Exploring the Opaqueness of the Patent System - Evidence from a Natural Experiment

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Abstract Many observers accept the notion that the patent system contributes to the disclosure of technical information, and that patent information can be used to detect and identify competing approaches and firms easily. This article differs from this belief by suggesting that the patent system is highly opaque and that it is probably limited as a source of information. We use data from a natural experiment to explore this issue. In December of 2001, the European Patent Office (EPO) began to treat requests for accelerated examination as confidential information. Prior to that date, all interested parties were able to observe if an applicant had filed a request for acceleration, which was largely viewed as a signal of high value. After that date, information on acceleration requests was concealed from the public, but it is provided exclusively to us as researchers by the EPO. This article develops a model of patent opposition and acceleration requests in order to identify the extent to which the patent system is opaque with respect to patent value. We confirm that the opposition and acceleration rates of high-value patents change significantly once the change in information policy is implemented and acceleration requests are unobservable. Based on our model, we interpret these results as evidence that the system is highly opaque.

Keywords: patent value; opaqueness; accelerated examination; patent opposition; European Patent Office (EPO).

JEL Classification Numbers: K40, L00

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1 Introduction

The fundamental "deal" between the applicant of a patent and society is often stated as the granting of exclusion rights in exchange of the disclosure of a technical teaching that underpins the patented invention. In the assessment of the patent system's welfare balance, most work has focused on the incentive effect for inventors (respectively, applicants) - the "bait" of the promised exclusion rights is supposed to motivate inventors to spend more resources on research and development than they would in the absence of patent rights. The corresponding disclosure effects have received considerably less scrutiny, but many authors take as given that they exist and that they are sizeable.

Currently, the underlying assumption of policy makers and researchers alike is that the patent system is relatively transparent, that is, that searching for information on potentially conflicting prior art (which would limit the patentability of an invention) is rather costless. The patent system is apparently made to fulfill this ideal - disclosure by patent applicants is supposed to be complete, and insufficient disclosure can be held against the applicant by the examiner, leading to a refusal of the patent grant. At the same time, some users of the patent system have complained that the relevance of inventions is skillfully disguised by applicants who use arcane and complex language in order to avoid in-depth scrutiny by rivals. Bessen and Meurer (2008), for example, explicitly recommend a reform which would require patent applicants to use "plain language" in order to avoid intransparent descriptions of the patented invention and excessive opaqueness of the overall patent system.

The evidence presented in this article supports the notion that the patent system is highly opaque. We use a quasi-experimental setting in which publicly available information - the request for acceleration - became private information at the EPO. Ex ante, the observability of the acceleration may have guided rivals of a patent applicant in detecting particularly valuable inventions. The information may have contributed to an above-average rate of oppositions against these patents (once granted).

We develop a theoretical model of the ex ante and ex post applicant and opponent behavior. Using aggregate data computed by the EPO from the non-public information on accelerations, we show that in three of the five main technological areas of the European patent system (after Schmoch, 2008) the predictions of our model regarding changes in behavior in reaction to the EPO's 2001 decision to conceal acceleration information are met: Absent an observable signal of patent value, either the propensity of patent applicants to request accelerated patent examination increases or the likelihood of a patent being opposed drops. These changes once the signal is no longer available suggest that (at least in some major parts of the European patent system) potential opponents face problems in finding substitute signals or identifying the patent's contribution merely from the conventional data generated by the patent office. Given the quasi-experimental setting used here, we argue that our results provide fairly strong evidence in favor of the opaqueness presumption.

The article proceeds in four subsets. Section 2 describes the institutional setting and thus the nature of the quasi-experiment. In section 3, we specify a theoretical model in which requests for acceleration are related to patent value, and thus the likelihood of opposition. The model lends itself to developing a number of hypotheses regarding the identification and extent of opaqueness in the patent system. Section 4 describes the empirical setup and employs the quasi-experimental setup in our data to provide evidence that the patent system is indeed opaque with respect to patent value . Section 5 concludes.

2 Institutional Background

The legal foundation for the activities of the European Patent Office (EPO) is given by the European Patent Convention (EPC) and a body of rules accompanying the Convention. The timing of patent filings and subsequent actions by the EPO is rather complex, but can be summarized as follows (see Harhoff and Wagner, 2009, for more details). Patent filings at the EPO are typically based on previous priority filings at national patent offices. These filings are then forwarded to the EPO and published there 18 months following the original priority date. With the publication of the patent document, the EPO also publishes a search report. The report is accessible to any third party and published prominently on the EPO's websites. Information contained in the search report may be crucial for the applicant in order to assess his or her chances of obtaining a strong patent grant. The information can also be crucial for rivals who wish to assess the legal strength of a particular patent.

Within six months of the publication, the patent applicant has to request the examination of the patent application, otherwise the patent filing will lapse. The examination process itself can be rather lengthy, and in many cases, applicants seek to delay the final decision by the EPO, since a patent grant with subsequent translation into national languages is rather expensive. However, some applicants are interested in fast resolution of patent examination. Reasons for being interested in a quick resolution may be that the patent holder wants to have the right to request an injunction against an infringer. Injunctions are only available after the patent application has been granted. Moreover, important investment decisions may have to be made by the applicant in order to enter product markets with patent protection. This may again explain why some applicants would like to see an acceleration of patent examination.

At the EPO, the applicant may request examination early (Article 96 (1) EPC). He may also unconditionally waive his right to receive an invitation from the EPO to confirm that he desires to proceed with the application. This waiver allows the application to reach the examining division more quickly. Typically, the request is made when filing the European patent application, but it can also be submitted later by separate communication to the EPO.

In Rule 93(d) - OJ2001, 458 - published on September 7, 2001 - the President of the European Patent Office announced that effective of December 3rd, 2001 (EPO 2001) requests for accelerated search and accelerated examination would no longer be made public (as they had been before).[1] This rule change meant that information that had been observable by

[1]Accelerated search is usually a precursor to accelerated examination. Therefore, we do not address any differences between the two institutions here. A differential treatment of the two proceedings is planned for

any third party was now private information between the EPO and the applicant.

We exploit this setting by comparing statistics describing applicants' and their rivals' behaviors before and after the rule had been changed at the EPO. To have a foundation for interpreting the statistics, we first develop a theoretical model in the subsequent section.

3 Theoretical Framework

In this section, we develop a theoretical framework to structure our derivation of hypotheses regarding changes in the behavior of patent applicants and their rivals in reaction to the EPO's 2001 decision to keep information about applicants' acceleration requests secret. In particular, we are interested in changes in behavior which are *specific for the case* that the patent system were *intransparent* with regard to what technology is protected by a patent. Our framework focuses on two special features of the European patent system: The possibility of patent applicants to request accelerated examination of their patent, and the fact that third parties can oppose a granted patent centrally at the EPO only within a limited time window.[2] For modeling purposes, we operationalize the "technological content" of a given patent by the "value" of that patent. By value of a given patent we understand the stream of revenues the patent holder can generate in case his patent is granted, is not (successfully) opposed during the limited time period in which central opposition at the EPO is possible, and is used to introduce an innovation into a certain market. We make the stylized assumptions that the patent applicant can predict the value of its patent, and that, given the hypothetical case that direct inspection of the applicant's technology was possible, his rivals would arrive at the same prediction.[3]

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an extended version of this article.

[2]As soon as the window during which central opposition at the EPO is possible closes, the patent can no longer be revoked in a single procedure - separate opposition proceedings have to be initiated in each single state the patent got validated in, which increases costs of opposition considerably.

[3]These assumptions stylize the weaker assumptions that on average a patent applicant has a reasonably good *estimate* of the value of his patented technology, and that, also on average, this value estimate would coincide with that from another firm which is active in the same technological area and which could (hypothetically) inspect the applicant's technology. If we replaced our stylized assumptions by the weaker ones

Our goal is to derive predictions regarding changes in behavior which are specific for the case that the patent system is intransparent. In terms of our model, we define the patent system to be intransparent when only the patent applicant but not third parties are informed about the technology protected and thus the value of the patent. In turn, we define the patent system to be transparent when a patent fully discloses the technology it protects, which, given the assumptions above, means that both the applicant and third parties are informed about its value. Both for the case of a transparent and that of an intransparent patent system we will derive predictions on changes in behavior of patent applicants and their rivals in reaction to the EPO's 2001 policy change. For each information regime, we will do so by comparing the outcomes of our model in case information about acceleration requests is public (the case before 2001) to the outcomes in case this information is concealed from third parties (the case after 2001). We will then compare the predictions about changes in behavior for the case of a transparent and that of an intransparent patent system, and in doing so we will derive predictions regarding changes in behavior which are specific for the case that the patent system is intransparent.

3.1 Model Setup and Assumptions

We assume that there are two firms, firm A and firm B. We further assume that firm A has filed a patent application, and that the EPO has published the search report for this application. The search report lists the prior art which the EPO regards as relevant with respect to the patentability of firm A's invention. That is, it informs both firm A and firm B about the legal strength of firm A's patent application. The strength of firm A's patent application determines whether (in case of a grant) it withstands opposition by firm B. In the following we operationalize the strength of firm A's patent as the probability p that a patent is found valid in opposition cases. We further assume that firm A does not withdraw its patent application, and that its patent gets granted with certainty, regardless of whether

just mentioned, our model would become far less tractable but the results should stay the same.

firm A opts for the accelerated or for the standard examination procedure.[4]

We model the case of an intransparent patent system by assuming that firm A knows about the value of its patent, but that firm B does not. We understand the value of firm A's patent to be the cash flow firm A can generate if it uses the technology protected by its patent to introduce an innovation into the market - conditional on its patent being granted and not being revoked due to central opposition at the EPO (which is only possible during a short time period after grant). We further assume that firm B is active in the same market as firm A, and that firm A's innovation is rivalrous to firm B. That is, its introduction would lead to a decrease in firm B's profits.

When requesting examination of its patent, firm A shall be able to choose between an accelerated (a) and a standard ($\neg a$) examination procedure. If firm A chooses accelerated patent examination and its patent gets granted and survives the opposition period, the profit (respectively the discounted present value of the cash flow) firm A gains from its patented technology will be higher than in case of standard examination. Formally, we will denote the profit firm A reaps from its patented technology by $\pi_{(\cdot)}^{(\cdot)}$. This profit shall depend on the value of the patent, which is either high (h) or low (l), and on whether the patent examination has been accelerated (a) or not ($\neg a$). Firm A's costs of accelerated patent examination shall be $c_a > 0$. We assume that firm A is only interested in accelerating a high-value patent: $\pi_h^a - \pi_h > c_a$, and for simplicity $\pi_l^a = \pi_l^{\neg a} = \pi_l$. It shall hold that $\pi_h^a > \pi_h > \pi_l$.

The discounted present value of firm B's profit shall decrease if firm A's patent is granted. For simplicity, we assume that firm A and firm B play a zero-sum game, which means that the gains of firm A in case its patent gets granted and survives the opposition period equal firm B's losses. That is, if firm A successfully patents its technology, the profit it makes equals the losses firm B incurs. To avoid reduction in its profits, during a short time window after grant firm B has the possibility to oppose the patent of firm A centrally at the EPO.[5]

[4] This assumption approximates reality quite well: 95% of all patents which were applied for from 1995 to 2004 and which were not withdrawn by the applicant got granted.

[5] After the short time window during which opposition at the EPO is possible closes, in practice firm B still has the possibility to take action against firm A's patent. However, firm B then has to file separate

If firm B decides to oppose firm A's patent, both firms have to pay c_o for the then enfolding opposition process. At the end of the opposition process, firm A's patent remains granted with probability p.

The timing of the game firm A and firm B play is as follows: First, nature draws the probability p with which a patent withstands opposition and the value v of firm A's patent. The value v can be high (h) or low (l). h shall be drawn with probability θ, l with probability $1 - \theta$. The probability p with which firm A's patent withstands opposition shall be public information. In contrast, whereas firm A always gets informed about the value v of its patent. Firm B gets informed about the value of the patent of firm A only in case the patent system is assumed to be transparent with respect to patent value. (A more detailed discussion of the different information structures we are looking at follows in the next paragraph.) After getting informed, firm A can request either standard or accelerated examination of its patent ($\neg a$ respectively a). If firm A chooses accelerated patent examination, it incurs costs c_a. Next, firm B has the possibility to oppose firm A's patent. In case firm B decides to oppose firm A's patent, both firms have to pay costs c_o. At the end of the then enfolding opposition process firm A's patent remains granted with probability p. Finally, payoffs are realized. These depend on the patent value (h respectively l) and whether patent examination has been accelerated (a respectively $\neg a$).

We want to use the model we develop in this section to draw conclusions from behavioral changes in reaction to the EPO's 2001 decision to conceal acceleration information on the transparency of the patent system. In the following analysis, we will therefore differentiate between the case of a transparent and that of an intransparent patent system, and between the case of public and that of private acceleration information. We call the patent system "transparent" if both firm A and firm B are informed about the value v of firm A's patent, and "intransparent" if only firm A is informed. By "public" acceleration information we

lawsuits in each state firm A's patent got validated in, which both increases the costs of legal action and decreases the chance of an Europe-wide invalidation of firm A's patent by far. That is, filing separate suits at the national patent offices should usually be inferior to central opposition at the EPO, and in our model we thus focus on the latter.

mean that firm B is informed about whether firm A chose to request accelerated patent examination, and by “private” acceleration information we mean that firm B is not informed about whether firm A requested acceleration patent examination.

Before we sum up our game, we have to make some parametric assumptions. In general, if firm A’s innovation is patented, firm A’s profits increase and firm B’s profits decrease. We already made the simplifying assumptions that we have a zero-sum game, which means that firm A’s increase in profits equals firm B’s decrease, and that acceleration is only worthwhile for high-value patents, which means that if a patent is of low value there is nothing to gain from acceleration. In order to establish a clear payoff-structure for our game, we make three small additional assumptions. First, we assume that the profits which can be gained from a low-value patent are larger than opposition and acceleration costs combined. Second, we assume that opposition costs are larger than acceleration costs.[6] Put together, our parametric assumptions are:

A1 We have a zero-sum game, that is firm A’s gains from its patented innovation equal firm B’ losses: $\pi_h^a(A) = \pi_h^a(B) = \pi_h^a$, $\pi_h^{\neg a}(A) = \pi_h^{\neg a}(B) = \pi_h^{\neg a}$, $\pi_l(A) = \pi_l(B) = \pi_l$.

A2 Firm A shall only be interested in accelerating a high value patent: $\pi_h^a - \pi_h^{\neg a} > c_a$, and for simplicity $\pi_l^{\neg a} = \pi_l^a = \pi_l$.

A3 The profit from a granted low-value patent is larger than opposition and acceleration costs combined: $\pi_l > c_o + c_a$.

A4 Costs of acceleration are smaller than costs of opposition: $c_a \leq c_o$.

The extensive form of our game is given by the game-tree in figure 1. Depending on the assumptions about the transparency of the patent system with respect to patent value and

[6] These assumptions are made with a look at the field. Gambardella et al. (2008) estimate the median patent value to be €0.3 m. According to Levin and Levin (2002), opposition costs at the EPA amount to around €0.1 m. If a firm chooses accelerated patent examination it does not have to pay an extra fee, but only has to cope with increased administrative effort, which makes it reasonable to assume that the costs of acceleration are smaller than those of opposition.

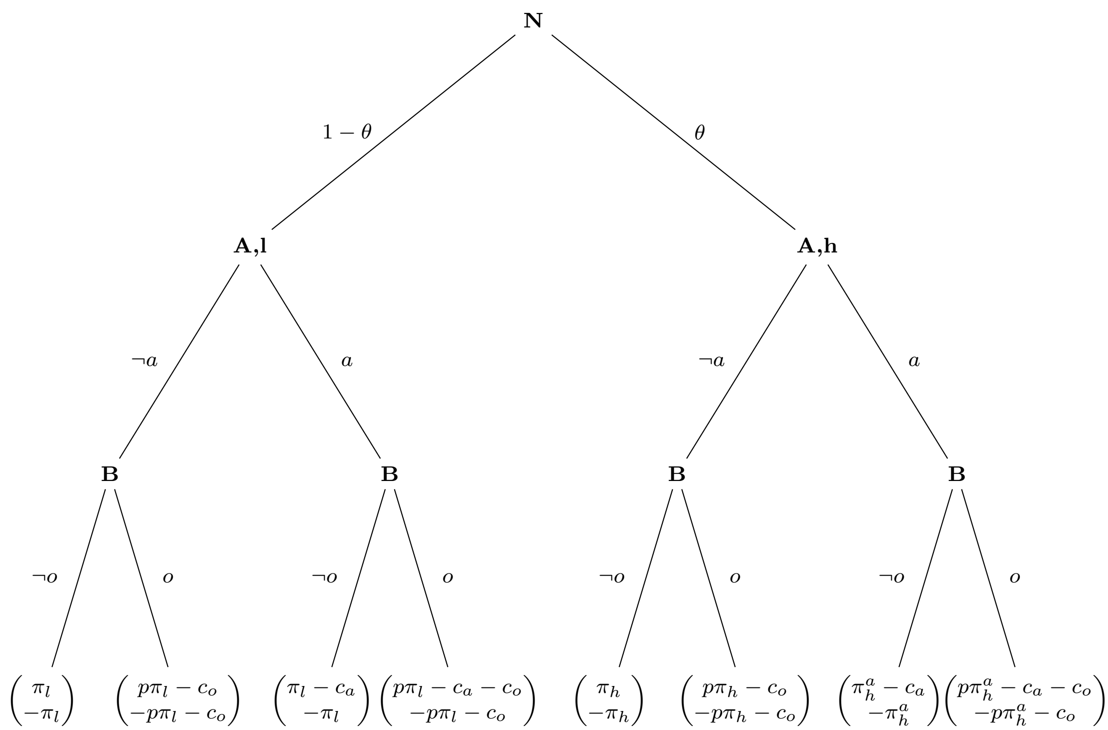

Figure 1: **Extensive form of the game.** The graph shows the extensive form of the game firm A (the patent applicant) and firm B (its rival) play. The mapping of the decision nodes of firm B to information sets depends on the assumptions about the transparency of the patent system (transparent vs. intransparent) and the visibility of firm A's acceleration decision (public vs. private): In the "transparent-public" case, each node forms one set. In the "transparent-private" case, the two nodes on the left branch of the tree form one set and the two nodes on the right another. In the "intransparent-public" case, the first and the third node form one set and the second and the fourth another. In the "intransparent-private" case, all four nodes form one set.

the visibility of firm A's acceleration decision, the mapping of the decision nodes of firm B to information sets is different. For the sake of clarity, the different information sets for the different information structures we analyze are not explicitly drawn in the game tree but described in the caption. We solve our model for the different information structures by applying the concept of the perfect Bayesian Nash equilibrium (PBNE). In addition, in order to rule out implausible equilibria we apply the "intuitive criterion", which was introduced in the context of signaling games by Cho and Kreps (1987). Appendix A.1 describes the solution of our model in detail.

3.2 Results

We are interested in how the behavior of firm A (the patent applicant) and firm B (its rival) is affected by concealment of information about whether firm A requested accelerated patent examination in case the patent system is transparent with respect to patent value and in case it is intransparent. Figure 2 summarizes what our model tells us in this regard. The left sequence of graphs represents the case that the patent system is transparent with respect to patent value, the right sequence the case that it is intransparent. The first row of graphs shows the p-θ-space for low gains from acceleration, the second row for intermediate gains from acceleration, and the third row for high gains from acceleration. In each graph we marked the subsets of the p-θ-space in which the outcomes in case the patent system is transparent are different from those in case the patent system is intransparent.[7] The sequence of graphs from top to bottom shows how the outcome-relevant subsets evolve with increasing gains from acceleration (that is, with increasing π_h^a).

We first discuss the results on changes in the behavior of firm A and firm B in reaction to concealment of acceleration information for the case that the patent system is transparent with respect to patent value. For the case of a transparent patent system we observe changes in behavior only for a quite limited region of the parameter space, namely that where gains from acceleration are low to intermediate and the probability p that the applicant's patent withstands opposition is between the thresholds p_2^B and p_2^A (subset 1 in figure 2; the definition of the thresholds is given in appendix A.1). There, in case of public acceleration information firm A does not accelerate a high-value patent and firm B does not oppose, whereas in case of private acceleration information firm A does accelerate a high-value patent and firm B does oppose. The intuition here is simple: In the limited region of the parameter space

[7]The division into subsets is done by cut-off values $p_{(\cdot)}^{(\cdot)}$. We only depict cut-off values which are relevant with respect to outcomes. (As the derivation of the outcomes in appendix A.1 shows, with respect to firms' strategies the p-θ space can be divided into smaller sections.) The ordering of these cut-off values depends on the value of π_h^a at which a cross-section was produced. Note that the graphs in figure 2 give all possible relative orderings of the cut-off values - that is, with respect to the position of the cut-off values relative to each other, the π_h^a space is divided into one subset where the gains from acceleration are low, one where they are intermediate, and one where they are high.

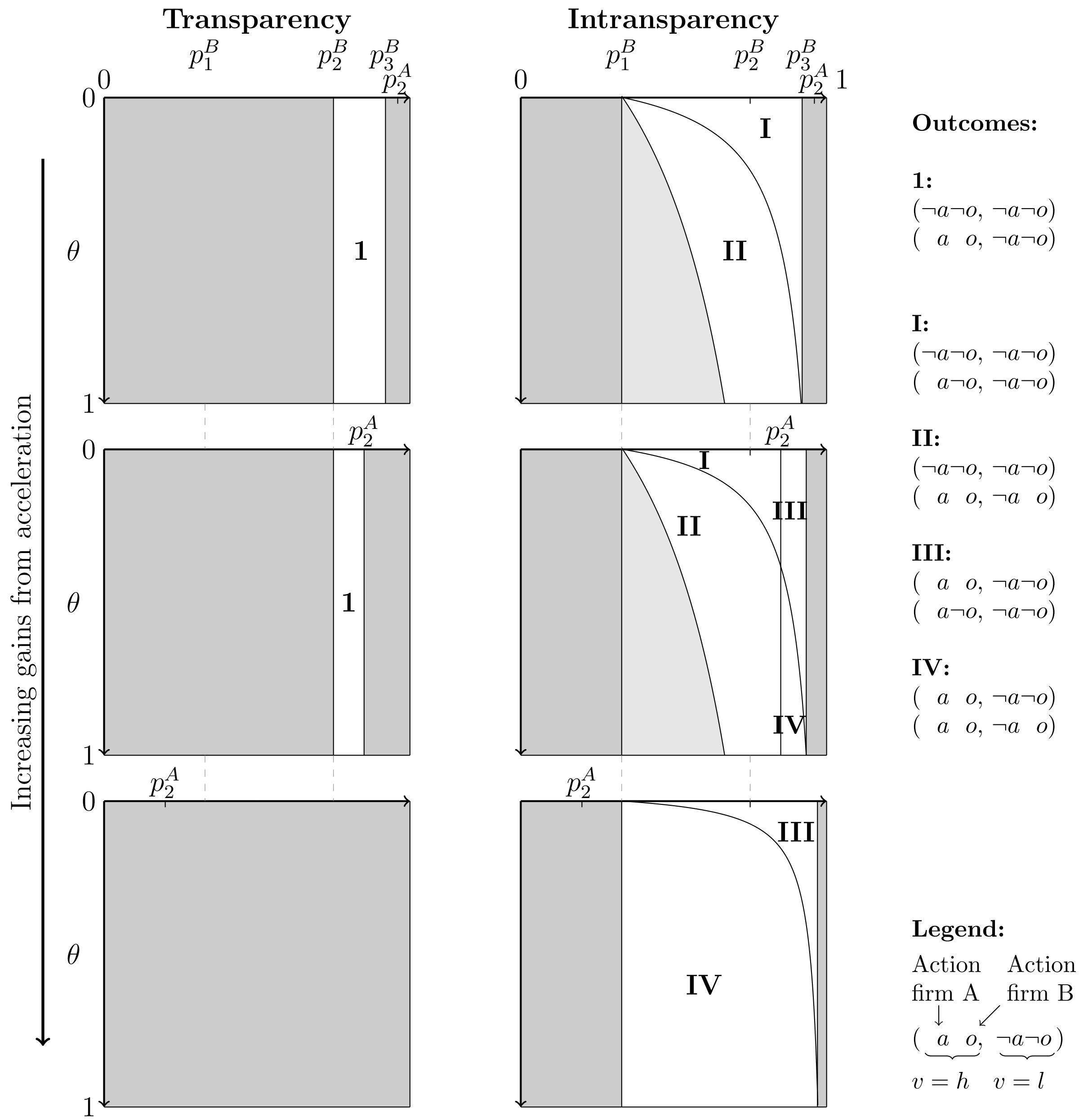

Figure 2: **Changes in outcomes in case acceleration information gets concealed.** The graphs show the subsets of the p-θ-space for which outcomes in case acceleration information is public are different from outcomes in case it is concealed. The graphs on the left depict the outcomes for the case of a patent system which is transparent with respect to patent value, the graphs on the right for the case of a patent system which is intransparent. Each sequence of graphs shows how the outcome-relevant subsets evolve with increasing gains from acceleration. Outcomes are given conditional on nature's draw of patent value v (high or low) and are described by firm A's action, that is acceleration (a) or no acceleration ($\neg a$), and firm B's subsequent action, that is opposition (o) or no opposition ($\neg o$). For each subset, the upper parenthesis give outcomes for the case that acceleration information is public, and the lower parenthesis for the case that it is concealed.

considered, firm B only has an incentive to oppose firm A's high-value patent in case it had been accelerated. The reason is that only when the patent value is increased to π_h^a through acceleration, the expected value of opposition, which is determined by the chance of winning $(1-p)$ and the patent value (π_h^a), outweighs the cost of opposition (c_o). Firm A is better off when its non-accelerated high-value patent is not opposed than when its accelerated high-value patent is opposed. However, only in case acceleration information is public firm A can "credibly commit" to not accelerating its patent (which then does not trigger opposition by firm B). In case acceleration information is private, regardless of firm B's action firm A is better off when it accelerates its patent. Thus, with private acceleration information firm A accelerates high-value patents and firm B opposes.

We now turn to the case of a patent system which is intransparent with respect to patent value: When patents are very weak ($0 < p < p_1^B$) or very strong ($p_3^B < p < 1$), we do not observe changes in both the applicant's and his rival's behavior. The reason is that if patents are very weak the rival will always oppose the applicant's patent, whereas if patents are very strong the rival will always refrain from opposition. That is, information about patent value does not play a role for the rival's behavior, and thus also the applicant does not have to care about whether by accelerating his patent he sends a signal about patent value.

When patents are of intermediate strength ($p_1^B < p < p_3^B$; subsets I to IV in figure 2), we observe different outcomes in case acceleration information is public than in case acceleration information is concealed. There are two basic patterns of changes, one for the case that patents are weak and/or gains from acceleration are low (subsets I and II), and one for the case that patents are strong and/or gains from acceleration are high (subsets III and IV):

In case patents are weak and/or gains from acceleration are low (subsets I and II), the acceleration behavior of the applicant changes in an unambiguous way- in case information about his acceleration decision gets concealed, the applicant changes from no acceleration of high-value patents to acceleration. The reason is that, from the applicant's perspective, the risk that his rival can use information about his acceleration request to identify and oppose his high-value patent outweighs the gains he has from requesting accelerated examination. Thus, the applicant refrains from acceleration in case information about his acceleration decision is public (he "hides" a high-value patent by not sending the acceleration signal) and accelerates high-value patents only in case acceleration information becomes concealed. As a consequence of the applicant's behavior, neither in case acceleration information is private nor in case it is public the rival is able to infer information on patent value from the applicant's action. That is, the rival needs to base his decision on the expected gains from opposition given the a-priori probability θ that a patent is of high value. It turns out that in subset I the probability that a patent is of high value is too low to make the rival in expectation better off when he chooses to oppose the applicant's patent. (Note that the rival only benefits from opposition if he "hits" a high-value patent.) Therefore, in subsets I and II the rival in general refrains from opposition. In subset II, however, the probability that a patent is of high value is large enough such that in case of concealed acceleration information - where the applicant accelerates high-value patents "in disguise" - the increase in patent value from acceleration is high enough such that the rival is better off in expectation when he opposes the applicant's patent.

In case patents are strong and/or gains from acceleration are high (subsets III and IV), we observe changes only in the opposition behavior of the rival. The reason is that the applicant does not care that by accelerating a high-value patent he might inform his rival about the value of his patent, as his patent is either quite likely to withstand opposition or the gains from acceleration make up for the risk of being opposed. That is, the applicant always accelerates high-value patents, whereas he never accelerates low-value patents (the reason being that by assumption the gain from acceleration of low-value patents is zero.) Thus, when acceleration information is public, the applicant informs his rival about the value of his patent. Knowing that accelerated patents are high-value patents, the rival in consequence opposes accelerated patents only. When acceleration information becomes concealed the rival no longer knows whether a given patent had been accelerated. Thus, for small probabilities that a patent is of high-value (subset III), he refrains from opposition, because chances for a “hit” (opposition of a high-value patent) are too low. (Note that opposition of a low-value patent is costly to the rival.) In contrast, for large probabilities that a patent is of high-value (subset IV), the rival opposes the applicant’s patent, because chances for a “‘hit” are high enough such that in expectation the gains from opposing a high-value patent make up for the losses from opposing a low-value patent.

3.3 Derivation of hypotheses

We constructed our theoretical framework to derive hypotheses on how the EPO’s 2001 decision to conceal information about applicants’ requests for accelerated patent examination affected the behavior of both applicants and their rivals in case the European patent system was intransparent. In the above subsection we presented the results on behavioral changes for the whole space of possible parameter values. For the derivation of hypotheses, in this subsection we will focus on subsets of the parameter space which are of relevance for our application at hand. To do so, we first take a short look into the literature on the European patent system to derive information on our model parameters. These parameters are the costs of acceleration and opposition (c_a and c_o), the distribution and the value of patents (θ and π_l respectively π_h), and the probability with which a patent withstands opposition (p). The possibility to request accelerated patent examination has not received much attention in the patent literature yet. Thus, instead of coming up with one concrete parametrization (of π_h^a), we will derive predictions for the cases of low and high gains from acceleration.

We first turn to the costs of acceleration and opposition. In line with others, Graham et al. (2002), who interviewed senior representatives of the European Patent Office, report that opposition costs c_o can be expected to be of a size of around €50 k to €100 k. Costs of acceleration c_a solely arise due to the need to cooperate closely with the EPO in case accelerated examination is requested (there is no fee for accelerated examination), and thus should be quite small. There are no numbers on acceleration costs in the literature, but we expect acceleration costs to be at most in the range of opposition costs.

With respect to the value of patents the literature is ambiguous: The common finding here is that the distribution of patent value is heavily skewed - that is, the bulk of patents is of relatively low value, whereas a few patents are of quite high value. This is expressed by the fact that the median of the value distribution is commonly found to be far smaller than its mean. However, due to different methodologies and data sets, estimates of these two quantities range from magnitudes of below €0.1 m for both the median and the mean to an estimated median of €0.3 m and an estimated mean of €3 m in Gambardella et al. (2008). Put together, the picture which emerges from studies on patent value is that the value of the bulk of patents seems to be not far away from the costs of opposition, whereas the value of a minority of high-value patents exceeds that of the majority of low-valued patents by more than one order of magnitude. In terms of our model parameters, an established finding in the literature on patent value is that θ is rather small and $\pi_l \ll \pi_h$.

Information on the strength of patents - that is, the probability that a granted patent withstands opposition - can be found in Harhoff and Reitzig (2004). In their sample, opposed patents were revoked in around one third and amended in 40% of all cases. In one fifth of the cases opposition was rejected. (In 10% of the cases the opposition procedure was closed due to unspecified reasons.) Note that the amendment of a patent can involve a narrowing of its scope, which might be counted as a (partial) success of the competing party. If we count half of the occasions were a patent was amended as successful, that means p lies somewhere in the range between 50% to 70%.

We operationalize the stylized facts collected above by the following parameter assumptions: c_o=€0.1 m, c_a=€0.05 m, π_l=€0.15 m and π_h= €1.0 m.[8] As information on the value of acceleration is basically non-existent in the literature, we do not use a single parametriza-

[8]Note that with respect to the mechanics of our model the exact numerical values of the single parameters are not critical. What matters is the relationship between the different parameters. In particular, these relationships are that between c_o and π_l and that between c_o and π_h. These relationships determine the positions of the cutoff-values p_1^B, p_2^B and p_3^B.

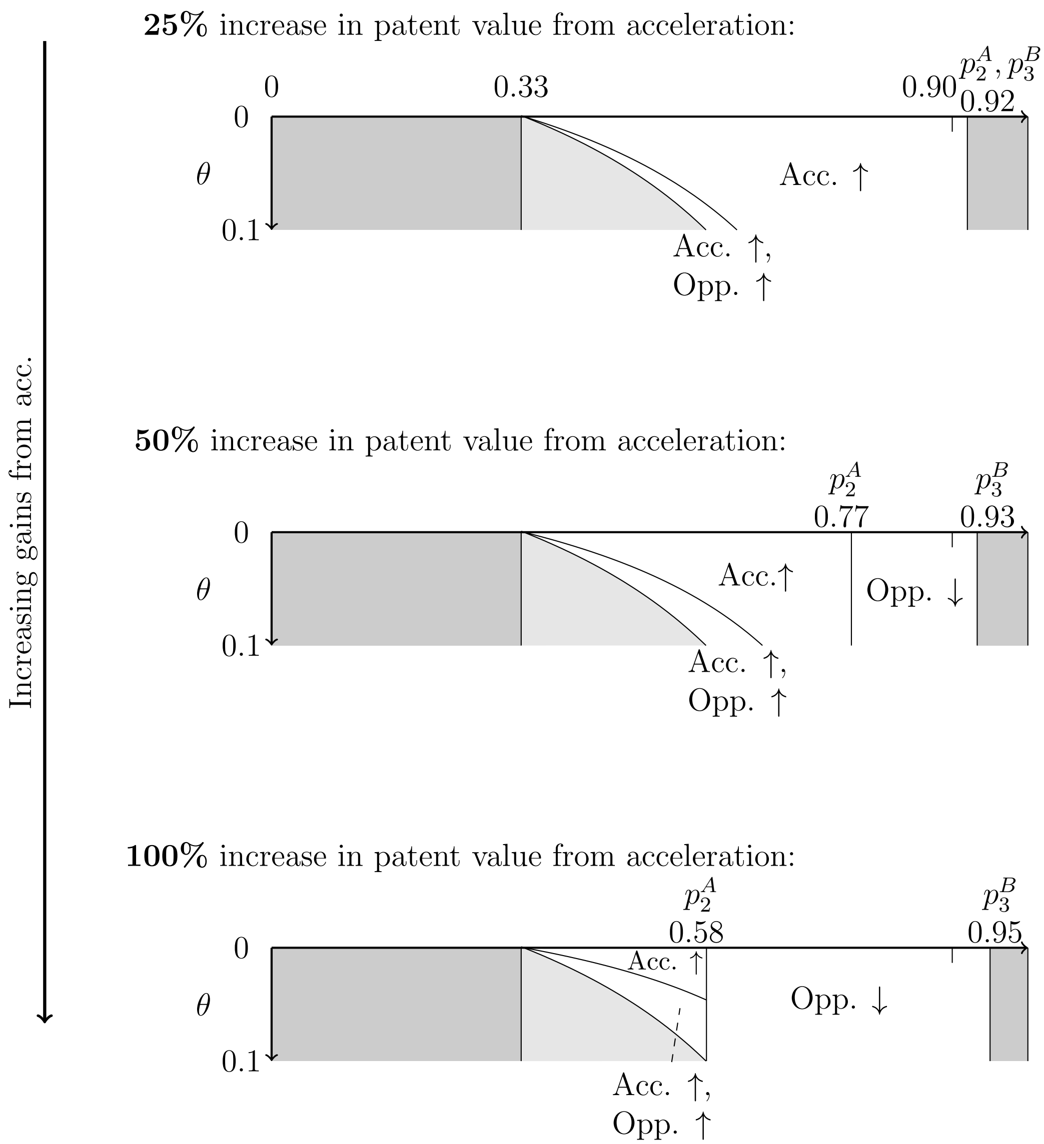

Figure 3: **Predictions on changes in acceleration and opposition frequencies.** The graphs display how we expect acceleration and opposition frequencies to change in case the patent system is intransparent with respect to patent value and information about applicants' acceleration requests gets concealed. The parameter assumptions made mirror stylized facts about the application and opposition process in the European patent system. These parameter assumptions are c_a=€ 0.05 m, c_o=€ 0.1 m, π_l=€ 0.15 m and π_h= € 1.0 m, and given these the graphs are drawn to scale. For the gray areas we do not expect do observe any changes in case acceleration information gets concealed. Note that changes in behavior in case the patent system is transparent are not depicted here, as we would expect to observe any only if $p > p_2^B = 0.90$.

tion for the value of acceleration (respectively π_h^a) but look at three cases: The case where gains from acceleration are low (25%, that is π_h^a =€ 1.25 m), the case where they are intermediate (50%, that is π_h^a =€ 1.5 m), and the case where they are high (100%, that is

$\pi_h^a =$€ 2 m). The graphs in figure 3 show the parameter space (to scale) for the above parameter assumptions and the cases of low, intermediate and high gains from acceleration. As we expect the share of high-value patents to be very small, we only depicted the parameter space up to $\theta = 10\%$.

For the derivation of hypotheses on how the behavior of patent applicants and their rivals in the European patent system changed in reaction to the EPO's 2001 decision to conceal information about requests for accelerated examination, we interpret the predictions of our model on changes in individual behavior as predictions on changes in the frequencies of acceleration requests and oppositions (which we observe in our data). In the graphs in figure 3, we marked how our model predicts these frequencies to change in case acceleration information gets concealed and the patent system is intransparent with respect to patent value.[9]

We now use our results, which are summarized in figure 3, to derive hypotheses regarding changes in behavior *which are specific for the case that the European patent system is intransparent with respect to patent value*:

H1 In reaction to the EPO's 2001 decision to conceal information about applicants' acceleration requests, we expect to observe changes in the frequency of acceleration requests or the frequency of oppositions.

Note that from the literature on patent oppositions we know that the probability p with which a patent withstands opposition is well below $p_2^B = 0.9$, and thus we expect to observe changes in acceleration and opposition frequencies only in case the European patent system is intransparent with respect to patent value, but not in case it is transparent.

Our first hypothesis makes a general statement on the kind of behavioral changes to expect in reaction to the EPO's 2001 decision to conceal acceleration information in case the

[9]Note that for the case that the patent system is transparent with respect to patent value we expect to observe any changes in behavior only for $p > p_2^B = 0.90$. As according to the literature on patent oppositions we expect the probability p with which a patent withstands opposition to lie somewhere in the range between around 50% to 70%, in figure 3 we did not mark changes in case of a transparent patent system separately.

European patent system was intransparent. The next two hypotheses make more specific predictions regarding the expected changes in behavior:

H2 For technological areas where gains from acceleration are low and/or the probability that patents withstand opposition is low, in reaction to concealment of acceleration information we expect to observe a significant increase in the frequency of acceleration requests for high-value patents.

H3 For technological areas where gains from acceleration are high and/or the probability that patents withstand opposition is high, in reaction to concealment of acceleration information we expect to observe a significant decrease in the frequency of oppositions against high-value patents.

The intuition behind these hypotheses is straightforward: For the case where gains from acceleration are low and/or patents are weak, an applicant requests accelerated patent examination only in case his request is concealed from third parties, because otherwise the risk that rivals use the acceleration signal to identify, oppose and possibly revoke his patent outweighs the expected gains from acceleration. Thus, for low gains from acceleration and/or weak patents we expect the EPO's 2001 decision to conceal acceleration information to be accompanied by an increase in the rate of acceleration requests. For the case where gains from acceleration are high and/or patents are strong, an applicant does not care whether by requesting acceleration he transmits a signal to rivals which possibly leads to his patent being opposed. However, omission of the value signal by the EPO's 2001 decision to treat requests for acceleration confidentially makes it harder for third parties to identify valuable patents, and we thus expect to observe a drop in the rate of oppositions.

4 Empirical Evidence

In December 2001, the EPO changed its information policy regarding acceleration requests of patent applicants: While before December 2001 information about acceleration requests of applicants was publicly available, after December 2001 this information was concealed from the public. If the European patent system was indeed opaque with respect to patent value, we would expect this change in the EPO's information policy to impact the behavior of both patent applicants and their rivals. In this section, we use data provided to us by the EPO to look into empirical evidence on opaqueness of the European patent system with respect to patent value. Above we derived predictions on the way the EPO's 2001 policy change should have affected the behavior of the parties involved in the patent application process in case the patent system was intransparent. We now take a look at the data to see how the behavior of applicants and rivals actually changed in reaction to the EPO's 2001 policy change. We do our analysis first for the European patent system as a whole, and then break our analysis down further by focusing on the five main technological areas into which (according to Schmoch, 2008) patents can be grouped, namely "Electrical Engineering", "Instruments", "Chemistry", "Mechanical Engineering" and "Other Fields".

4.1 Data and descriptive evidence

For our empirical analysis we have available very detailed data on all patent applications at the EPO which were filed from 1980 to 2013. Our dataset covers information on patent characteristics (destination of inventor, priority country, number of claims, and so on) and procedural information (time of application, status of application, time of grant, citations, and so on). In particular, for each application we know whether it has been accelerated and whether it has been opposed. For our analysis we concentrate on data covering the years 1995 to 2004. Also, as a patent can only be opposed after it got granted, we focus on granted patents only. From 1995 to 2004, each year around fifty-thousand patent applications were filed and granted later on. For the years 1995 to 2004, table 1 shows the number of applications filed, the fraction for which accelerated examination was requested, and the fraction of filings which were opposed after getting granted.

The graphs in figure 4 show the development of the acceleration frequency and that of the

Year	Filings (#)	Accelerated examination (%)	Opposition (%)
1995	44,326	4.8	5.7
1996	46,909	5.8	5.6
1997	49,868	6.7	5.3
1998	53,350	7.4	5.1
1999	55,605	7.4	5.4
2000	59,193	7.0	5.1
2001	59,070	7.2	5.3
2002	55,822	7.3	4.9
2003	53,889	8.0	5.0
2004	51,323	8.8	4.7

Table 1: **Yearly data on the number of filings and acceleration and opposition frequencies.** For each of the years 1997 to 2006, the table displays the number of filed patent applications (which were granted in the end), the fraction of these for which accelerated search was requested, the fraction for which accelerated examination was requested, and the fraction which was opposed after getting granted.

opposition frequency over time. After the EPO's decision to conceal information about applicants' acceleration requests in 2001, the frequency of requests for accelerated examination seemed to increase and that of oppositions seemed to decrease. Figure 5 takes a closer look at the development of the frequency of oppositions. The graphs display the development of the frequency of oppositions for the fraction of patents for which accelerated examination was requested and for the fraction of patents for which there was no request. Whereas there seems to be no change in the frequency of oppositions for the fraction of patents which were not accelerated, the frequency of oppositions for the fraction of accelerated patents dropped considerably .

In order to further investigate how the EPO's 2001 decision to conceal information about acceleration requests affected the behavior of applicants and their rivals, we interpret the EPO's 2001 policy change as "treatment" and divide our data into patents which were filed in a "pre-treatment" period and patents which were filed in a "post-treatment" period. In dividing our data into these two periods timeliness is of crucial importance: For the majority of patents the request for accelerated examination is made up to three years after the filing of the application at the EPO. Thus, in order to ensure that the patents in our pre-treatment

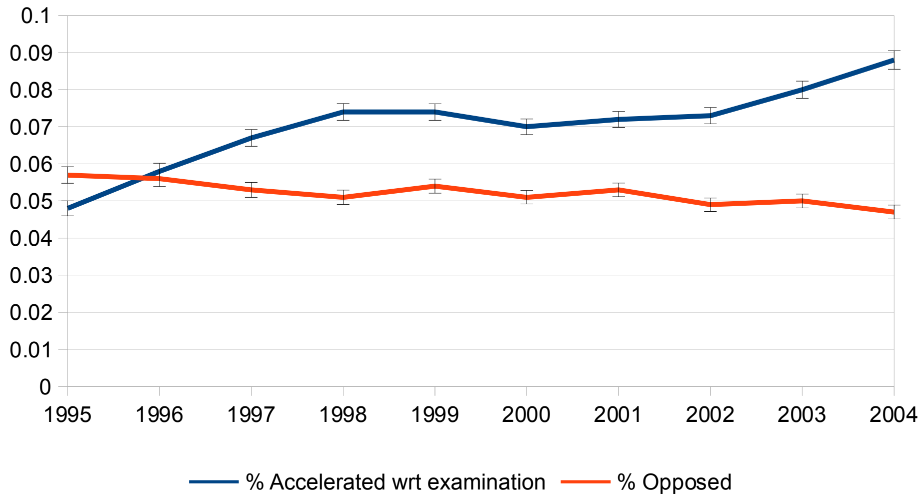

Figure 4: **Acceleration and opposition frequencies over time.** For the years 1995 to 2004, the graphs depict the fractions of patents for which accelerated examination were requested and the fractions which were opposed after getting granted. At each data point a 95% confidence intervals is displayed.

period are not affected by the EPO's 2001 rule change, we define the pre-treatment period to cover the years 1995 to 1997. We define the post-treatment period to cover the years 2001 to 2003. This definition makes sure that patents in the post-treatment period are affected by the EPO's 2001 rule change, while at the same time it makes the time gap between the two periods as small as possible.[10] Also, we group the patents in our sample into the five main technological areas after Schmoch (2008). These are "Electrical Engineering", "Instruments", "Chemistry", "Mechanical Engineering" and "Other Fields".

Table 2 displays comparisons of the frequency of acceleration requests and that of oppositions between the pre- and the post-treatment period. For the sample of all patents we observe a significant (both statistically and economically) increase in the frequency of acceleration requests and a significant decrease in the frequency of oppositions. As we will discuss in more detail further down, these observations correspond with the predictions of

[10]Note that our results do not depend on the exact definitions of the pre- and the post-treatment group. As demonstrated in appendix A.3, they are in fact quite robust against variations in the length and the location of these periods. Also, whether we include into our samples patents which were granted before 31 May 2012 or patents which were granted after six years the latest makes no significant difference. (We will need the latter condition for our difference-in-difference estimations below.)

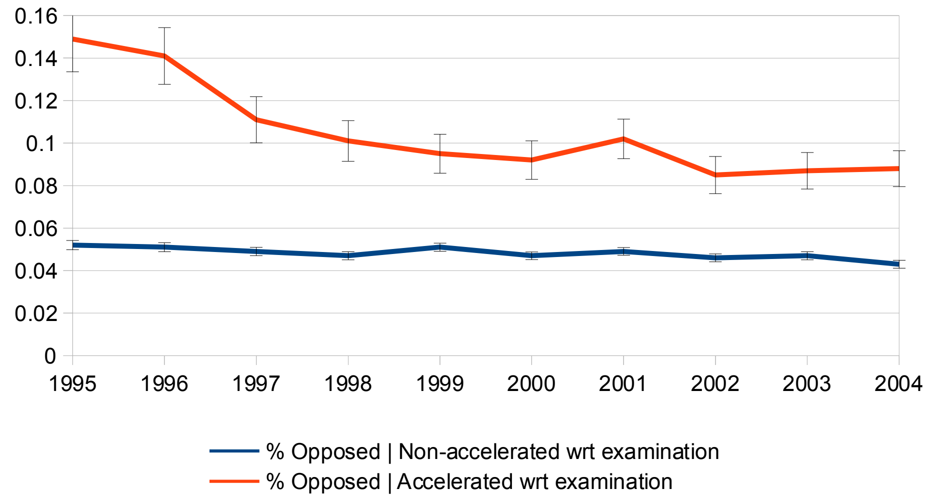

Figure 5: **Frequency of opposition conditional on acceleration status.** For the years 1995 to 2004, the graphs display the development of opposition frequencies over time, once for the fractions of patents for which accelerated examination were requested, and once for the fractions for which there were no request. At each data point a 95% confidence intervals is displayed.

our model. A more differentiated picture emerges when we take a look at the frequency changes in the five main technological areas: In mainareas "Electrical Engineering" and "Instruments" we still observe a significant increase in the frequency of acceleration requests and a significant decrease in the frequency of oppositions. However, for mainareas "Chemistry", "Mechanical Engineering" and "Other Fields" we no longer observe a significant decrease in the frequency of oppositions but only a significant increase in the frequency of acceleration requests. Albeit significant, the increase in the frequency of acceleration requests is least pronounced in mainarea "Chemistry".

The descriptive evidence we just presented gives first indications that the EPO's 2001 decision to conceal information about applicants' acceleration requests affected the behavior of both applicants and their rivals, and that the way behavior was affected is in line with the predictions of our model. However, the descriptive evidence above comes with three drawbacks: First, the frequencies of acceleration requests and oppositions might have changed simply due to different compositions of patents in the pre-treatment and the post-treatment period. Second, the frequency of acceleration requests and that of oppositions might have

		Pre	Post	Difference	p-Value	Change	Nbr. of Obs.
All	Acc. freq.	0.058	0.074	0.016***	0.000	0.272***	305952
	Opp. freq.	0.055	0.052	-0.003***	0.000	-0.060***	305952
Electrical Eng.	Acc. freq.	0.065	0.089	0.024***	0.000	0.364***	68980
	Opp. freq.	0.026	0.020	-0.007***	0.000	-0.252***	68980
Instruments	Acc. freq.	0.062	0.080	0.018***	0.000	0.284***	45768
	Opp. freq.	0.046	0.042	-0.004**	0.020	-0.097**	45768
Chemistry	Acc. freq.	0.059	0.063	0.005***	0.006	0.078***	81855
	Opp. freq.	0.079	0.079	-0.000	0.887	-0.003	81855
Mechanical Eng.	Acc. freq.	0.043	0.062	0.018**	0.000	0.418***	88793
	Opp. freq.	0.059	0.057	-0.002	0.173	-0.036	88793
Other Fields	Acc. freq.	0.081	0.104	0.024***	0.000	0.297***	20556
	Opp. freq.	0.054	0.055	0.001	0.809	0.014	20556

Table 2: **Comparison of acceleration and opposition rates of the pre- and the post-treatment period for all patents and the main technological areas.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The sample comprises all patents which were granted until 31 May 2012 the latest. Whether differences between the pre- and the post-treatment period are significant is tested via a two-sample ttest. Significance niveaus are indicated by stars: ***: 1%, **: 5%, *: 10%

changed over time due to reasons unrelated to the EPO's 2001 policy change. Third, the aggregate numbers presented so far do not inform us about whether there are changes in the frequencies of acceleration requests and oppositions of high-value patents relative to those of low-value patents (which is what our model actually predicts). In the next subsection we employ a difference-in-difference approach in order to counter these drawbacks.

4.2 Difference-in-difference approach

■ **Identification and econometric specification.** In order to causally link the observed changes in applicants' and their rivals' behavior to the 2001 change in the EPO's information policy (the treatment) we need to control both for possible changes in the composition of patent applications and for changes in the propensity to accelerate patents (respectively to oppose them) over time unrelated to the 2001 policy change. Controlling for differences in the composition of patent applications between the the pre-treatment sample and the post-treatment sample is relatively easy, as our dataset provides us with a large amount of variables on patent characteristics which can be used as controls. Controlling for changes in the propensity to accelerate patents respectively to oppose them is less straightforward - our goal is to identify changes in behavior over a rather short observation period[11], which makes running simple regressions with time-trends or period dummies included impracticable.

One method often applied in order to identify the causal effects of a treatment is difference-in-difference (DID). The idea here is to compare changes over time in a group not affected by the treatment (the non-treatment group) to changes over time in a group affected by the treatment (the treatment group). Given the assumption that there are no differences in changes over time *unrelated* to the treatment between the non-treatment and the treatment group (also called the "common-trend assumption"), observed differences in the changes of the variables of interest can be causally attributed to the treatment.

As elaborated by for example Angrist and Pischke (2008), a computationally easy way to implement the DID estimator is to regress the variable of interest on a period dummy, a group dummy, and the interaction of the two:

$$\text{VOI} = \alpha + \beta\text{POST} + \gamma\text{TG} + \delta\text{POST} * \text{TG} + \epsilon \qquad (1)$$

VOI denotes the variable of interest. In our case VOI would be equal to one in case a patent is accelerated (respectively opposed) and zero otherwise. POST equals one for observations from the post-treatment period and zero for those from the pre-treatment period, and TG equals one for observations from the treatment group and zero for observations from the non-treatment group. For the following analysis we denote POST∗TG as DIFF. The coefficient

[11] Note that the length of the observation period suited for our analysis is not only restricted by the availability of data, but also by the subject of analysis per se: The European patent system is constantly changing both with respect to its rules and the players active in it, which makes comparisons over long time-periods quite difficult.

δ measures the treatment effect. In case of a binary variable of interest δ measures the difference in the change of probability that VOI equals one between the treatment and the non-treatment group:

$$\begin{aligned}\delta &= \{E[Pr(VOI)|POST = 1, TG = 1] - E[Pr(VOI)|POST = 0, TG = 1]\} \\ &\quad -\{E[Pr(VOI)|POST = 1, TG = 0] - E[Pr(VOI)|POST = 0, TG = 0]\}\end{aligned}$$

By adding variables which capture observation characteristics to equation (2) it is easy to control for different compositions of the treatment and the non-treatment group (respectively changes therein).

In order to apply DID estimation to our application we need to define as well a pre- and a post-treatment period as a treatment and a non-treatment group. We start with the definition of the treatment and the non-treatment group: In principle, the EPO's 2001 policy change affected all patent applications in the European patent system. Thus, unlike in other applications where a treatment affects only one subgroup of a given population but not another, in our application it is not obvious how to define the treatment and the non-treatment group. However, albeit the EPO's 2001 policy change nominally concerned all patents, our theoretical considerations show that its practical impact should have been limited to patents of high-value. That is, we can define the treatment group to be comprised of high-value patents, and the non-treatment group to be comprised of low-value patents. We identify high- and low-value patents by employing a slightly modified version of the scope-year index suggested (amongst others) by Van Pottelsberghe de la Potterie and Van Zeebroeck (2008): We assign every patent a score by simply counting in how many countries and for how many full years the patent is held valid after it got granted. We do this for the 18 oldest member states of the European Patent Convention and the first two full years after grant and normalize every patent's score by the maximum score.[12] The argument here is that validating

[12]For example, if a patent for the first full year after grant is valid in Germany, the UK, France, and Italy, and for the second full year it is valid in Germany and the UK, its score would be six. After normalization

and upholding a patent in several countries is quite expensive for the patent holder, and therefore the number of years and the number of countries a patent is upheld in should reliably reflect that patent's economic value. We assign patents to the treatment group if their scope-year index is in the top quartile of the distribution of the scope-year index, and to the non-treatment group if it is in the bottom quartile.[13]

For the definition of the pre- and the post-treatment period timeliness is of crucial importance. As already mentioned above, for most patent applications accelerated examination is requested up to three years after the application is filed. Thus, in order to make sure that the patents filed during the pre-treatment period are not affected by the EPO's 2001 policy change we define the pre-treatment period to cover the years 1995 to 1997. When defining the post-treatment period, we have to take into account that we need to observe three years after a patent got granted in order to construct the scope-year index. Data on all observables is fully available until 31 December 2012. That is, we can only include patents in our sample which were granted on 31 December 2009 the latest. The majority of patents gets granted after five years (from the date of application). Therefore, we include into our post-treatment group all patents whose applications were filed in the years 2001 to 2003 and which got granted after six years the latest. This ensures that we are able to construct the scope-year index for all patents from the post-treatment group, and that all patents from the post-treatment period were affected by the EPO's 2001 policy change. For reasons of comparability also in the pre-treatment group we only include patents which got granted after six years the latest.[14]

Put together, for the sample of all patents and for all five main technological areas we

with the maximum score ($2 * 18 = 36$) this patent's scope-year index results as 1/6.

[13]We do this assignment separately for the whole sample of patents and the different main technological areas.

[14]Note that our results are quite robust against different definitions of the pre- and the post-treatment group regarding both their exact scope and location. Compare the results presented in appendix A.4.

estimate two regression equations:

$$\text{accex} = \alpha + \beta\text{POST} + \gamma\text{TG} + \delta\text{POST} * \text{TG} + CTRLS + \epsilon \quad (2)$$

$$\text{opp} = \alpha + \beta\text{POST} + \gamma\text{TG} + \delta\text{POST} * \text{TG} + CTRLS + \epsilon \quad (3)$$

The vaiable accex equals one if for a given patent application accelerated examination was requested, and zero otherwise. The variable opp equals one if a given patent was opposed, and zero otherwise. The sample consists of all patents which were applied for during either the pre- or the post-treatment period (1995 to 1997 respectively 2001 to 2003), which are either in the treatment or the non-treatment group (top respectively bottom quartile of the scope-year index distribution), and which got granted six years after the application the latest. POST equals one if a patent was applied for during the post-treatment period and zero otherwise, and TG equals one if a patent is from the treatment group and zero otherwise. CTRLS is short for control variables which capture the sample composition. The coefficient of particular interest is δ. It captures the treatment effect, that is the effect of the EPO's 2001 decision to conceal information about acceleration requests on the frequency of acceleration requests respectively oppositions of high-value patents.

■ **Results.** Table 3 displays the coefficient δ (that is, the treatment effect) for the frequency of acceleration requests respectively the frequency of oppositions for the whole sample of patents and for all five main technological areas. Full regression tables can be found in appendix A.5. For the full sample of patents, the frequency of acceleration requests for high-value patents increased after the EPO's 2001 policy change. A more detailed picture (which accounts for the well-known fact that behavior in the European patent system is category-specific) emerges when we split our sample into the five main technological areas "Electrical Engineering", "Instruments", "Chemistry", "Mechanical Engineering", and "Other Fields". It shows that the EPO's 2001 policy change had no effect on the main areas "Chemistry" and "Other Fields". For main areas "Electrical Engineering" and "Mechanical Engineering"

	All patents:	Main technological areas:				
		Electrical Engineering	Instruments	Chemistry	Mechanical Engineering	Other Fields
	Treatment effect on acceleration frequency:					
Coeff.	0.014***	0.031***	0.002	0.003	0.019***	0.019
t-Stat.	4.66	4.704	0.230	0.433	4.464	1.504
	Treatment effect on opposition frequency:					
Coeff.	0.003	-0.003	-0.018**	0.007	0.004	0.011
t-Stat.	1.13	-0.721	-2.564	1.211	0.817	1.106

Table 3: **Treatment effects.** The table displays the effect of the EPO's 2001 decision to conceal information about acceleration requests (coefficient δ from equations (2) and (3)) on the frequency of acceleration requests respectively oppositions for the sample of all patents and the five main technological areas. The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after six years the latest. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

the EPO's 2001 policy change led to increases in the frequencies of acceleration requests, whereas for main area "Instruments" it lead to decreases in the frequency of oppositions.

■ **Robustness.** The pattern of treatment effects displayed in table 3 is highly robust. It emerges independently from the exact definition of the pre- and post-treatment period, the construction of the scope-year index (which affects the composition of the treatment and the non-treatment group), inclusion of controls for sample composition, and the patents which are included into our sample with regard to the timing of the grant. The results for different specifications can be found in appendix A.4.

In particular, we do not bias our estimate of the treatment effect by using ex-post information on in how many EPC member states a patent was valid for how long to construct a value proxy: The concern here might be that patents which actually were of high value but which were revoked after successful opposition are spuriously assigned to the group of low-value patents, and that this incorrect assignment subsequently biases our results.[15] To counter this concern we repeat our DiD estimations by using a less fine value proxy which only counts the number of EPC member states a given patent is active in one year from its grant date on. In doing so we essentially capture in how many states a granted patent got validated in,[16] while at the same time, as the notice of opposition has to be filed within nine month after patent grant and as the EPO then needs on average three years to reach a decision, this value proxy should be unaffected by whether a given patent got opposed (and possibly revoked) after grant. Table 18 shows that using this more conservative (with respect to timing issues) value proxy does not change our results.

4.3 Discussion and Interpretation

The first hypothesis we derived from our model was that in case the patent system was opaque, in reaction to the EPO's 2001 decision to conceal information about acceleration requests we would expect to observe changes in the frequency of acceleration requests and the frequency of oppositions. The descriptives presented in table 2 show that indeed these frequencies differ significantly between the periods before and after the EPO's 2001 policy change. This gives a first indication that the European patent system might in fact be opaque with respect to the value of patents. To explore these results further we employed a difference-in-difference approach to control for possible changes in the propensity to accelerate patent applications respectively that to oppose patents unrelated to the EPO's 2001 policy change. (Also, the DID approach allows us to control for changes in the composition of our sample

[15] For example, assume that patents only get opposed when rivals observe that they had been accelerated, that as a result of opposition patents always get revoked, and that the acceleration rate for high-value patents *actually* does not change. Then before the treatment high-value patents which got accelerated would be wrongly assigned to the non-treatment group/the group of low-value patents (because they do not survive long enough to be assigned to the group of high-value patents), whereas after the treatment high-value patents which got accelerated would be correctly assigned to the treatment group/the group of high-value patents. This in turn would mean that our estimator would spuriously identify an increase in acceleration frequency of high-value patents due to the treatment.

[16] If a patent applicant wishes to validate his granted patent in a given EPC member state he has to do so within three month after his patent got granted. Getting a patent validated in a given EPC member states involves costs for formal proceedings and (sometimes) translations, and therefore the number of EPC member states a patent got validated in should be closely connected to its value.

of patent applications.) In that way (given that the common trend assumption holds) we are able to establish a causal link between the EPO's 2001 policy change and changes in the behavior of patent applicants respectively their rivals. Indeed, as indicated by the results from our descriptive analysis, we find that the EPO's 2001 decision to conceal information about acceleration requests caused changes in the frequency of acceleration requests and oppositions in all main technological areas except "Chemistry" and "Other Fields". The changes in areas "Electrical Engineering", "Instruments" and "Mechanical Engineering" are in line with the predictions of our model and of economically significant size. Thus, we conclude that in these areas the European patent system does not (or at least only partially) transmit information about the value of patents.

Note that we do not find an effect of the EPO's 2001 policy change for main area "Chemistry" is in line with expectations, as patents from this area are known to transmit precise information about the invention they protect. This, for example, is mirrored in the finding that inventors active in this area seem to learn extraordinarily much from the study of patents, which can be explained by the fact that inventions from main area "Chemistry" are usually described by plain and non-ambiguous chemical formulas. Accordingly, we would expect patents from main area "Chemistry" to be quite transparent with respect to patent value, and the fact that we do not find an effect in this area suggests that the effects we find in other areas area are actually caused by the omission of a signal about patent value.

Our second and third hypotheses related the kind of changes to expect due to the EPO's 2001 policy change to the value of acceleration of the patent examination process: In case the value of acceleration is low we expect to observe an increase in the frequency of acceleration request, whereas in case the value of acceleration is high we expect to observe a decrease in the frequency of oppositions. In our data we observe increases in frequencies of acceleration requests for areas "Electrical Engineering" and "Mechanical Engineering", and a decrease in the frequency of opposition requests for area "Instruments". For "Mechanical Engineering" this is in line with expectations: The area "Mechanical Engineering" assembles to a large part older and matured technologies (like, for example, (non-electrical) automobile engines), where innovation cycles are rather long and thus the value of acceleration should be rather small. Also, it seems reasonable to assume that gains from acceleration in area “Instruments” are rather high on average: The largest sub-field of main area “Instruments” is “Medical technology”, which is characterized by short development and innovation cycles.

A little bit puzzling, however, are the results for main area “Electrical Engineering”: There one might expect the value of acceleration to be large, as this area assembles subfields like telecommunications or computer technology, which usually are associated with short innovation cycles. In this case, contrary to our observation (which is, an increase in the frequency of acceleration requests), our model would predict a decrease in the frequency of oppositions. A possible explanation for the unexpected results in main area “Electrical Engineering” might be that patents in the field of modern information technology play a different strategic role than in more “traditional” technology fields (that is, they might mainly be used to build up defensive patent arsenals and as bargaining chips in licensing negotiations).

5 Conclusion

This article adds to a better understanding of the fundamental deal between the applicant of a patent and society - that is, the granting of exclusion rights in exchange to disclosure of technical knowledge - by asking whether the European patent system is indeed transparent with respect to what technology is protected by a patent or instead rather opaque. We try to give an answer to this question by exploiting a rule change in the European patent system: While before December 2001 applicants’ requests for accelerated search and examination were disclosed to the public, afterwards these requests were treated as confidential information. We developed a model of the patent application and opposition process which shows that concealment of the acceleration signal leads to specific changes in the behavior of applicants and their rivals for the case that the European patent system is opaque with respect to patent value. In particular, in reaction to the EPO's 2001 policy change, we expect the frequency of acceleration requests to increase and that of oppositions to decrease. Using a difference-in-difference approach, we show that in three of the five main technological areas (after Schmoch, 2008) these predictions are met by the data. (These areas are "Electrical Engineering", "Instruments" and "Mechanical Engineering".) These findings give support to the notion that the European patent system is (at least in parts) opaque with respect to what technology is protected by a given patent. Thus, the main conclusion we draw from our analysis is that it seems difficult to identify a patent's contribution solely on the basis of the conventional data generated by the EPO.

As the Federal Trade Commission notes in its 2011 report on patent notice and patent remedies,[17] failure of patents to clearly inform third parties about what they cover can be detrimental to competition among technologies. Reasons are that without knowing which technologies are out there, firms are not able to make informed decisions on in which new technologies to invest, what technologies to license, and with which other firms to collaborate. Also, if firms have to make technological investment decisions under incomplete information about the patent landscape, they risk to run into patent litigation after the market launch of an innovation. Our finding that in some areas of the European patent system it is unclear what exactly is covered by a given patent suggests that through the channels just mentioned also the European patent system does not properly contribute to competition among technologies (at least in parts). It thus seems necessary to put some effort into improving the notice function of European patents. First steps in this direction might be to tighten the disclosure requirements and, like demanded by Bessen and Meurer (2008), to place an obligation on patent applicants to use "plain language" in the construction of their patent claims.

[17]Federal Trade Commission. "The Evolving IP Market Place: Aligning Patent Notice and Remedies with Competition, March 2011." (2012). Download: www.ftc.gov/reports/evolving-ip-marketplace-aligning-patent-notice-remedies-competition .

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A Appendix

A.1 Solution of model

Table 5 displays the normal form of the signaling game for information structures “public” and “private”. We look for all Perfect Bayesian equilibria of these games which satisfy the “intuitive criterion” of Cho and Kreps (1987). The Perfect Bayesian equilibrium concept is a refinement of the Bayesian Nash equilibrium concept in the context of dynamic games with incomplete information, and Bayesian Nash equilibria can be deduced from the normal form of dynamic games. In practice, the determination of Bayesian Nash equilibria from the normal form of dynamic games is based on payoff comparisons.

In the following we first establish relationships between the payoffs of firm and between that of firm B. These relationships turn out to be dependent on specific parameters. As a second step we therefore divide the π_h^a-p-θ parameter space into subsets where the payoff relationships are non-ambiguous. Third, for each of these subsets we then derive all Bayesian Nash equilibria. Fourth, we check for every Bayesian Nash equilibrium whether if fulfills the criteria of a Perfect Bayesian Nash equilbrium (Bayesian beliefs and sequential rationality). Fifth, We check for every Perfect Bayesian Nash equilibrium whether it satisfies the “intuitive criterion”. For reasons of brevity, we will describe steps three to five exemplarily for one subset of the π_h^a-p-θ parameter space only. The approach for all other subsets is completely analogous.

■ **Relationships between payoffs.** The first step in solving our game for both information structures is to find all Bayesian Nash equilibria. Essentially, the search for Bayesian Nash equilibria can be reduced to simple payoff comparisons, and these payoff comparisons can be traced back to comparisons of the payoffs in case both the value of firm A's patent and firm A's acceleration decision are public knowledge. We denote this information structure by “full”. Note that information structure “full” describes the situation where the patent system is transparent with respect to patent value (and firm A's acceleration decision). The normal forms for information structure “full” are given in table 4. We start with comparing the payoffs of the signaling game for information structure “full”.

$\theta = h$	(o,o)		$(o,\neg o)$		$(\neg o,o)$		$(\neg o,\neg o)$	
a	$p\pi_h^a - c_a - c_o$	$-p\pi_h^a - c_o$	$p\pi_h^a - c_a - c_o$	$-p\pi_h^a - c_o$	$\pi_h^a - c_a$	$-\pi_h^a$	$\pi_h^a - c_a$	$-\pi_h^a$
$\neg a$	$p\pi_h - c_o$	$-p\pi_h - c_o$	π_h	$-\pi_h$	$p\pi_h - c_o$	$-p\pi_h - c_o$	π_h	$-\pi_h$

$\theta = l$	(o,o)		$(o,\neg o)$		$(\neg o,o)$		$(\neg o,\neg o)$	
a	$p\pi_l - c_a - c_o$	$-p\pi_l - c_o$	$p\pi_l - c_a - c_o$	$-p\pi_l - c_o$	$\pi_l - c_a$	$-\pi_l$	$\pi_l - c_a$	$-\pi_l$
$\neg a$	$p\pi_l - c_o$	$-p\pi_l - c_o$	π_l	$-\pi_l$	$p\pi_l - c_o$	$-p\pi_l - c_o$	π_l	$-\pi_l$

Table 4: **Payoffs for full information.** The upper table shows the payoffs for full information in case $\theta = h$. The lower table shows the payoffs for full information in case $\theta = l$.

For firm A if the patent is of high value ($\theta = h$) the payoff comparisons are

$$p\pi_h^a - c_a - c_o \quad \text{vs.} \quad p\pi_h - c_o, \tag{A1}$$
$$p\pi_h^a - c_a - c_o \quad \text{vs.} \quad \pi_h, \tag{A2}$$
$$\pi_h^a - c_a \quad \text{vs.} \quad p\pi_h - c_o, \tag{A3}$$
$$\pi_h^a - c_a \quad \text{vs.} \quad \pi_h, \tag{A4}$$

and if the patent is of low value ($\theta = l$) the comparisons are

$$p\pi_l - c_a - c_o \quad \text{vs.} \quad p\pi_l - c_o, \tag{A5}$$
$$p\pi_l - c_a - c_o \quad \text{vs.} \quad \pi_l, \tag{A6}$$
$$\pi_l - c_a \quad \text{vs.} \quad p\pi_l - c_o, \tag{A7}$$
$$\pi_l - c_a \quad \text{vs.} \quad \pi_l. \tag{A8}$$

For firm B the payoff comparisons if the patent is of high value ($\theta = h$) are

$$-p\pi_h^a - c_o \quad \text{vs.} \quad -\pi_h^a, \tag{A9}$$
$$-p\pi_h - c_o \quad \text{vs.} \quad -\pi_h, \tag{A10}$$

and if the patent is of low value ($\theta = l$) the comparions are

$$-p\pi_l - c_o \quad \text{vs.} \quad -\pi_l. \tag{A11}$$

The relationships between the payoffs in A3 to A8 are directly determined by our assumptions A1 to A4. For each other comparison there exists a certain cut-off value $p^{(\cdot)}$ at which the payoffs are equal. For all p smaller respectively larger then these $p^{(\cdot)}$ there exists a clear relationship between the underlying payoffs which follows directly from our assumptions A1 to A4. With "$\cdot|\cdot$" denoting the relationship left respectively right of the cut-off value $p^{(\cdot)}$, we have for firm A if the patent is of high value ($\theta = h$)

$$\begin{aligned}
p\pi_h^a - c_a - c_o &\lesseqgtr p\pi_h - c_o, \quad \text{defines } p_1^A,\ <|>, \\
p\pi_h^a - c_a - c_o &\lesseqgtr \pi_h, \quad \text{defines } p_2^A,\ <|>, \\
\pi_h^a - c_a &> p\pi_h - c_o, \\
\pi_h^a - c_a &> \pi_h.
\end{aligned}$$

For firm A if the patent is of low value ($\theta = l$) we have

$$\begin{aligned}
p\pi_l - c_a - c_o &< p\pi_l - c_o, \\
p\pi_l - c_a - c_o &< \pi_l, \\
\pi_l - c_a &> p\pi_l - c_o, \\
\pi_l - c_a &< \pi_l.
\end{aligned}$$

For firm B if the patent is of high value ($\theta = h$) we have

$$
\begin{aligned}
-p\pi_h^a - c_o &\lesseqgtr -\pi_h^a, \quad \text{defines } p_3^B, \; > \mid <, \\
-p\pi_h - c_o &\lesseqgtr -\pi_h \quad \text{defines } p_2^B, \; > \mid <,
\end{aligned}
$$

and if the patent is of low value ($\theta = l$)

$$
-p\pi_l - c_o \lesseqgtr -\pi_l, \quad \text{defines } p_1^B, \; > \mid < .
$$

Public	(o,o)		$(o,\neg o)$		$(\neg o,o)$		$(\neg o,\neg o)$	
(a,a)	$(1-\theta)p\pi_l+\theta p\pi_h^a-c_a-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h^a-c_o$	$(1-\theta)p\pi_l+\theta p\pi_h^a-c_a-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h^a-c_o$	$(1-\theta)\pi_l+\theta\pi_h^a-c_a$	$-(1-\theta)\pi_l-\theta\pi_h^a$	$(1-\theta)\pi_l+\theta\pi_h^a-c_a$	$-(1-\theta)\pi_l-\theta\pi_h^a$
$(a,\neg a)$	$(1-\theta)p\pi_l+\theta p\pi_h^a-\theta c_a-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h^a-c_o$	$(1-\theta)\pi_l]+\theta p\pi_h^a-\theta c_a-\theta c_o$	$-(1-\theta)\pi_l-\theta p\pi_h^a-\theta c_o$	$(1-\theta)p\pi_l+\theta\pi_h^a-(1-\theta)c_o-\theta c_a$	$-(1-\theta)p\pi_l-\theta\pi_h^a-(1-\theta)c_o$	$(1-\theta)\pi_l]+\theta\pi_h^a-\theta c_a$	$-(1-\theta)\pi_l-\theta\pi_h^a$
$(\neg a,a)$	$(1-\theta)p\pi_l+\theta p\pi_h-(1-\theta)c_a-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h-c_o$	$(1-\theta)p\pi_l+\theta\pi_h-(1-\theta)c_a-(1-\theta)c_o$	$-(1-\theta)p\pi_l-\theta\pi_h-(1-\theta)c_o$	$(1-\theta)\pi_l+\theta p\pi_h-(1-\theta)c_a-\theta c_o$	$-(1-\theta)\pi_l-\theta p\pi_h-\theta c_o$	$(1-\theta)\pi_l+\theta\pi_h-(1-\theta)c_a$	$-(1-\theta)\pi_l-\theta\pi_h$
$(\neg a,\neg a)$	$(1-\theta)p\pi_l+\theta p\pi_h-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h-c_o$	$(1-\theta)\pi_l+\theta\pi_h$	$-(1-\theta)\pi_l-\theta\pi_h$	$(1-\theta)p\pi_l+\theta p\pi_h-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h-c_o$	$(1-\theta)\pi_l+\theta\pi_h$	$-(1-\theta)\pi_l]-\theta\pi_h$

Private	o		$\neg o$	
(a,a)	$(1-\theta)p\pi_l+\theta p\pi_h^a-c_a-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h^a-c_o$	$(1-\theta)\pi_l+\theta\pi_h^a-c_a$	$-(1-\theta)\pi_l-\theta\pi_h^a$
$(a,\neg a)$	$(1-\theta)p\pi_l+\theta p\pi_h^a-\theta c_a-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h^a-c_o$	$(1-\theta)\pi_l]+\theta\pi_h^a-\theta c_a$	$-(1-\theta)\pi_l-\theta\pi_h^a$
$(\neg a,a)$	$(1-\theta)p\pi_l+\theta p\pi_h-(1-\theta)c_a-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h-c_o$	$(1-\theta)\pi_l+\theta\pi_h-(1-\theta)c_a$	$-(1-\theta)\pi_l-\theta\pi_h$
$(\neg a,\neg a)$	$(1-\theta)p\pi_l+\theta p\pi_h-c_o$	$-(1-\theta)p\pi_l-\theta p\pi_h-c_o$	$(1-\theta)\pi_l+\theta\pi_h$	$-(1-\theta)\pi_l-\theta\pi_h$

Table 5: **Normal form of the game for information structures "public" and "private".** For both information structures each row represents a possible strategy of firm A, while each column represents a possible strategy of firm B. For each strategy of firm A its actions are conditional on nature's draw of the patent value. That is, (a,a) is short for $(a|v=h,a|v=l)$, and so on. For information structure "public", for each strategy of firm B its actions are conditional on whether firm B observes accelerated patent examination. That is, (o,o) is short for $(o|a,o|\neg a)$. For each information structure each box displays the payoffs of firm A (left) and firm B (right) if the respective strategies are played.

The cut-off values are defined as follows:

$$
\begin{aligned}
p_1^A &= \frac{c_a}{\pi_h^a - \pi_h}, \\
p_2^A &= \frac{c_a + c_o + \pi_h}{\pi_h^a}, \\
p_1^B &= \frac{\pi_l - c_o}{\pi_l}, \\
p_2^B &= \frac{\pi_h - c_o}{\pi_h}, \\
p_3^B &= \frac{\pi_h^a - c_o}{\pi_h^a}.
\end{aligned}
$$

The payoffs for information structures "public" and "private" are composed from the payoffs for information structure "full". Thus, with information about the relationships between the payoffs for information structure "full" it is easy to derive the relationships between the payoffs for information structures "public" and "private". Each row in table 5 corresponds to a strategy of firm A, and each column to a strategy of firm B. First, we determine the best reactions of firm A to each possible strategy of firm B. Based on our results for the payoffs of firm A for information structure "full" and our assumptions A1 to A4 we find for information structure "public":

1st column: 4th row if $p < p_1^A$, 2nd row if $p > p_1^A$.

2nd column: 4th row if $p < p_2^A$, 2nd row if $p > p_2^A$.

3rd column: 1st row.

4th column: 2nd row.

The results for firm A and Information structure "private" are:

1st column: 4th row if $p < p_1^A$, 2nd row if $p > p_1^A$.

2nd column: 2nd row.

With that, the relationships between the payoffs of firm A are fully determined.

The results for firm B and information structure "public" are:

2nd row: 1st column if $0 < p < p_1^B$, 2nd column if $p_1^B < p < p_3^B$, 4th column if $p_3^B < p < 1$.

3rd row: 1st column if $0 < p < p_1^B$, 3rd column if $p_1^B < p < p_2^B$, 4th column if $p_2^B < p < 1$.

For the 1st row of information structure "public" and the 1st and 2nd row of information structure "private" the same payoffs have to be compared. The comparison to be made is

$$-(1-\theta)p\pi_l - \theta p \pi_h^a - c_o \text{ vs. } -(1-\theta)\pi_l - \theta\pi_h^a.$$

The relationship between these payoffs depends on the relationship between p and θ. With

$$p_{\theta,1} = 1 - \frac{c_o}{\theta\pi_h^a + (1-\theta)\pi_l}, \tag{A12}$$

we have equality for $p = p_{\theta,1}$. For values of p smaller than $p_{\theta,1}$ the former payoff is larger than the latter, and vice versa. For $\theta = 0$ $p_{\theta,1}$ equals p_1^B, and for $\theta = 1$ $p_{\theta,1}$ equals p_3^B. We denote the inverse function of $p_{\theta,1}(\theta)$ by $\theta_1(p)$. The situation for the 4th row of information structure "public" and the 3rd and 4th row of information structure "private" is analogous: The comparison to be made is

$$-(1-\theta)p\pi_l - \theta p\pi_h - c_o \text{ vs. } -(1-\theta)\pi_l - \theta\pi_h.$$

The relationship between these payoffs depends on the relationship between p and θ. With

$$p_{\theta,2} = 1 - \frac{c_o}{\theta\pi_h + (1-\theta)\pi_l}, \tag{A13}$$

we have equality for $p = p_{\theta,2}$. For values of p smaller than $p_{\theta,2}$ the former payoff is larger than the latter, and vice versa. For $\theta = 0$ $p_{\theta,2}$ equals p_1^B, and for $\theta = 1$ $p_{\theta,2}$ equals p_2^B. We denote the inverse function of $p_{\theta,2}(\theta)$ by $\theta_2(p)$. With that we can complete the payoff comparisons for firm B. For information structure "public" we have:

1st row: 1st and 2nd column if $< p_{\theta,1}$, 3rd and 4th column if $p > p_{\theta,1}$.

4th row: 1st and 3rd column if $p < p_{\theta,2}$, 2nd and 4th column if $p > p_{\theta,2}$.

For information structure "private" the results are:

1st row: 1st column if $< p_{\theta,1}$, 2nd column if $p > p_{\theta,1}$.

2nd row: 1st column if $< p_{\theta,1}$, 2nd column if $p > p_{\theta,1}$.

3rd row: 1st column if $< p_{\theta,2}$, 2nd column if $p > p_{\theta,2}$.

4th row: 1st column if $p < p_{\theta,2}$, 2nd column if $p > p_{\theta,2}$.

With that, the relationships between the payoffs of firm B are fully determined.
■ **Subsets of the π_h^a-p-θ parameter space.** From assumptions A1 to A4 it follows that $p_1^A < p_2^A$ and $p_1^B < p_2^B < p_3^B$. The relationship between the boundaries of firm A (p_1^A, p_2^A) and that of firm B (p_1^B, p_2^B, p_3^B) depends on the value of π_h^a. We can define different subsets

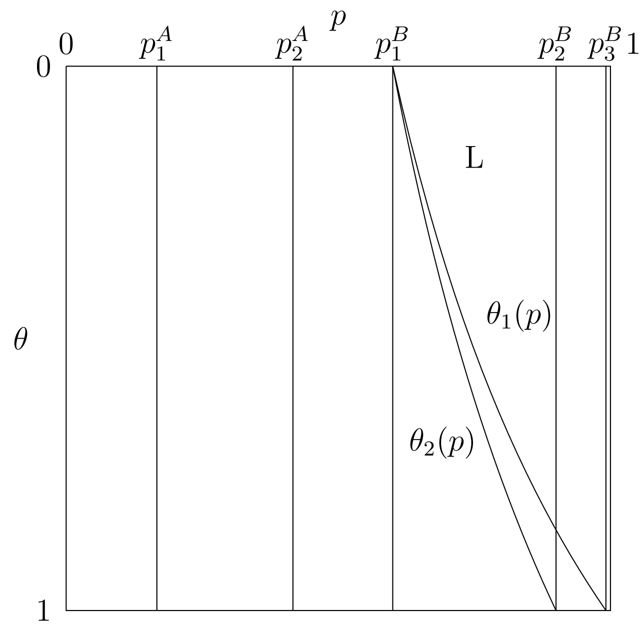

Figure 6: p-θ **subsets for the** π_h^a **subset** Π_6**.**

$\Pi_{(\cdot)}$ for π_h^a:

$$\begin{aligned}
\Pi_1 : &\quad c_a + \pi_h < \pi_h^a < \frac{\pi_l}{\pi_l - c_o} c_a + \pi_h \\
\Pi_2 : &\quad \frac{\pi_l}{\pi_l - c_o} c_a + \pi_h < \pi_h^a < c_a + c_o + \pi_h \\
\Pi_3 : &\quad c_a + c_o + \pi_h < \pi_h^a < c_a + 2c_o + \pi_h \\
\Pi_4 : &\quad c_a + 2c_o + \pi_h < \pi_h^a < \frac{\pi_h}{\pi_h - c_o}[c_a + c_o + \pi_h] \\
\Pi_5 : &\quad \frac{\pi_h}{\pi_h - c_o}[c_a + c_o + \pi_h] < \pi_h^a < \frac{\pi_l}{\pi_l - c_o}[c_a + c_o + \pi_h] \\
\Pi_6 : &\quad \frac{\pi_l}{\pi_l - c_o}[c_a + c_o + \pi_h] < \pi_h^a
\end{aligned}$$

For each subset $\Pi_{(\cdot)}$ there follows a clear relationship between the boundaries of firm A (p_1^A, p_2^A) and that of firm B (p_1^B, p_2^B, p_3^B) from our assumptions A1 to A4 :

$$\begin{aligned}
\Pi_1 : &\quad 0 < p_1^B < p_1^A < p_2^B < p_3^B < 1 \\
\Pi_2 : &\quad 0 < p_1^A < p_1^B < p_2^B < p_3^B < 1 \\
\Pi_3 : &\quad 0 < p_1^A < p_1^B < p_2^B < p_3^B < p_2^A < 1 \\
\Pi_4 : &\quad 0 < p_1^A < p_1^B < p_2^B < p_2^A < p_3^B < 1 \\
\Pi_5 : &\quad 0 < p_1^A < p_1^B < p_2^A < p_2^B < p_3^B < 1 \\
\Pi_6 : &\quad 0 < p_1^A < p_2^A < p_1^B < p_2^B < p_3^B < 1
\end{aligned}$$

For each subset $\Pi_{(\cdot)}$, the curve $p_{\theta,1}$ runs from ($p = p_1^B, \theta = 0$) to ($p = p_3^B, \theta = 1$), and the curve $p_{\theta,2}$ from $(p = p_1^B, \theta = 0)$ to $(p = p_2^B, \theta = 1)$.

To this point we have separated the 3-dimensional π_h^a-p-θ parameter space into several subsets. Figure 6 exemplarily displays the p-θ subsets for the π_h^a subset Π_6.

■ **Bayesian Nash equilibria.** A Bayesian Nash equilibrium is a pair of strategies for which firm A's strategy is a best response to firm B's strategy given his own type and his beliefs about firm B's type, and vice versa. A Bayesian Nash equilibrium can be interpreted as a Nash equilibrium of an expanded game, where the firms' pure strategies are type-contingent. Thus, a Bayesian Nash equilibrium is a pair of strategies of the expanded game for which firm A's strategy is a best response to firm B's strategy and vice versa.

The payoff matrices in table 5 are payoff matrices of expanded games. Each possible strategy of firm A is represented by a row, and each possible strategy of firm B by a column. In order to determine Bayesian Nash equilibria, we have to determine the best reaction of firm A to each strategy of firm B and vice versa. In practice, that means for each column of the matrices in table 5 we first have to find the row with the highest payoff for firm A (respectively for each row the column with the highest payoff for firm B). A Bayesian Nash equilibrium then corresponds to a cell in the output matrix for information structure "public" (respectively to a cell in the output matrix for information structure "private") which contains both the highest payoff of firm A in the respective column and the highest payoff of firm B in the respective row.

As the relationships between the payoffs depend on which subset of the π_h^a-p-θ parameter space we are in, we have to determine Bayesian Nash equilibria separately for every subset of the π_h^a-p-θ space. The procedure thereby is always the same. Thus, for reasons of brevity we will exemplarily demonstrate the determination of Bayesian Nash equilibria (and the subsequent determination of Perfect Bayesian Nash equilibria and the application of the intuitive criterion) for one subset of our parameter space. We marked this subset as subset "L" in figure 6.

In the schematic payoff matrices in table 6 the highest payoffs of firm A in each column and of firm B in each row are marked for each payoff structure. Bayesian Nash equilibria are cells which contain both the highest payoff of firm A and firm B. In case the patent system is transparent and the patent is of high value there are two Bayesian Nash equilibria: $[a; (o, o)]$ and $[a; (o, \neg o)]$. In case the patent system is transparent and the patent is of low value there are three equilibria: $[\neg a; (o, \neg o)]$, $[a; (\neg o, o)]$ and $[\neg a; (\neg o, \neg o)]$. For information structure "public" there are two equilibria: $[(a, \neg a); (o, \neg o)]$ and $[(a, a); (\neg o, o)]$. For information structure "private" there is one equilibrium: $[(a, \neg a); \neg o]$.

■ **Perfect Bayesian Nash equilibria.** For information structures "public" and "private" we check for every Bayesian Nash equilibrium whether it fulfills the criteria of a Perfect Bayesian Nash equilibrium - that is, whether there is a belief structure which is consistent with this equilibrium. We exemplarily demonstrate the procedure for the two equilibria of information structure "public" in subset "L".

For the separating equilibrium $[(a, \neg a); (o, \neg o)]$ a belief structure of firm B which is consistent with this equilibrium is as follows: Firm B puts probability one on the event "firm A's patent is of high value" if it observes acceleration. If it does not observe acceleration it puts probability one on the event "firm A's patent is of low value". It is easy to show that this belief is consistent with the equilibrium: If firm B believes that firm A's patent is of high value, it is optimal for firm B to oppose firm A's patent. The reason is that for

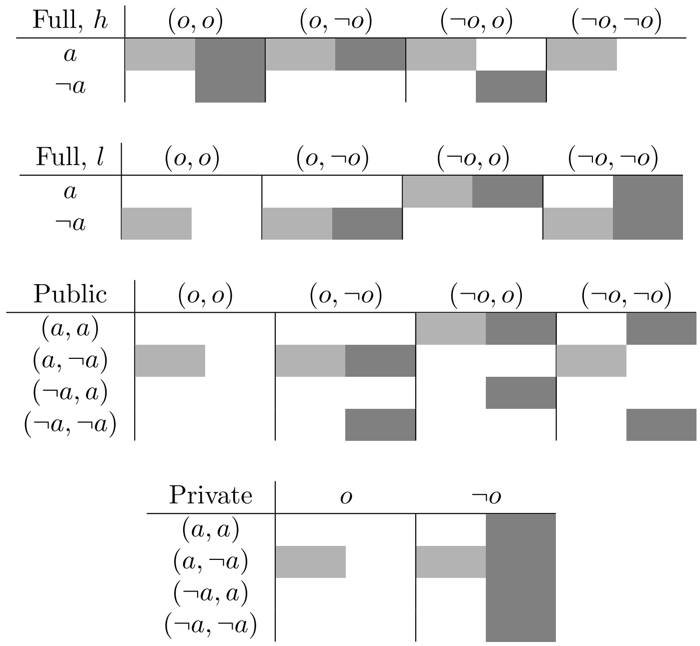

Table 6: **Bayesian Nash equilibria.** Displayed are schematic payoff matrices for information structures "full", "public" and "private" and subset "L" of the parameter space (see figure 6). In each matrix the highest payoffs of firm A in each column and of firm B in each row are marked. Bayesian Nash equilibria are cells which contain both the highest payoff of firm A and firm B.

$p < p_3^B = \frac{\pi_h^a - c_o}{\pi_h^a}$ (which is the case for subset "L") firm B's payoff in case it opposes an accelerated high-value patent of firm A ($-p\pi_h^a - c_o$) is larger than its payoff in case it does not oppose ($-\pi_h^a$). If firm B believes that firm A's patent is of low value it is optimal for firm B not to oppose firm A's patent. The reason is that for $p > p_1^B = \frac{\pi_l - c_o}{\pi_l}$ (which is the case for subset "L") firm B's payoff in case it does not oppose a non-accelerated low-value patent of firm A ($-\pi_l$) is larger than its payoff in case it does not oppose ($-p\pi_l - c_o$). Given that firm B opposes an accelerated patent, firm A only benefits from accelerating a high-value patent. The reason is that in subset "L" in case firm A has a low-value patent its payoff in case it does not accelerate the patent (π_l) is obviously larger than its payoff in case it accelerates the patent ($p\pi_l - c_o$). (Note that $p < 1$.) In contrast, in case firm A has a high-value patent its payoff in case it accelerates the patent ($p\pi_h^a - c_o - c_a$) is larger than its payoff in case it does not accelerate the patent (π_h). (In subset "L" it holds that $p > p_2^A = \frac{\pi_h + c_a + c_o}{\pi_h^a}$. Thus, in subset "L" it holds that $p\pi_h^a - c_o - c_a \geq \pi_h$.)

For the pooling equilibrium $[(a,a);(\neg o,o)]$ a belief structure of firm B which is consistent with this equilibrium is as follows: Off the equilibrium path firm B puts probability one on the event "firm A has a high-value patent". On the equilibrium path firm B puts probability θ on the event "firm A has a high-value patent" and probability $1-\theta$ on the event "firm A has a low-value patent". Given this belief structure, on the equilibrium path firm B's payoff in case it does not oppose ($(1-\theta)(-\pi_l) + \theta(-\pi_h^a)$) is larger than its payoff in case it does oppose ($(1-\theta)(-p\pi_l - c_o) + \theta(-p\pi_h^a - c_o)$). The reason is that in subset "L" it holds that

$p > p_{\theta,1} = 1 - \frac{c_o}{\theta\pi_h^a + (1-\theta)\pi_l}$:

$$\begin{aligned} p &> 1 - \frac{c_o}{\theta\pi_h^a + (1-\theta)\pi_l} \quad \Leftrightarrow \\ c_o &> (1-p)\theta\pi_h^a + (1-p)(1-\theta)\pi_l \quad \Leftrightarrow \\ (1-\theta)(-\pi_l) + \theta(-\pi_h^a) &> (1-\theta)(-p\pi_l - c_o) + \theta(-p\pi_h^a - c_o) \end{aligned}$$

As in subset "L" it holds that $p < p_2^B = \frac{\pi_h - c_o}{\pi_h}$, off the equilibrium path firm B's payoff in case it opposes $(-p\pi_h)$ is larger than its payoff in case it does not oppose $(-\pi_h)$. Given that in case firm B would observe acceleration it would oppose, firm A is better off accelerating both high-value and low-value patents. The reason is that both for high-value patents and for low-value patents the payoff of firm A in case it does accelerate and firm B does not oppose is larger than its payoff in case it does not accelerate and firm B does oppose ($\pi_l - c_a > p\pi_l - c_o$ and $\pi_h^a - c_a > p\pi_h - c_o$).

■ **Intuitive criterion.** For some subsets of the π_h^a-θ-p parameter space we find several Perfect Bayesian Nash equilibria for information structures "public" and "private". We use the "intuitive criterion" introduced by Cho and Kreps (1987) to reduce the number of equilibria. The "intuitive criterion" uses a forward induction argument: It eliminates equilibria when firm A would be better off if it deviated from the equilibrium. We demonstrate the use of the "intuitive criterion" exemplarily for information structure "public" and subset "L" of our parameter space. There we have two equilibria which fulfill the criteria of a Perfect Bayesian Nash equilibrium. These are the separating equilibrium $[(a, \neg a); (o, \neg o)]$ and the pooling equilibrium $[(a, a); (\neg o, o)]$. For the separating equilibrium there is no deviation which would make firm A better off. However, the pooling equilibrium fails the intuitive criterion:

For the pooling equilibrium $[(a, a); (\neg o, o)]$ to be sequentially rational firm B has to believe that firm A has a high-value patent if it does not accelerate. However, this belief is not plausible: If firm A has a high-value patent, in equilibrium it gets $\pi_h^a - c_a$. When firm A deviates, it only gets π_h. Yet, if firm A has a low-value patent, it has an incentive to deviate: In equilibrium, firm A gets $\pi_l - c_a$ if it has a low-value patent. However, if firm A deviates and convinces firm B that it has a low-value patent, it gets π_l (because if convinced firm B would not oppose). Thus, firm B should put zero probability on firm A having a high-value patent when firm A does not accelerate. However, in this case firm B would play $\neg o$ in reaction to $\neg a$, which upsets the equilibrium. That is, the pooling equilibrium $[(a, a); (\neg o, o)]$ fails the intuitive criterion.

■ **Results.** We summarize our results in figure 7 and table 7. Figure 7 displays all subsets of the π_h^a-θ-p parameter space with specific relationships between the payoffs of firm A and firm B. We marked these subsets by romanic upper-case letters. For each of these subsets and each information structure table 7 displays all Perfect Bayesian Nash equilibria which fulfill the intuitive criterion introduced by Cho and Kreps (1987). Note that we did not display the subsets for very low gains from acceleration (Π_1 and Π_2). The reason is that cases where there are no economically significant gains from acceleration are uninteresting for our analysis. From the equilibrium strategies of the firms it is easy to derive expected outcomes for each subset of the parameter space and each information structure. It shows

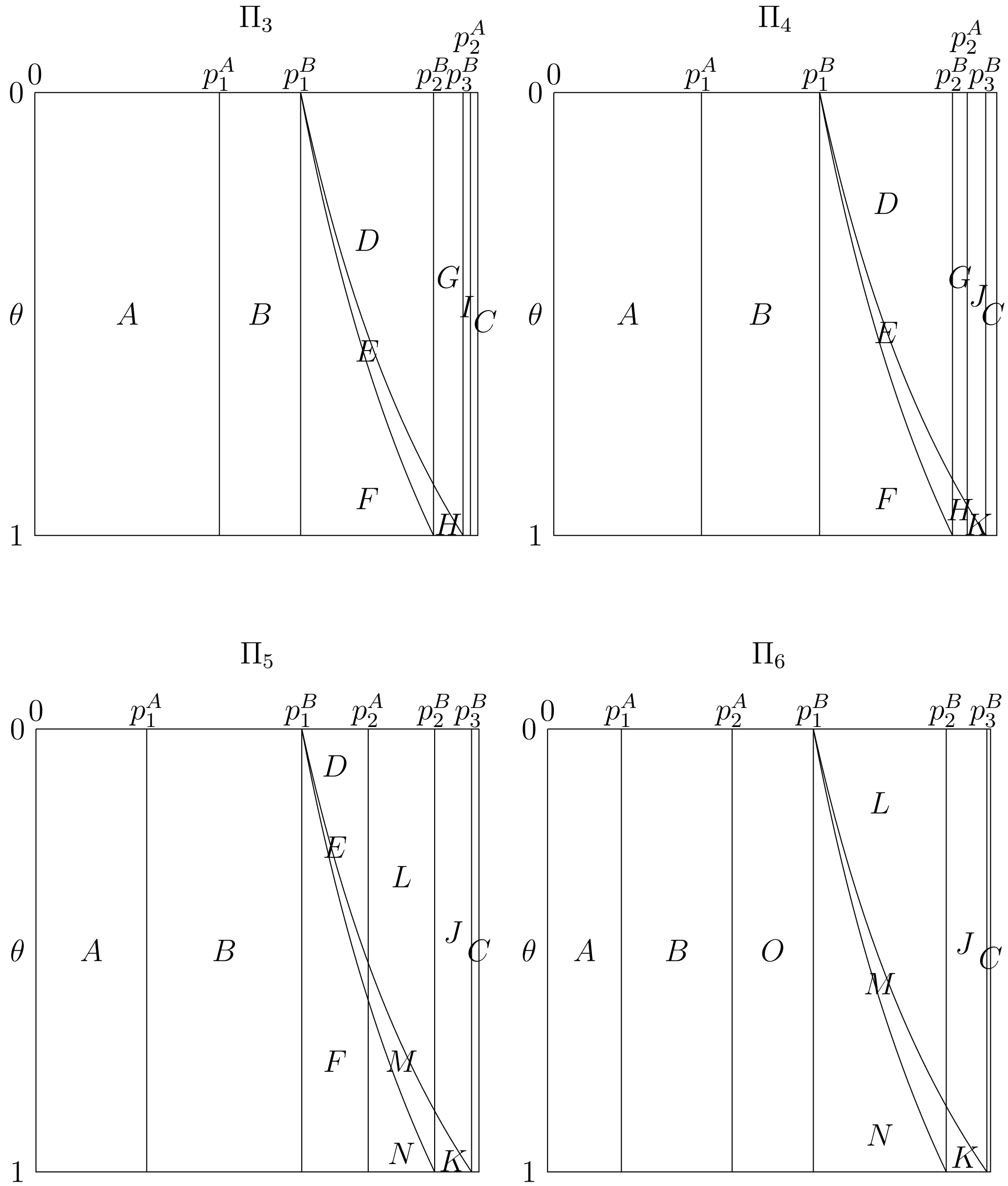

Figure 7: **Subsets of the π_h^a-θ-p parameter space.** Each graph displays the complete θ-p parameter space for a subset $\Pi_{(\cdot)}$ of the π_h^a parameter space. We marked subsets of the π_h^a-θ-p parameter space with specific payoff relationships by romanic upper-case letters. For each of these subsets and each information structure all Perfect Bayesian Nash equilibria which fulfill the intuitive criterion are given in table 7.

that for some of the subsets marked in figure 7 outcomes are the same for all information structure. Thus, with respect to outcomes we can combine some of the subsets. In result we get the graphs in figures **??** and **??**, which display the outcomes for every subset of the parameter space.

	A	B	C	D
Full, h	$\neg a; (o, o)$	$a; (o, o)$	$a; (\neg o, \neg o)$	$a; (o, o)$
Full, l	$\neg a; (o, o)$	$\neg a; (o, o)$	$\neg a; (\neg o, \neg o)$	$\neg a; (\neg o, \neg o)$
Public	$(\neg a, \neg a); (o, o)$	$(a, \neg a); (o, o)$	$(a, \neg a); (\neg o, \neg o)$	$(\neg a, \neg a); (o, \neg o)$
Private	$(\neg a, \neg a); o$	$(a, \neg a); o$	$(a, \neg a); \neg o$	$(a, \neg a); \neg o$

	E	F	G	H
Full, h	$a; (o, o)$	$a; (o, o)$	$\neg a; (o, \neg o)$	$\neg a; (o, \neg o)$
Full, l	$\neg a; (\neg o, \neg o)$	$\neg a; (\neg o, \neg o)$	$\neg a; (\neg o, \neg o)$	$\neg a; (\neg o, \neg o)$
Public	$(\neg a, \neg a); (o, \neg o)$	No eq.	$(\neg a, \neg a); (o, \neg o)$	$(\neg a, \neg a); (o, \neg o)$
Private	$(a, \neg a); o$	$(a, \neg a); o$	$(a, \neg a); \neg o$	$(a, \neg a); o$

	I	J	K	L
Full, h	$a; (\neg o, \neg o)$	$a; (o, \neg o)$	$a; (o, \neg o)$	$a; (o, o)$
Full, l	$\neg a; (\neg o, \neg o)$	$\neg a; (\neg o, \neg o)$	$\neg a; (\neg o, \neg o)$	$\neg a; (\neg o, \neg o)$
Public	$(a, \neg a); (\neg o, \neg o)$	$(a, \neg a); (o, \neg o)$	$(a, \neg a); (o, \neg o)$	$(a, \neg a); (o, \neg o)$
Private	$(a, \neg a); \neg o$	$(a, \neg a); \neg o$	$(a, \neg a); o$	$(a, \neg a); \neg o$

	M	N	O
Full, h	$a; (o, o)$	$a; (o, o)$	$a; (o, o)$
Full, l	$\neg a; (\neg o, \neg o)$	$\neg a; (\neg o, \neg o)$	$\neg a; (o, o)$
Public	$(a, \neg a); (o, \neg o)$	$(a, \neg a); (o, \neg o)$	$(a, \neg a); (o, o)$
Private	$(a, \neg a); o$	$(a, \neg a); o$	$(a, \neg a); o$

Table 7: **Perfect Bayesian Nash equilibria which fulfill the intuitive criterion for all subsets of the π_h^a-θ-p parameter space and all information structures.** For each subset of the parameter space and each information structure firm A's strategy is given before the semicolon, and firm B's strategy is given after the semicolon. In case firm A's actions ("accelerate" or "not accelerate") are contingent on the draw of the patent value, the first entry in the parentheses gives firm A's action in case the patent is of high value, and the second entry gives firm A's action in case the patent is of low value. In case firm B's actions ("oppose" or "not oppose") are contingent on firm A's acceleration decision, the first entry in parentheses gives firm B's action in case firm A accelerates, and the second entry gives firm B's action in case firm A does not accelerate.

A.2 Welfare calculations

Table 8 displays the differences in firms' expected payoffs between information structures "public", "private" and "full" for subsets I to IV (see figures **??** and **??**). Information structure "full" denotes the case of full transparency of the patent system with respect to patent value (and firm A's acceleration decision). The differences are computed for each firm individually and for both firms in aggregation. In case firms are considered in aggregation table 8 shows that whether the displayed differences in payoffs are positive or negative is clear from our assumptions A1 to A4. In case firms are considered individually also most of the payoff differences are of a clear sign. However, there are some payoff differences which critically depend on p and which we consider separately in the following:

☐ **Full I, II - Public I, II.** In subsets I and II it holds that $p < p_2^A = \frac{\pi_h + c_a + c_o}{\pi_h^a}$. With that it follows directly that the payoff difference for firm A is negative. The sign of the payoff difference for firm B remains ambiguous: It is (weakly) positive if $p \leq \frac{\pi_h - c_o}{\pi_h^a}$ and negative otherwise. Depending on the exact relationship between c_o, π_l and π_h the cut-off $\frac{\pi_h - c_o}{\pi_h^a}$ lies

	Firm A		Firm B	
Full I, II - Public I, II	$\theta[p\pi_h^a - \pi_h - c_a - c_o]$	$(-)$	$\theta[\pi_h - p\pi_h^a - c_o]$	$(+\|-)$
Full III, IV - Public III, IV	0	(0)	0	(0)
Full I, III - Private I, III	$-\theta[(1-p)\pi_h^a + c_o]$	$(-)$	$\theta[(1-p)\pi_h^a - c_o]$	$(+)$
Full II, IV - Private II, IV	$(1-\theta)[(1-p)\pi_l + c_o]$	$(+)$	$(1-\theta)[-(1-p)\pi_l + c_o]$	$(+)$
Public I - Private I	$-\theta[\pi_h^a - \pi_h - c_a]$	$(-)$	$\theta[\pi_h^a - \pi_h]$	$(+)$
Public II - Private II	$\theta[\pi_h - p\pi_h^a + c_a]$ $+c_o + (1-\theta)(1-p)\pi_l$	$(+)$	$\theta[-\pi_h + p\pi_h^a]$ $+c_o - (1-\theta)(1-p)\pi_l$	$(-\|+)$
Public III - Private III	$-\theta[(1-p)\pi_h^a + c_o]$	$(-)$	$\theta[(1-p)\pi_h^a - c_o]$	$(+)$
Public IV - Private IV	$(1-\theta)[(1-p)\pi_l + c_o]$	$(+)$	$(1-\theta)[-(1-p)\pi_l + c_o]$	$(+)$

	Firm A + Firm B	
Full I, II - Public I, II	$-\theta(c_a + 2c_o)$	$(-)$
Full III, IV - Public III, IV	0	(0)
Full I, III - Private I, III	$-2\theta c_o$	$(-)$
Full II, IV - Private II, IV	$(1-\theta)2c_o$	$(+)$
Public I - Private I	θc_a	$(+)$
Public II - Private II	$\theta c_a + 2c_o$	$(+)$
Public III - Private III	$-2\theta c_o$	$(-)$
Public IV - Private IV	$(1-\theta)2c_o$	$(+)$

Table 8: **Payoff Differences.** Displayed are the differences in payoffs between subsets I to IV and information structures "public", "private" and "full" for firms A and B individually and considered together. Information structure "full" means full transparency of the patent system. The subsets I to IV are marked in figures **??** and **??**. The payoff difference for firm B between information structures "full" and "public" and subsets I and II is positive if $p < \frac{\pi_h - c_o}{\pi_h^a}$ and negative otherwise. The payoff difference for firm B between information structures "public" and "private" and subset II is negative if $p < \frac{\theta\pi_h + (1-\theta)\pi_l - c_o}{\theta\pi_h^a + (1-\theta)\pi_l}$ and positive otherwise.

either between p_1^B and p_2^A or is smaller than p_1^B. (Our assumptions A1 to A4 allow both.)

□ **Full II, IV - Private II, IV and Public IV - Private IV, firm B.** In subsets II and IV it holds that $p > p_1^B = \frac{\pi_l - c_o}{\pi_l}$. It follows that $1 - p < \frac{c_o}{\pi_l}$. With that it is clear that the payoff difference is positive.

□ **Public II - Private II.** In subset II it holds that $p < p_2^A = \frac{\pi_h + c_a + c_o}{\pi_h^a}$. Given that relation and assumption A4 ($c_a \leq c_o$), it follows directly that the payoff difference for firm A is positive. Whether the payoff difference for firm B is positive or negative is not clear: It is (weakly) negative if $p \leq \frac{\theta\pi_h + (1-\theta)\pi_l - c_o}{\theta\pi_h^a + (1-\theta)\pi_l}$ and positive otherwise. Depending on the exact relationship between c_o, π_l and π_h the cut-off value $p_W = \frac{\theta\pi_h + (1-\theta)\pi_l - c_o}{\theta\pi_h^a + (1-\theta)\pi_l}$ lies either between $p_{\theta,1}$ and $p_{\theta,2}$ or is smaller than $p_{\theta,2}$. (Our assumptions allow both.)

A.3 Descriptive pre-post-comparisons

	before	after	diff	p-Value	change	NObs
Acc	0.061	0.078	0.017***	0.000	0.274***	214348
Opp	0.058	0.055	-0.003***	0.001	-0.067***	214348
Opp | accex==1	0.128	0.099	-0.029***	0.000	-0.225***	15139
Opp | accex==0	0.053	0.051	-0.002**	0.012	-0.047**	199209

Table 9: **Comparison of acceleration and opposition rates of the pre- and the post-treatment period for all patents.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The sample comprises all patents which were granted after six years the latest). Whether differences between the pre- and the post-treatment period are significant is tested via a two-sample ttest. Significance niveaus are indicated by stars: ***: 1%, **: 5%, *: 10%

	before	after	diff	p-Value	change	NObs
1(ElectrEng),Acc	0.071	0.099	0.028***	0.000	0.397***	41852
Opp	0.029	0.022	-0.007***	0.000	-0.243***	41852
2(Instruments),Acc	0.076	0.089	0.013***	0.000	0.174***	27900
Opp	0.050	0.042	-0.008***	0.001	-0.163***	27900
3(Chemistry),Acc	0.063	0.067	0.005**	0.027	0.074**	56028
Opp	0.079	0.082	0.003	0.180	0.039	56028
4(MechEng),Acc	0.044	0.063	0.019***	0.000	0.424***	72395
Opp	0.060	0.059	-0.001	0.586	-0.016	72395
5(OthFields),Acc	0.086	0.112	0.026***	0.000	0.301***	16173
Opp	0.057	0.057	-0.001	0.851	-0.012	16173

Table 10: **Comparison of acceleration and opposition rates of the pre- and the post-treatment period for the main technological areas.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The sample comprises all patents which were granted after six years the latest). Whether differences between the pre- and the post-treatment period are significant is tested via a two-sample ttest. Significance niveaus are indicated by stars: ***: 1%, **: 5%, *: 10%

A.4 DID estimations - robustness checks

	All	1 (Electr Eng) 201 to 208	2 (Instruments) 209 to 213	3 (Chemistry) 214 to 224	4 (Mech Eng) 225 to 232	5 (Oth Fields) 233 to 235
AccCoeff	0.014	0.031***	0.003	0.003	0.020***	0.021*
AccTStat	4.88	4.752	0.292	0.515	4.584	1.647
OppCoeff	0.003	-0.004	-0.019***	0.007	0.003	0.010
OppTStat	1.06	-1.070	-2.665	1.215	0.620	0.959

Table 11: **Treatment effects.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after six years the latest. No composition controls are included. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	1 (Electr Eng) 201 to 208	2 (Instruments) 209 to 213	3 (Chemistry) 214 to 224	4 (Mech Eng) 225 to 232	5 (Oth Fields) 233 to 235
AccCoeff	0.020***	0.000	0.006	0.013***	0.018
AccTStat	2.882	0.016	0.952	2.914	1.347
OppCoeff	-0.005	-0.014**	0.000	0.003	0.002
OppTStat	-1.210	-2.107	0.021	0.762	0.245

Table 12: **Treatment effects.** The pre-treatment period covers the years 1996 to 1998, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after six years the latest. No composition controls are included. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	1 (Electr Eng) 201 to 208	2 (Instruments) 209 to 213	3 (Chemistry) 214 to 224	4 (Mech Eng) 225 to 232	5 (Oth Fields) 233 to 235
AccCoeff	0.023***	-0.003	0.002	0.013***	0.010
AccTStat	3.053	-0.266	0.390	2.621	0.677
OppCoeff	-0.002	-0.015**	-0.003	-0.001	0.003
OppTStat	-0.528	-1.969	-0.446	-0.128	0.225

Table 13: **Treatment effects.** The pre-treatment period covers the years 1996 to 1997, the post-treatment period the years 2001 to 2002. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after seven years the latest. No composition controls are included. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	1 (Electr Eng) 201 to 208	2 (Instruments) 209 to 213	3 (Chemistry) 214 to 224	4 (Mech Eng) 225 to 232	5 (Oth Fields) 233 to 235
AccCoeff	0.007	-0.000	0.007	0.004	0.021
AccTStat	0.933	-0.047	1.116	0.838	1.396
OppCoeff	0.001	-0.007	-0.008	-0.001	-0.003
OppTStat	0.290	-1.062	-1.181	-0.282	-0.289

Table 14: **Treatment effects.** The pre-treatment period covers the years 1997 to 1998, the post-treatment period the years 2001 to 2002. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after seven years the latest. No composition controls are included. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	1 (Electr Eng) 201 to 208	2 (Instruments) 209 to 213	3 (Chemistry) 214 to 224	4 (Mech Eng) 225 to 232	5 (Oth Fields) 233 to 235
AccCoeff	0.024***	0.001	0.008	0.020***	0.015
AccTStat	4.337	0.147	1.447	4.969	1.314
OppCoeff	-0.002	-0.018***	0.006	0.003	0.003
OppTStat	-0.592	-3.511	1.056	0.671	0.283

Table 15: **Treatment effects.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted until 31 Dec 2009 the latest. No composition controls are included. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	1 (Electr Eng) 201 to 208	2 (Instruments) 209 to 213	3 (Chemistry) 214 to 224	4 (Mech Eng) 225 to 232	5 (Oth Fields) 233 to 235
AccCoeff	0.019***	0.002	0.001	0.015***	0.015
AccTStat	3.687	0.239	0.229	4.029	1.389
OppCoeff	-0.006*	-0.024***	0.001	0.002	0.001
OppTStat	-1.941	-4.291	0.177	0.440	0.159

Table 16: **Treatment effects.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted until 31 May 2012 the latest. No composition controls are included. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	All	1 (Electr Eng) 201 to 208	2 (Instruments) 209 to 213	3 (Chemistry) 214 to 224	4 (Mech Eng) 225 to 232	5 (Oth Fields) 233 to 235
AccCoeff	0.008***	0.034***	-0.006	-0.004	0.020***	0.009
AccTStat	2.60	4.593	-0.649	-0.741	4.355	0.663
OppCoeff	0.001	-0.009**	-0.019***	0.007	0.003	0.014
OppTStat	0.29	-2.065	-2.887	1.117	0.687	1.389

Table 17: **Treatment effects (one year valid after grant).** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for one full year of validation. Captured are patents which were granted after six years the latest. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	All	1 (Electr Eng) 201 to 208	2 (Instruments) 209 to 213	3 (Chemistry) 214 to 224	4 (Mech Eng) 225 to 232	5 (Oth Fields) 233 to 235
AccCoeff	0.018***	0.038***	-0.001	0.009	0.022***	0.029**
AccTStat	5.96	5.469	-0.154	1.561	4.994	2.213
OppCoeff	0.002	-0.004	-0.016**	0.010*	0.004	0.007
OppTStat	0.89	-0.941	-2.433	1.679	0.923	0.664

Table 18: **Treatment effects (three years valid after grant).** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for three full years of validation. Captured are patents which were granted after six years the latest. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

A.5 DID estimations - full regressions

	(1)	(2)	(3)	(4)	(5)
	accex	accex	accex	accex	accex
post2	0.0271***	0.0144***	0.00838***	0.0145***	0.0195***
	(0.00330)	(0.00446)	(0.00281)	(0.00227)	(0.00755)
TG	0.0485***	0.0714***	0.0659***	0.0395***	0.0604***
	(0.00444)	(0.00664)	(0.00405)	(0.00285)	(0.00880)
diff	0.0313***	0.00264	0.00303	0.0195***	0.0211*
	(0.00658)	(0.00902)	(0.00588)	(0.00426)	(0.0128)
_cons	0.0473***	0.0467***	0.0342***	0.0267***	0.0600***
	(0.00230)	(0.00313)	(0.00195)	(0.00159)	(0.00525)
N	34057	17568	32814	48621	8992
adj. R^2	0.018	0.017	0.018	0.014	0.016

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 19: **Treatment effects - full DID regressions, acceleration.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after six years the latest. No composition controls are included. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	(1)	(2)	(3)	(4)	(5)
	opp	opp	opp	opp	opp
post2	-0.00324**	-0.00265	0.000801	0.00163	-0.00902*
	(0.00158)	(0.00304)	(0.00342)	(0.00246)	(0.00517)
TG	0.0346***	0.0638***	0.0357***	0.0461***	0.0528***
	(0.00305)	(0.00566)	(0.00425)	(0.00324)	(0.00737)
diff	-0.00423	-0.0189***	0.00734	0.00275	0.00955
	(0.00395)	(0.00711)	(0.00604)	(0.00443)	(0.00996)
_cons	0.0140***	0.0251***	0.0573***	0.0377***	0.0351***
	(0.00127)	(0.00232)	(0.00249)	(0.00188)	(0.00407)
N	34057	17568	32814	48621	8992
adj. R^2	0.011	0.016	0.006	0.010	0.015

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 20: **Treatment effects - full DID regressions, opposition.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after six years the latest. No composition controls are included. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	(1)	(2)	(3)	(4)	(5)
	accex	accex	accex	accex	accex
post2	0.0232***	0.0108**	0.00683**	0.0136***	0.0183**
	(0.00338)	(0.00461)	(0.00285)	(0.00229)	(0.00765)
TG	0.0472***	0.0600***	0.0580***	0.0302***	0.0614***
	(0.00465)	(0.00691)	(0.00426)	(0.00291)	(0.00886)
diff	0.0310***	0.00207	0.00253	0.0190***	0.0193
	(0.00659)	(0.00902)	(0.00585)	(0.00426)	(0.0128)
PCT	-0.0131***	-0.0177***	-0.0236***	-0.0160***	-0.00899
	(0.00351)	(0.00495)	(0.00318)	(0.00235)	(0.00679)
ADest_DE	0.00191	0.0152**	0.0139***	-0.00774**	-0.0144*
	(0.00527)	(0.00745)	(0.00467)	(0.00334)	(0.00855)
ADest_FR	-0.0254***	-0.0283***	0.00128	-0.0388***	-0.0224**
	(0.00630)	(0.00923)	(0.00632)	(0.00407)	(0.0108)
ADest_GB	-0.0161*	-0.0482***	-0.0140**	-0.0289***	-0.0257*
	(0.00852)	(0.00917)	(0.00695)	(0.00543)	(0.0135)
ADest_JP	-0.0166***	-0.0447***	-0.0318***	-0.0374***	0.00226
	(0.00488)	(0.00674)	(0.00432)	(0.00349)	(0.0132)
ADest_US	-0.00744	-0.0340***	-0.0244***	-0.0370***	-0.0166
	(0.00474)	(0.00615)	(0.00409)	(0.00332)	(0.0107)
CLMSNR	0.00109***	0.00116***	0.00155***	0.000807***	0.00130***
	(0.000169)	(0.000220)	(0.000156)	(0.000136)	(0.000373)
RINV	0.00430***	-0.00441***	-0.00472***	-0.00473***	-0.0122***
	(0.00106)	(0.00125)	(0.000674)	(0.000655)	(0.00207)
_cons	0.0374***	0.0738***	0.0530***	0.0570***	0.0792***
	(0.00498)	(0.00710)	(0.00488)	(0.00351)	(0.00903)
N	34057	17568	32814	48621	8992
adj. R^2	0.021	0.026	0.028	0.020	0.019

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 21: **Treatment effects - full DID regressions, acceleration.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after six years the latest. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.

	(1)	(2)	(3)	(4)	(5)
	opp	opp	opp	opp	opp
post2	-0.00539***	-0.00588*	0.000434	-0.00212	-0.0130**
	(0.00163)	(0.00315)	(0.00348)	(0.00248)	(0.00528)
TG	0.0297***	0.0605***	0.0319***	0.0392***	0.0483***
	(0.00308)	(0.00585)	(0.00439)	(0.00331)	(0.00749)
diff	-0.00286	-0.0182**	0.00731	0.00362	0.0110
	(0.00397)	(0.00710)	(0.00604)	(0.00443)	(0.00997)
PCT	0.00165	0.00864**	-0.0112***	0.000108	-0.00338
	(0.00191)	(0.00344)	(0.00327)	(0.00237)	(0.00525)
ADest_DE	0.00593*	-0.00158	0.00424	0.0119***	0.00587
	(0.00320)	(0.00529)	(0.00454)	(0.00324)	(0.00679)
ADest_FR	-0.0118***	-0.0215***	0.00610	-0.0211***	-0.0144*
	(0.00349)	(0.00636)	(0.00643)	(0.00403)	(0.00788)
ADest_GB	0.0111*	-0.0195***	0.00769	-0.00906	-0.0177*
	(0.00604)	(0.00716)	(0.00775)	(0.00586)	(0.00976)
ADest_JP	-0.0115***	-0.00879*	-0.0148***	-0.0172***	-0.0213***
	(0.00235)	(0.00476)	(0.00450)	(0.00342)	(0.00767)
ADest_US	-0.00680***	-0.00342	-0.00657	-0.0191***	-0.0126
	(0.00254)	(0.00479)	(0.00432)	(0.00339)	(0.00830)
CLMSNR	0.000150	0.000203	0.000682***	0.00108***	0.00120***
	(0.0000971)	(0.000133)	(0.000150)	(0.000143)	(0.000354)
RINV	0.00196***	0.00605***	-0.00210***	0.00404***	0.00452**
	(0.000576)	(0.00108)	(0.000671)	(0.000762)	(0.00211)
_cons	0.0130***	0.0114**	0.0646***	0.0247***	0.0204***
	(0.00299)	(0.00502)	(0.00487)	(0.00347)	(0.00749)
N	34057	17568	32814	48621	8992
adj. R^2	0.013	0.020	0.007	0.014	0.018

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 22: **Treatment effects - full DID regressions, opposition.** The pre-treatment period covers the years 1995 to 1997, the post-treatment period the years 2001 to 2003. The treatment group is comprised of patents from the top quartile of the distribution of the scope-year-index, the non-treatment group is comprised of the bottom quartile. The scope-year index proxies for patent value and is computed for the 18 oldest member states of the EPC and for two full years of validation. Captured are patents which were granted after six years the latest. Significance niveaus are given by stars: ***: 1%, **: 5%, *: 10%.