts because it is by large subject to innovation and industry-specific characteristics.

The effect that the technology diffusion induced by the RUE has on the leader's investment depends on the extent of his technological headstart γ. With a small headstart, the threat of losing a lead through technology diffusion via patenting is rather small. A high level of diffusion (low α) aligns the hazard rates of the leader and his rivals, so the leader attempts to increase his probability of winning the race by higher investments in R&D. The lower the level of diffusion is, the more promising this strategy becomes, as the hazard functions differ more, the higher α is (and a higher α means a lower diffusion-level). In the case that the leader has a large headstart, the effect remains the same for a high level of technology diffusion, but changes when α increases beyond the critical level $1/(2\gamma)$. Then the small level of diffusion does not threaten the patentee: his headstart is sufficiently high to allow him to decrease his R&D investments in accordance with the decreasing level of technology diffusion. The following Lemma summarizes these findings.

Lemma 2 *(i) If $\alpha \leq \frac{1}{2\gamma}$ a decreasing level of diffusion ($\alpha \uparrow$) increases the R&D investments of the leader.*

(ii) If $\alpha > \frac{1}{2\gamma}$ the effect is reversed and a decreasing level of technology diffusion has a negative effect on the leader's R&D investments.

With a strong RUE, such that the threat of punishment is weak and the level of technology diffusion is high, a further increase of technology diffusion increases the aggregate R&D investments of followers. Again, this is in line with economic intuition and displays the desirable effect of a RUE. If technology diffusion is low, increasing technology diffusion can also lead to decreasing investments of followers. As before, this is due to the fact that the probability of winning the race decreases for the followers, because on the one hand the leader's investments increase with increasing technology diffusion (see Lemma 2 *(ii)* and on the other hand their hazard rates are low due to the low level of technology diffusion. Thus, the overall effect of higher technology diffusion can only be positive, if the possibly negative effects on both, followers' aggregate investments and investments of the leader are overcompensated by the positive effects. Computing the overall effect we find that this is the case so we formulate

Lemma 3 *In a regime with a probabilistic RUE, increasing technology diffusion increases aggregate R&D investments.*

Summarizing these findings, we can state for a regime with probabilistic RUE that aggregate R&D investments are highest, if legal certainty as well as technology diffusion are high.
Regimes II can be derived directly from the above results by inserting the respective values for α and σ.

Regime II In the case of a strong RUE we have $\alpha < 1$ and $\sigma = 1$ meaning that the threat of punishment disappears compared to Regime I. We thus have

$$\Pi_{\ell}^{II*} = \frac{(1-\beta)^2 v_w^2 + cv_1}{v_w}. \tag{13}$$

From the comparative statics above we know that the expected profit of the leader is smaller in this regime, than in the case of a probabilistic RUE. This is simply due to the fact that we only consider independent follow-up inventions, such that in case of losing the race, the owner of the first patent collects no payments from the owner of the follow-up invention. Because in

Regime II there is no probability of earning compensation payments for input infringements, the expected profits are smaller than in Regime I. Inserting $\sigma = 1$ in equation 11 we have the leader's R&D investments

$$x_\ell^{II} = \frac{(1-\beta)\beta v_w}{c} - \frac{v_1}{v_w}. \tag{14}$$

Recall that x_ℓ^I increases as the threat of punishment decreases, meaning that R&D investments of the leader are higher in the case of a dependable RUE with $\sigma = 1$ than in the case of a probabilistic RUE where $\sigma < 1$. As the payoffs in case of losing the race become zero, winning the race is the only way to collect positive profits, so the leader is willing to invest more in R&D to increase his probability of winning the race. Concerning the effect of technology diffusion on the leader's R&D investments, Lemma 2 continues to hold.

Inserting $\sigma = 1$ in equation (10) we calculate the aggregate R&D investments of followers as

$$X_f^{II*} = \frac{c(v_1 - r v_w) + \beta^2 v_w^2}{c v_w \beta}. \tag{15}$$

Compared to regime I it depends on the level of technology diffusion whether the aggregate investments of followers are higher or lower in this regime. If technology diffusion lies above a critical threshold $\bar{\beta}$, followers' investments are higher in the dependable regime than in the probabilistic RUE regime, and vice versa. This is due to the fact that the probability of winning the race for the followers decreases with a decreasing technology spillover: On the one hand the leader's investments increase with increasing technology diffusion (see Lemma 2 (*ii*)) and on the other hand their hazard rates are low due to the low level of technology diffusion. To compensate this negative effect followers invest more when the level of technology diffusion falls below $\bar{\beta}$. the same arguments apply for the effect of increasing technology diffusion on the aggregate R&D investments of followers in regime II. They increase as long as β is sufficiently high (above $\bar{\beta}$). This desirable effect of a RUE changes if technology diffusion initially lies below the critical threshold $\bar{\beta}$. Then increasing technology diffusion can also lead to decreasing investments of followers, see the argumentation above. Thus, the overall effect of higher technology diffusion can only be positive, if the possibly negative effects on both, followers' aggregate investments and investments of the leader are overcompensated by the positive effects. Computing the overall effect we find that this is the case so we formulate

Lemma 4 *In a regime with a dependable RUE, increasing technology diffusion increases aggregate R&D investments.*

Summarizing these results, we find that a strong RUE, meaning high technology diffusion and high legal certainty, yields high aggregate investments in R&D. Supplementing this finding with a comparison of aggregate investments in the alternative regimes we can state

Proposition 1 *In both regimes, strengthening the RUE leads to an increase of aggregate R&D investments. If technology diffusion is sufficiently high, overall R&D expenditures are higher with a dependable RUE.*

While this is obviously a desirable effect of a policy measure such as the RUE, the possible backside may be that the propensity to patent decreases because increasing technology spillover and legal certainty - positive effects from the viewpoint of the followers - have seemingly negative effects from the viewpoint of a leading firm.

3.2 The Patenting Decision

Clearly, at the beginning of the race the early innovator will choose the protection strategy which yields the highest expected profits. Thus, we simply compare his expected profits in the cases (a) the basic innovation is kept secret and (b) the basic innovation is patented, given the leader's optimum investment decision and the aggregate investment level of the rivals participating in the R&D race. Analytically this boils down to a comparison of the functions Π_ℓ^{I*}, Π_ℓ^{II*} and Π_ℓ^{s*}.
Comparing these expected profits we derive a critical condition for the parameters α and σ such that the leading firm expects higher profits from patenting, $\Pi_\ell^{I*} - \Pi_\ell^{s*} \geq 0$, whenever the critical condition is fulfilled, see the following figure.

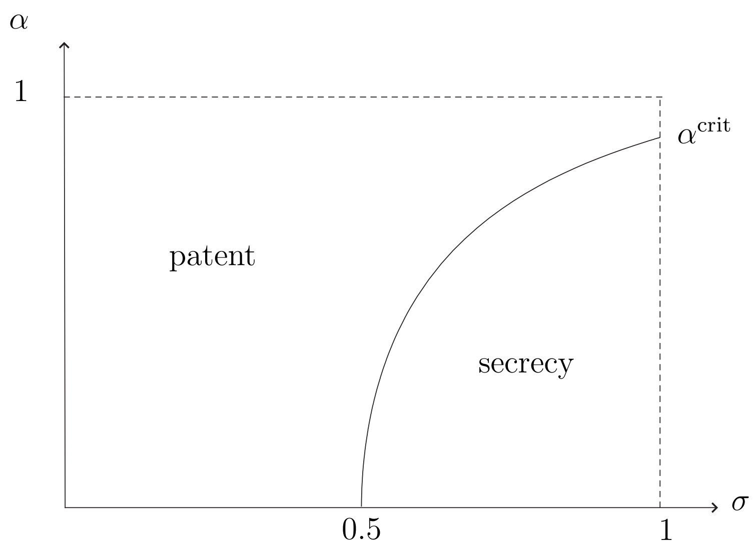

Figure 2: The propensity to patent for parameter values $v_1 = 10$, $v_w = 30$, $r = 0.25$, $\gamma = 0.8$ and $c = 10$

Recall from Figure 1 that the RUE is strong (i.e. the threat of punishment is low and the diffusion of technology is high) in the lower right quadrant of an α-σ-diagram, and it is weak in the upper left quadrant. Interpreting our results with regard to this specification, we find that with a strong RUE the propensity to patent is low, while for a weak RUE the propensity to patent is very high. Separating the effects of technology diffusion and the threat of punishment, the propensity to patent decreases as the legal certainty regarding the use of patented knowledge increases. Comparing Regimes I and II we thus find a lower propensity to patent in the dependable RUE regime, than in the probabilistic regime. In figure 2 the propensity to patent in Regime II is represented by the vertical line at $\sigma = 1$. Here only variations in the level of technology diffusion influence the propensity to patent: Obviously for the chosen parameter values, the leader chooses to patent only if technology disclosure is very low. Regarding Regime I we find analogously that higher technology diffusion decreases the propensity to patent.

Proposition 2 *In both regimes strengthening the RUE decreases the propensity to patent.*

This leaves us to analyse the effects of moving from one regime to another, for example, what would the introduction of legal certainty imply for the U.S. ? Given all the restrictive assumptions of our model, we find that this would have the positive effect of increasing overall investments in R&D, but at the same time it would reduce the propensity to patent of leading firms. An analysis of the net effect is not possible within the scope of this simple model, nevertheless we feel that we contribute important insights concerning the different effects of a research use exemption.

4 Concluding Remarks

A patent consists of two countervailing effects: a protective and a disclosure effect. Many scholars assume that the disclosure effect of a patent becomes effective after a patent expires while during the patent term, the patented invention is protected from the use of third parties. However, one specific use of a patented matter is often – either implicitly or explicitly – exempted from infringement, namely the research on patent matter. For example, if a patent is the starting point for a competitor's research process this action does not constitute an infringement. The goal of such a research use exemption is to foster technological progress.

The implementation of a research use exemption depends on a country's juridical system. For illustration, we chose two countries with differing implementations: In Germany, a country with a statutory research exemption, the extent of the exemption is certain, whereas in the U.S., a country with a common law exemption, the applicability of the exemption is uncertain.

To capture these varying extents of the research use exemption, we propose a model of cumulative innovation in a patent race setting and distinguish two different regimes: a *probabilistic* RUE regime where the legal certainty, that the RUE will not be challenged in court, varies and a *dependable* RUE regime where legal certainty is given. This paper addresses the question whether the RUE has an impact on the overall technological progress and on the patenting decision of leading firms.

For the model, we assume ex-ante asymmetric firms. The leader holds an invention which gives him a higher probability to win the race, i.e. a technological headstart.

The research use exemption only plays a role when the leader decides to patent his invention. Hence, the two regimes of probabilistic vs. dependable exemption are compared to the situation in which the leader decides to keep his invention secret.

Regarding the impact of the RUE on technological progress, we find that the aggregate R&D investments are highest if legal certainty as well as technological diffusion are high. With respect to the exemption's influence on the leader's propensity to patent, we find a negative effect, i.e. the stronger

the exemption, the more attractive secrecy becomes. Thus strengthening the RUE has countervailing effects: On the one hand it increases overall R&D investments, but on the other hand it decreases the propensity to patent.
An analysis of the net effect of a RUE is not possible within the scope of this simple model, nevertheless we feel that we contribute important insights concerning the differing effects of a research use exemption.

Appendix

work in progress

References

Aoki, R. and Spiegel, Y.: 2009, Pre-grant patent publication and cumulative innovation, *International Journal of Industrial Organization* **27**, 333–345.

Bhattacharya, S. and Guriev, S.: 2006, Patents vs. trade secrets: Knowledge licensing and spillover, *Journal of the European Economic Association* **4**(6), 1112–1147.

Cohen, W., Nelson, R. and Walsh, J.: 2000, Protecting their intellectual assets: Appropriability conditions and why U. S. manufacturing firms patent (or not), *NBER working paper* **7552**.

Denicolò, V.: 2000, Two-stage patent races and patent policy, *RAND Journal of Economics* **31**, 488–501.

Erkal, N.: 2005, The decision to patent, cumulative innovation, and optimal policy, *International Journal of Industrial Organization* **23**, 535–562.

Heger, D. and Zaby, A.: 2013, The heterogeneous costs of disclosure and the propensity to patent, *Oxford Economic Papers,* forthcoming .

Heger, D. and Zaby, A. K.: 2009, The propensity to patent with vertically differentiated products – an empirical investigation, Tübinger Diskussionsbeitrag Nr. 325.

Holzapfel, H.: 2004, *Das Versuchsprivileg im Patentrecht und der Schutz biotechnologischer Forschungswerkzeuge*, Vol. 10 of *Schriftenreihe Recht, Ethik und Ökonomie der Biotechnologie*, Nomos Berlin.

Lee, T. and Wilde, L.: 1980, Market structure and innovation: A reformulation, *Quarterly Journal of Economics* **94**(2), 429–436.

Loury, G. C.: 1979, Market structure and innovation, *Quarterly Journal of Economics* **93**(3), 395–410.

Nagaoka, S. and Aoki, R.: 2006, Economics of research exemption, IIR Working paper 06-04. Institute of Innovation Research, HitotsubashiUniversity.

Nagaoka, S. and Aoki, R.: 2007, Economic analysis of patent law exemption for research on a patented innovation, Mimeo.

Scotchmer, S.: 2004, *Innovation and Incentives*, The MIT Press, Cambridge, MA.

Scotchmer, S. and Green, J.: 1990, Novelty and disclosure in patent law, *RAND Journal of Economics* **21**(1), 131–146.

Thumm, N.: 2003, Research and patenting in biotechnology. a survey of switzerland., *Publication No 1 (12.03), Swiss Federal Institute of Intellectual Property* .