Patent portfolio races in concentrated markets for technology

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Florian Jell[1, 2] and Joachim Henkel[1, 3, 4]

[1] Technische Universität München
Schöller Chair in Technology and Innovation Management, Arcisstr. 21, D-80333 Munich, Germany.
Phone: +49-89-289-25748; fax: +49-89-289-25742. Email: florian.jell@wi.tum.de, henkel@wi.tum.de
[2] Microsoft Fellow, Program in Law, Economics, and Technology at University of Michigan, Fall 2009
[3] Center for Economic Policy Research (CEPR), London
[4] Corresponding author

Abstract

Patent application numbers grow exponentially in many industries, a phenomenon that has been linked to high fragmentation of patent ownership. Contradicting these findings and theoretical arguments, we show that such fragmentation is not a precondition for sudden and strong increases in patenting. We describe and analyze a patent portfolio race in an industry with highly concentrated patent ownership, namely the newspaper printing machines oligopoly. Triangulating data from patent analysis, interviews, and document research, we find that patent strategy change by one player triggered a patent portfolio race with its main competitor. Implications for managers are that increasing patent output may yield temporary advantages but, as in a price war, implies the risk of a prisoner's dilemma-type outcome with potentially severe implications for effectiveness and efficiency of the innovation process.

Keywords: Patent strategy, motives to patent, intellectual property, patent thickets

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1 Introduction

Recent economic research has identified high fragmentation of patent ownership as the major driver of patent portfolio races among industrial firms, leading to (possibly inefficiently) high patenting rates in certain industries (Grindley and Teece, 1997; Hall and Ziedonis, 2001; Heller, 2008; Heller and Eisenberg, 1998; Scotchmer, 1991; Ziedonis 2004). In this paper we show that even under very low fragmentation of patent rights dramatic patent portfolio races occur. We study the industry of newspaper printing machines, which has seen a more than three-fold increase in the number of patent applications within less than five years (while research and development [R&D] headcount hardly changed), although relevant patents are held by only four major firms.

Based on transaction cost theory, scholars have argued that high fragmentation of patent ownership, with possibly thousands of potential patentees, decreases the odds of identifying *ex ante* the holders of patents relevant to the design and manufacturing of a focal firm (Hall and Ziedonis; 2001, Williamson, 1985; Ziedonis, 2004). Thus, it increases the risk that patent infringement by the focal firm will be identified only after the firm has made significant investments in the infringing technology and invent around is inadequately costly. Furthermore, *ex ante* coordination is harder to establish and to sustain the more players that are involved. Literature predicts that firms faced with high fragmentation of intellectual property (IP fragmentation) will amass defensive patents in order to mitigate the risk of rent expropriation in case of holdup—the rationale being the ability to countersue a potential attacker (Cohen et al., 2000; Hall and Ziedonis, 2001; Ziedonis 2004). This behavior ultimately spawns patent portfolio races that might lead to a prisoner's dilemma-type outcome (Cohen et al., 2000).

Empirical findings on such excessive patenting stem from dynamic[1] high-tech industries that face highly fragmented markets for technology, such as semiconductors, electronics, and software (Cockburn and MacGarvie, 2009; Grindley and Teece, 1997; Hall and Ziedonis, 2001; Noel and Schankerman, 2006; Ziedonis, 2004). Based on this literature, one would reasonably assume that if IP fragmentation was the main driver of excessive patenting, less dynamic and more consolidated industries with highly concentrated patent ownership devise *ex ante* solutions to the potential holdup problems, and thus are able to avoid inefficient patent portfolio races.

In this paper, we provide empirical evidence from a contrasting scenario. We study a highly consolidated, stable market—the newspaper printing machines industry. It consists of four major players, and product life cycles range between 10 and 20 years. With only four major players and the specificity of their products, the fragmentation of intellectual property right holders relevant to this market is very low. Thus, it should be possible for the firms in this market to identify the owners of important and potentially dangerous patents. This fact, in turn, should render *ex ante* contracting more feasible, decrease holdup risk, and inhibit portfolio races. Nonetheless, this industry has seen a more than three-fold increase in the number of patent applications within less than five years, even an almost quadruple increase for one firm, while R&D headcount hardly changed.

This observation shows that the potential of firms in the machinery sector to effectuate *ad hoc* increases of their patent portfolios without related increases in R&D inputs is tremendous. More importantly, it shows that even in the absence of IP fragmentation sudden, explosive increases in patenting activity can occur.

[1] Industry dynamicity aggravates the problem of *ex ante* coordination. A patent spends 18 months at the patent office before it is published. During this period, other firms are ignorant of the application. This fact poses problems in particular if the respective industry has developed very fast during these 18 months, since firms do not even know who the relevant future rights holders will be.

We identify the perceived ineffectiveness of single patents as the main motive of the first mover to change its strategy and file more patents per invention. The larger patent portfolio of its most important competitor, in turn, prompted the second player to follow suit and increase its patenting. A patent portfolio race, or "arms race" ensued.[2] To make our point, we rule out alternative explanations of the explosive increase in patenting. Furthermore, our results show that the problem of patent arms races is not limited to the United States. Even in Europe, where arms races were considered less likely due to higher standards of patentability (Hall et al., 2004), dramatic races occur.

Our results contribute further insights into the effects of industry and IP fragmentation on patenting. Whereas IP fragmentation may really drive a focal firm's patenting in the semiconductor industry, low IP fragmentation apparently does not prevent patent portfolio races in the machinery sector. Moreover, if low IP fragmentation did reduce the patent arms race risk, this reduction seems to be outweighed by other factors, such as perceived ineffectiveness of single patents and close competition in a specific product market. This finding adds to the knowledge of determinates of patenting behavior by showing that high IP fragmentation is not the only—and not even a necessary—driver of a patent arms race.

Drawing on game-theoretical arguments about repeated interaction, in particular the folk theorem (e.g. Tirole, 1988, p. 245), we argue that increasing patent output may yield temporary advantages but, as in a price war, implies the risk of a prisoner's dilemma-type outcome. The combatants are worse off in the new equilibrium than before, since more resources have to be devoted to filing, managing, monitoring, enforcing, inventing around, and invalidating patents as well as to resolving patent disputes. As a result, their innovation processes are

[2] Note that a "patent arms race" is different from a "patent race". In a patent arms race, firms compete for the largest patent portfolio. In a patent race, firms compete in a race to be first to achieve a specific invention and to obtain a patent on it (cf. Dasgupta and Stiglitz, 1980; Loury, 1979; Reinganum, 1982).

likely to become less efficient, and possibly even less effective if engineers work on patents instead of inventions.

In our conclusion, we discuss potential solutions to the arms race. Due to the low number of incumbents, patent pools (which are common in e.g. the electronics industry) would be subject to antitrust considerations. Rather, other coordination mechanisms, in particular tacit collusion, are likely to evolve.

The remainder of this article is organized as follows: Section 2 discusses extant literature on firms' motives to increase patenting; Section 3 describes data collection and analysis; Section 4 presents results from patent data analysis, interviews, and document research; and Sections 5 and 6 conclude.

2 Background

2.1. Patenting and the fragmentation of intellectual property rights: Industry context

Pioneers in patent research have discussed whether the numbers of patent applications and grants are appropriate measures of inventive output (Pakes and Griliches 1980). Since scholars have begun to study propensity to patent (Kortum and Lerner, 1998; Scherer, 1983), evidence has grown that the surge in patenting observable in certain industries is largely due to increased propensity to patent rather than to increased inventive output (Hall, 2005; Hall and Ziedonis, 2001; Kim and Marschke, 2004). Patent portfolio races contribute to this increase.

Extant literature links patent portfolio races to a high level of IP fragmentation. The contribution of our study is to juxtapose this situation to an antipodal industry setting characterized by very low IP fragmentation, and to analyze why the latter, contrary to accepted wisdom, has similarly yielded a patent portfolio race. In the following, we discuss both industry settings with respect to incentives for patenting and for patent races in particular.

2.1.1. Fragmented markets for technology

Highly fragmented markets for technology are present in the semiconductor, electronics, and software industries, among others. In the semiconductor industry, for example, potential rights holders range from pure design firms to integrated manufacturers (Arora et al., 2001, p. 76; Macher et al., 1999; Ziedonis, 2003). Peter N. Detkin of Intel Corporation in his testimony before the U.S. Federal Trade Commission in 2002 estimates that the approximately 90,000 existing patents for central processing units are held by more than 10,000 parties.[3] For the communication electronics industry, Gilroy and D'Amato (2009) estimate that over 2,700 separate entities were actively patenting technology relevant to the fourth generation of cellular wireless networks and devices in 2008.

In such a situation firms face high holdup risk, and are likely to increase patenting in order to forearm against infringement suits. The increase is defensive and motivated by the goal to mitigate risks of expropriation. The rationale of this strategy is the ability to countersue potential plaintiffs, at least those that are practicing entities themselves (in contrast to "nonpracticing entities", or "patent trolls", see e.g. Lemley and Shapiro, 2007; Reitzig et al., 2007).

There is broad empirical evidence of patent portfolio races in fragmented markets for technology. Hall and Ziedonis (2001) analyze the doubling of patent output per R&D dollar for a sample of 95 publicly traded semiconductor firms over a period of 10 years. They find that firms entered patent portfolio races in order to forearm against holdup by competitors that owned patents required for the firms' own production. Ziedonis (2004), analyzing 67 semiconductor firms, concludes that a wide distribution of patent rights will lead to more aggressive patenting by capital intensive firms. This hypothesis is based on the reasoning that a high fragmentation of markets for technology makes *ex ante* licensing or acquisition of patent

[3] Peter N. Detkin, vice president, Legal and Government Affairs and assistant general counsel, Intel Corporation, 18 February 2002, http://www.ftc.gov/opp/intellect/020228peterndetkin.pdf (accessed 18 May 2010).

holders less feasible and thus increases holdup risk. Cockburn and MacGarvie (2009), based on an analysis of 27 distinct software product markets between 1980 and 2006, find evidence that firms without patents are less likely to go public if they operate in a market characterized by overlapping intellectual property rights (so called "patent thickets" [Shapiro, 2001]). This creates an incentive for firms owning fewer patents in "thicket-markets" to increase their patent portfolios in order to improve their chances of going public. Noel and Schankerman (2006), using panel data on software firms in the United States during 1980 to 1999, find that higher concentration of patent rights is associated with lower patenting activity.

2.1.2. Concentrated markets for technology

In a concentrated technology market, holdup risk due to patent infringement is lower than in a fragmented market since firms do not have to fear litigation by previously unknown patent holders. In line with Noel and Schankerman (2006), one would thus expect that, with low IP fragmentation, the mitigation of holdup risk is less important as a motive for excessive patenting. Rather, we would assume a course of action comparable to a price war: A first mover increases its patenting for some reason—to be analyzed below—and followers respond swiftly and in a way that is clearly directed at the first mover. This is because there are few firms against which the first mover could use its additional patents, be it for blocking or for extracting royalties, and so industry participants are strongly dependent on the behavior of rivals (Porter 1980: 91) and very likely to react. Also, due to the small number of relevant patent holders, visibility of competitors' patent applications is high.

Note that this scenario does not preclude patent infringement. Yet, in contrast to a situation characterized by high IP fragmentation, the alleged infringer will most likely have known the plaintiff before. Once involved in costly litigation, forced to pay license fees, or even to shut down a plant, a firm will, in a similar fashion as in a highly fragmented market, increase patenting in order to forearm against future attacks (Hall and Ziedonis 2001, Lanjouw and

Lerner 2001, von Hippel 1988: 53). Once such a "patent war" (Guellec and van Pottelsberghe, 2007, p. 81) or patent arms race has been started, it is very likely that mutually blocking positions will result. Firms may use cross-licenses to resolve such situations (Shapiro, 2001), or to avoid them in the first place. However, if balancing payments are negotiated on the basis of a comparison of patent counts, cross-licensing creates an incentive to further increase the number of patents rather than to improve the quality of the underlying inventions. An industry that fits this scenario to a high degree is the newspaper printing oligopoly.

2.2. First mover motives and triggers of an increase in patenting per R&D

The behavior of a follower in a patent arms race is triggered by that of the first mover. It is less obvious, though, what drives the first mover to deviate from hitherto stable patenting rates in its industry. Our review of the literature reveals a variety of potential drivers: the integration of IP management in corporate strategy, perceived ineffectiveness of individual patents, the threat of market entry, increased use of patents for retaliation and bargaining, loss of patents due to oppositions,[4] the aim to increase royalty income, a higher need to signal innovativeness, and changes in patenting standards.

If a firm's IP management becomes an explicit element of its corporate strategy (Adler et al., 1992, p. 27; Reitzig, 2007), we would expect that more sophisticated patent strategies would result, often involving increased filing numbers. Such attention to IP on the strategic level will, in turn, be caused by one of the drivers discussed in the following.

In many industries, patents are perceived as relatively ineffective in enabling firms to profit from their innovations (Arundel, 2001; Cohen et al., 2000; Levin et al., 1987; Mansfield, 1986; Sattler, 2003). Among other things, this is because single patents can be invented around relatively easily in many technology fields (Cohen et al., 2000). A way to increase

[4] At the European Patent Office and the German Patent and Trademark Office, third parties may file an opposition against a granted patent within nine respectively three months after the grant.

effectiveness of patent protection is to build patent "fences" (Guellec and van Pottelsberghe, 2007, p. 87; Reitzig, 2004b). To this end, a firm would not only patent the initial invention, but would also start patenting variations of it; for example, different geometric shapes or temperature conditions (Granstrand, 1999, p. 220). These patents, and even pending applications, then form fences to impede invent around, to block competitors, and to prevent rivals from patenting related inventions (Arundel and Patel, 2003; Blind et al., 2009; Cohen et al., 2000; Granstrand, 1999; Henkel and Jell, 2009; Kash and Kingston 2001).

Market entry or even the threat of it might be a further trigger for firms to increase patenting. In the absence of or in addition to alternative mechanisms such as complementary assets or complexity of design (Teece, 1986), firms might use patents to protect against new entrants, in which case patents effectively function as market entry barriers (Bain, 1956; Caves, 1974; Caves et al., 1991; Porter, 1980). Diversification strategies might provoke the same reaction and trigger the use of patents as mobility barriers (Caves and Porter, 1977).

A growing need for patents for the purposes of retaliation and bargaining arises when other intellectual property holders increasingly enforce their own patents against the focal firm (Grindley and Teece, 1997). In that case, this firm would defensively file more patents itself in order to forearm against expropriation. A prominent example is the industry's reaction to Texas Instruments patent enforcement. Facing severe income problems in the mid-1980s, the firm took a more aggressive stance toward intellectual property licensing in 1986, which, in turn, entailed increased patenting in the industry overall (Grindley and Teece, 1997; Hall and Ziedonis 2001).[5]

Increasing opposition rates may also create incentives to pursue a multiple-patents strategy (cf. Harhoff and Hall, 2002; Harhoff and Reitzig, 2004). Since preparing an opposition

[5] Hall and Ziedonis (2001, p. 109) quote from their interviews: "Indeed, interviewees were well aware of the strategies that Texas Instruments had put in place to manage—and profit from—its patent portfolio; representatives from several firms plan to adopt a similarly aggressive licensing strategy once their portfolios grow larger".

proceeding is far more labor-intensive than filing a patent, firms can mitigate the risk of losing patents through opposition by filing more patents on the same invention. The adoption of such strategies, likely triggered when a firm has suffered the loss of some patents through opposition, leads to an increase in patenting without additional innovation or even invention.

Similarly, if a firm starts to put more emphasis on royalty income from patents, it has incentives to increase its patenting. Since it is more difficult to invent around a larger patent portfolio, patenting increases the odds of receiving royalties. Such an increased focus on royalty income and thus on patenting may even have been triggered by the management literature (e.g. Reitzig, 2004a, 2007; Rivette and Kline, 2000a, b). An example is provided by Rubinfeld and Maness (2005) in their analysis of the personal watercraft industry where Yamaha uses its patents to raise its competitors' cost—which can fiercely hit a competitor when margins in the product market are thin.

A further important aspect of our discussion is the stance that a firm's managers have toward the signaling function of patents. If the management board adopts the view that high numbers of patent applications signal technology leadership to investors or customers, this firm would, *ceteris paribus*, start filing more patents than an otherwise comparable firm. Such a firm has "[…] an incentive to produce the indicator rather than what it is supposed to indicate" (Macdonald 2001, 2004, p. 145). The usage of patents to improve a firm's reputation has been empirically shown by Blind et al. (2006) and, with a focus on venture capital financing, by Haeussler et al. (2009) and Hsu and Ziedonis (2008).

Finally, changes in patenting standards and other system level factors will influence patent propensity. Hall (2005) discusses whether major changes in the U.S. patent system, such as the creation of the Court of Appeals for the Federal Circuit, have led to increases in the propensity to patent. The grant policies of patent offices may have also influenced this increase. It is a trivial but realistic assumption that a firm realizes at some point that minor inventions, such as new combinations or applications of state-of-the-art technology or new subject-matter

(e.g. software or business models), which would not have been patentable before, can successfully be pushed through the patenting process. It may adopt this practice and henceforth increasingly patent (minor) inventions of this kind (Merges, 1999). This is in line with Wagner (2008) who finds evidence that the European Patent Office (EPO), albeit prohibited by the European Patent Convention (Article 52(2)), has granted patents on business methods. Further support is presented by Bessen and Hunt (2004) who trace a strong increase in patenting of software without increase in R&D input to non-software firms.

3 Method and data

To the best of our knowledge no evidence on the detailed mechanics of patent arms races in low-IP fragmentation markets exists. Thus, we chose exploratory and qualitative methods for this study. The subject of our analysis is the newspaper printing machines industry, which allows for an in-depth analysis of a stable set of very few players. Analyzing all four of the relevant firms, we are able to include almost 90 percent of the industry's market share into our study.

Since the goal of this paper is to contribute to the theory on motives to patent, case study research is the appropriate methodological approach (Eisenhardt and Graebner, 2007). The power of qualitative research methods in this context has been demonstrated by Hall and Ziedonis (2001), who use field interviews, among other methods, to explore the essential mechanics of patent arms races in the semiconductor industry. Following Eisenhardt (1989) and Yin (2003, p. 14), we proceed by methodological triangulation. Our case study is based on patent data, document analysis, and interviews.

First, we use data from the Worldwide Patent Statistical Database (PATSTAT) and patent process information from the International Patent Documentation Center (INPADOC) be-

tween 1992 and 2006[6] in order to identify and analyze the development of patent portfolios in the industry. Second, we interpret these findings in light of 23 interviews and an analysis of press articles (e.g. from LexisNexis), financial data (e.g. from Compustat and Thomson/Reuters), and annual reports of printing press manufacturers. To this end, we conducted eight in-depth interviews with patent and R&D executives of printing machine manufacturers. We asked our interviewees about patenting related trends in their industry as well as about their own and their competitors' patenting behaviors. These interviews were complemented by intensive email exchanges and follow-up interviews, allowing us to ask clarifying questions and to obtain feedback on earlier drafts of the paper. Two further interviews were conducted with one patent examiner at the EPO and with one specialist from the printing department at the German Engineering Federation (VDMA).[7] One interview was conducted with the chief technology officer (CTO) of a newspaper publishing company, i.e. a firm that buys and operates newspaper printing machines. The above interviews had an average duration of 45 minutes and were recorded and transcribed. We conducted 12 further interviews that could not be recorded due to reasons of confidentiality, with an average duration of 30 minutes. During these interviews handwritten notes were taken. The interviewees comprised three other CTOs of newspaper printing houses and nine industry experts interviewed at the DRUPA 2008 printing trade fair in June 2008.[8] The latter were product managers, R&D engineers, sales managers, or executives of manufacturers of printing machines. The analysis of all documented material follows the approach of qualitative content analysis (Mayring, 2004) and was performed using the NVivo 8 software package.

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[6] We use an April 2009 version of PATSTAT. This version includes patent applications published until early 2009. Since there is a delay of 18 months before a patent application is made public, the first full year of observation is 2006.

[7] VDMA stands for "Verband Deutscher Maschinen- und Anlagenbau" (in English: German Engineering Federation). It is the largest engineering industry network in Europe. http://www.vdma.org/ (accessed 18 May 2010).

[8] DRUPA stands for "Druck und Papier" (in English: Print and Paper). It is the world's largest trade fair in the printing industry. http://www.drupa.de/ (accessed 18 May 2010).

4 Results

In Section 2, we suggested that the newspaper printing machines industry provides a good setting to analyze reasons of patent portfolio races apart from the fragmentation of ownership of intellectual property. Next, we sketch the structure of markets for technology in this sector and analyze patenting between 1992 and 2006. We then identify those players in the industry that directly reacted to the first mover and exclude alternative explanations of the sharp increase in patenting that we observe. We compare patent portfolios in more detail, and investigate what motives caused the increase in patenting by the first mover. Finally, we analyze by what measures the focal firms concretely effectuated their patent portfolio increases, and discuss timing and trigger events.

4.1. Patenting and market structure in the newspaper printing machines sector

4.1.1. Market structure and competition

The market for newspaper printing machines is a highly concentrated oligopoly, with the four largest firms accounting for nearly 90 percent of sales.[9] Since its emergence in the late nineteenth century, the industry has undergone a process of consolidation and is today dominated by four major manufacturers. These four players comprise the two largest ones, Manroland AG and Koenig & Bauer AG (both headquartered in Germany; market share of 28 percent each), as well as Goss International Inc. (United States; market share of 18 percent) and WIFAG Maschinenfabrik AG (Switzerland; market share of 13 percent). Almost 70 percent of the worldwide market is dominated by the firms headquartered in Europe. And even Goss, although headquartered in the United States, performs a significant share of manufacturing

[9] Worldwide market volume in 2007 is estimated at EUR 1.0 - 1.2 billion with the following market shares: Koenig & Bauer: 28 %; Manroland: 28 %; Goss: 18 %; WIFAG: 13 %; Source: KBA: http://www.kba-print.de/Filestore.aspx/aktuelle_kba-pr%C3%A4sentation.pdf?pool=kba&type=file&key=eea40870-d11c-49c6-901e-221137189c41&lang=en&filetype=pdf&index=true (accessed 18 May 2010).

and development in Europe.[10] This high market concentration makes Europe the most central market for newspaper printing technology. For that reason—and for the sake of clarity—the starting point of our analysis is constituted by patent applications at the EPO.

Product market competition is most intense between Koenig & Bauer AG (KBA hereinafter), Manroland, and WIFAG, leading to price pressure and fierce fights for market shares. "Ruinous price competition" is often emphasized by executives as one of the key challenges to the industry (Steidle, 2003). For Goss, the firm's focus on small format machines reduces its rivalry vis-à-vis the European firms.

4.1.2. Low fragmentation of patent ownership

The newspaper printing machines industry is characterized by a very low fragmentation of patent ownership. This is to a large degree a consequence of the high concentration of the market in general. It is supported by high specificity of products (newspaper printing machines, or parts thereof, are unlikely to be used by firms other than newspaper publishing houses) and high vertical integration of manufacturers (for example, Manroland even operates its own steel foundry)[11]. This increases the likelihood that relevant patents are held by manufacturers, instead of multiple suppliers or industry outsiders. As a consequence, firms in this industry should be able to identify dangerous patents by observing their competitors patenting activity. The observability of patents has been confirmed in our interviews: [12]

> *(a) "If there were no patents, firms would no longer know what their competitors are developing".*

We conclude that relevant patents are observable and to a large degree held by industry incumbents. Referring to the market for "rotary printing presses" (a technical term for news-

[10] http://www.gossinternational.com/ (accessed 18 May 2010).

[11] http://www.manroland.com/com/en/Products_Services_Manufacturing_Services_Foundry_patternmaking.htm (accessed 18 May 2010).

[12] Quotes in German were translated into English by the authors.

paper printing machines), one of our interviewees, supported by others, summarized the situation as follows:

> *(b) "[…] in the patent landscape of printing machines, particularly rotary printing presses, no fragmentation takes place. Rather, there are always the same market players who file patents or try to enforce granted property rights against competitors".*

4.1.3. Patenting activity

Giving a first quantitative indication of the patent arms race we study, Fig. 1 shows numbers of EPO patent applications of all four firms in the industry between 1992 and 2006. The diagram contains only applications pertaining to newspaper printing machines.[13]

--- Insert Fig. 1 here ---

Fig. 1 reveals a striking pattern. Before 1999, patenting by all four firms is on a stable level with only minor fluctuations. During the period between 1999 and 2002, we observe a dramatic increase in patenting by KBA. After 2002 patenting by KBA seems to level off, however at a level almost four times higher than during the pre-1999 period (and decreases in 2006, a point we will address in Section 4.3). We observe a subsequent increase, by a factor of 2.6, in Manroland's filings between 2004 and 2005. If Manroland's increase is indeed a reaction to KBA's, the time lag between the two events is not surprising. Since patent applications are not published until 18 months after the filing date, there is a natural lag between an

[13] Both KBA and Manroland also produce printing machines unrelated to newspaper production. We excluded the respective patent applications from our analysis. Since the International Patent Classification system does not separate newspaper printing machines from other printing machines (most patents are classified in B41F, "printing machines or presses"), we employed an algorithm based on geographical matching. We used the postal code of each first inventor indicated on a patent application and matched it to the companies' sites. Since for both companies facilities related to newspaper printing machines are at different and geographically distant locations than those related to other products, we can use this method to exclude nonrelevant patents. Less than 5 percent of the patent applications classified as relevant by this method have a second or further inventor from a facility related to other products, so that our classification should be correct in nearly all cases. In the case of WIFAG and Goss, we included all patent applications because both firms build exclusively rotary printing machines.

actual increase in patenting and it being observed by competitors. Whereas no increase is observed in the case of WIFAG, Goss shows a strong increase in patenting after 2003 as well.

4.2. Arms race versus alternative explanations

The marked increases in patenting by KBA after 1999, Goss after 2003, and Manroland after 2004 that we observe in Fig. 1 suggest an interpretation as a patent portfolio race. That is, we conjecture that Manroland's and Goss's increase in patenting was caused and triggered by KBA's (and possibly Goss's also by Manroland's). To support this conjecture, we discuss—and exclude—potential alternative explanations in the following. We start with Manroland and KBA, Goss and WIFAG follow.

4.2.1. Manroland and KBA

Evidence from our interviews clearly corroborates the patent portfolio race hypothesis in the case of Manroland and KBA, and in particular the conjecture that Manroland's increase in patenting was a reaction to KBA's. As one interviewee put it:

> *(c) „ […] a typical arms race occurred. One party dashes away, starts threatening you, you feel threatened, you get hit, then you follow. Finally you stand vis-à-vis bristling with weapons and then both parties realize: no one can really act without the other […]".*

We now discuss and exclude a number of alternative explanations. To start with, analysis of data from Thomson/Reuters and from our interviews reveals that no major merger and acquisition (M&A) activities took place during the phases of explosive patenting growth of KBA and Manroland that would explain the increase.[14]

Second, growth with the average can be excluded. The dramatic increases in KBA's and Manroland's application numbers are far above average growth rates (about 3.7 percent at the

[14] For KBA, a minor acquisition took place in 2001 (De La Rue Giori SA), which is unrelated to newspaper printing. In the case of Manroland, three small firms were acquired after 2001, which had filed no patent applications before the acquisition.

EPO)[15]. Also, patenting by Manroland and KBA increased sharply and *ad hoc* rather than continuously.

Third, we can exclude that increases in R&D inputs play a significant role in explaining the observed surge in patenting. Interviewees dismissed this explanation, and also data on R&D expenses from annual reports, while incomplete, show no increases that would explain the more than doubling of patenting by both firms.[16] Even more striking evidence is provided by R&D headcount numbers (

Table **1**). In the case of KBA, we observe a slight increase in R&D headcount between 1998 and 2002 (by 155 employees or 21 percent), but by far not a quadrupling. The pattern is even more striking for Manroland: while patenting increased more than three-fold between 2002 and 2005, R&D headcount decreased steadily between 2001 and 2004, (by 282 employees or 24 percent).

--- Insert Table 1 here ---

Fourth, in order to evaluate a potential increase in innovative output, we analyzed product portfolios of Manroland and KBA. The search does not reveal tremendously more new product introductions during the periods of the patenting explosion. In the case of KBA, new product variations such as the Commander 6/2® and Commander CT® and automation modules such as RollerTronic®, NipTronic®, and PlateTronic® were introduced, which certainly account for some of the additional patent applications. Yet, they are not major enough that they could independently underlie the quadrupling in the number of KBA's patent applications. These findings are supported by interview evidence. Since responses by manufacturing firm representatives would likely be biased, we asked users of newspaper printing machines. None

[15] Between 1982 and 2002; cf. EPO (2007: 36).

[16] Data was taken from the full text of annual reports since most of the companies do not report R&D expenses in the income statement.

of the four interviewees saw any relation between the respective manufacturers' innovativeness and the number of their patent filings. In fact, WIFAG, the firm with the lowest number of patent applications in the sample, is perceived at least as equally innovative as KBA, Manroland, and Goss. The CTO of a large German newspaper publisher put it as follows:

> *(d) "[…] from my perspective all of them are very active in patenting, but none of them had a real blockbuster product. […] I would say WIFAG was the most innovative firm in the past […]".*

Fifth and finally, collusive behavior might provide a potential explanation. It would be present if KBA and Manroland had jointly increased their patenting in order to erect market entry barriers for new entrants or to squeeze out other incumbents such as WIFAG. Our interviewees acknowledged that blocked market entry and increased pressure on third parties might be side effects of the portfolio race. However, they made clear that it was not the motive to initiate or join the race. One interviewee commented:

> *(e) "At the end it might be that you don't win against your strongest enemy, but against the rest of the world. We have thought of this outcome, […] but we do not observe that it is happening".*

Incumbents not involved in the race supported this view. The interviewees did not perceive KBA's and Manroland's increase in patenting as a joint strike against them, but rather as a fight between the two market leaders. Furthermore, all interviewees saw product complexity as a better entry barrier than patents.

4.2.2. Goss

Whereas in the case of Manroland and KBA we have clear evidence of a patent portfolio race, Goss's patent portfolio grew independently. Goss's patenting increase since 2004 is due to a major acquisition of a business line from Heidelberger Druckmaschinen AG in 2004. An analysis of Goss's patent applications reveals that 83 percent of the applications filed after

2003 originated from business units that were part of that transaction.[17] Thus, there is conclusive evidence that the increase in Goss's patenting is due to the expansion of the firm rather than to "strategic" patenting. It is plausible that Goss did not react directly to KBA's and Manroland's patent race since competition is much more intense between KBA and Manroland than between the latter two and Goss, the major reason being Goss's stronger focus on small-format machines and less focus on the European market. This interpretation is supported by our interviews.

4.2.3. WIFAG

In the case of WIFAG, no increase in patenting is observed. This is due to WIFAG's less aggressive intellectual property policy, which relies on securing freedom to operate through "prior use" defense rather than through growing the patent portfolio. This strategy appears sensible since WIFAG, due to its smaller size (around 1,400 employees, of those around 200 in engineering)[18], would likely not be able to compete in a patent arms race with its far bigger competitors Manroland and KBA (both more than 8,000 employees; more than 800 in R&D, cf. Table 1).

The previous paragraphs show that, whereas the patenting increase by Goss was due to M&A activity and WIFAG showed no increase at all, patenting by Manroland and KBA grew to a large extent independently of the firms' size, inputs to R&D, and innovative output, nor was it the result of collusive behavior. Having excluded all possible alternative explanations we can think of, we thus conclude that between the two industry leaders indeed a patent portfolio race took place. For this reason, our subsequent patent analysis concentrates on Manroland and KBA.

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[17] E.g. facilities located in Dover (NH, USA), Boxmeer (Netherlands), or Montataire (France). Goss acquired the web-fed offset business of Heidelberger Druckmaschinen AG in 2004. http://www.heidelberg.com/www/html/en/content/articles/investor/reports-figures-news/news/2004/170604_goss_international?msgId=4534825880538 (accessed 18 May 2010).

[18] See corporate Web site: http://www.wifag.ch/cmse/index.php?id=43,0,0,1,0,0 (accessed 18 May 2010).

4.3. KBA's and Manroland's patent portfolios

We now analyze Manroland's and KBA's patenting in more detail. As they share a common home market, Germany, we include patent applications at the German Patent and Trademark Office (GPTO) to our further analysis. In addition, we include patent stocks. We extracted grant dates of patent applications from our database and the dates of expiration for granted patents (either through nonpayment of renewal fees, withdrawal, or 20 years after filing). Using this information, we calculated the stock of granted, "active" patents in its portfolio for each firm. Since we are primarily interested in the bilateral relation of the two firms, we limit the analysis to patents valid in Germany. That is, we include patent applications filed at and granted by the EPO that indicate Germany as a designated state of protection (Fig. 2), and patent applications that were filed directly at and granted by the GPTO (Fig. 3). We further take into account patents that were acquired through M&A activity.[19]

Fig. 2 reveals an interesting pattern. Whereas Manroland has a rather stable portfolio of patents obtained through the EPO patenting process, KBA seems to have pursued a much more aggressive policy. KBA's dramatic increase in patenting after 1999 leads to a strong growth in its patent portfolio in the subsequent years. While KBA held fewer EPO-granted German patents than Manroland in 1997, its portfolio of such patents is almost three times as large as Manroland's in 2005. Manroland, in contrast, holds a portfolio of rather constant size, with around 140 EPO-granted German patents during the period between 2000 and 2006. Due to grant lag, we do not yet observe the impact of Manroland's more than doubling of EPO patent applications.

--- Insert Fig. 2 here ---

[19] In the case of KBA the acquisition of Albert-Frankenthal AG in 1988 was taken into account. In the case of Manroland, patents of Roland Offsetmaschinenfabrik, which created Manroland through a merger in 1979, are taken into account.

In Fig. 3, we present the results of an analogous analysis of patent applications filed directly at the GPTO. This diagram shows very clearly when industry incumbents abandoned their strategy of stable patent portfolios. While both firms' portfolios had a stable size of around 150 patents between 1992 and 2001, KBA's hike in patent application numbers, from 39 in 1999 to 105 in 2000, leads to a continuous growth of its portfolio in the subsequent years. In 2006, it is more than twice as high as in 2000. A reaction by Manroland is observed in 2004, with patenting rates more than tripling from 26 in 2003 to 91 in 2004. We observe the beginning of an increase in portfolio size in 2005.

--- *Insert Fig. 3 here* ---

It is noteworthy that Manroland's first reaction is stronger at the GPTO (65 more applications in 2004 than in 2003, up from 26) than at the EPO (30 more applications in 2005 than 2004, up from 18). Patent applications being less costly at the GPTO makes it is easier to effectuate a strong increase nationally. At the same time, GPTO patents are equally effective as EPO-granted patents in the bilateral relationship of Manroland and KBA, since both firms manufacture in Germany and patents can also be used to forbid production of infringing goods. The further increase in GPTO patenting (by 33 percent) by KBA in 2006 can be explained similarly. If patents are primarily used in the bilateral relationship, it is sensible to react to Manroland's increase by increasing patenting at the GPTO, a fact that would also explain the decrease in KBA's EPO patenting in 2006 (Figure 2). Since EPO patenting is costly and KBA's application rates have been about three times as high as Manroland's in the past, it is plausible that KBA substituted some of its EPO patent applications for equally effective, less costly GPTO patent applications.

4.4. Why KBA increased patenting

Having established that KBA and Manroland are in a patent portfolio race, we now analyze the drivers that induced KBA to start the race.

4.4.1. Perceived ineffectiveness of patents

Whereas patents play a less important role than product complexity for the protection of a whole printing machine against imitation through third parties or new entrants, they are necessary to protect product features and subsystems from being imitated by competitors. It is unlikely that competitors, having their own established product lines, would imitate a whole printing machine. Yet, there is a high risk that they would imitate improvements or new subsystems. According to our interviews, the belief that single patents are not effective to prevent such imitation evolved at KBA toward the end of the 1990s.

There are two major reasons underlying this view. The first is that inventing around a single patent is relatively easy for a competitor with comparable know-how. The second is that significant numbers of patent grants received by KBA were opposed. One interviewee estimated the rate of oppositions against KBA patents to be 20 percent, which is around three times as high as the average.[20]

This perceived weakness of single patents induced KBA to introduce a new protection strategy. The new strategy mainly consists of filing more patents per product, e.g. through patenting inventions that would not have been patented before or patenting different layouts of the same invention. This strategy serves to build up patent fences (cf. Granstrand, 1999), section 2.2) in order to mitigate the risks from invent-around and opposition. Using an analogy from navigation, one interviewee summarized KBA's strategy change:

[20] Wagner (2008) finds that 6.49 percent of all granted EPO patents are opposed. Harhoff et al. (2003) find that 8.7 percent of all granted GPTO patents are opposed.

(f) "Me, too, I'd rather have ten small barriers in the water than a single big one; because the latter is easy to circumnavigate".

The impact of low perceived patent effectiveness on patenting strategy that we observe here is in line with findings by Cohen et al. (2000: 25, emphasis added), who state that "*[f]irms do not, however, build such patent fences because individual patents effectively prevent imitation or substitution, but because they do not*".

4.4.2. Patents as signals

Our interviews clearly show that the usage of patents as signals of technology leadership and innovativeness is not a major reason behind the increase. Yet, firms tend to also exploit their high patenting rates in this way. It seems to be common for both firms to report increased patenting numbers in annual reports or press releases, and claim technology leadership based on these numbers.[21]

4.4.3. Patent enforcement and licensing

We observe very few patent infringement conflicts on the court level.[22] However, qualitative evidence from interviews suggests that licensing in the industry has grown over the last years, and that behind-the-scenes enforcement is intensive. Using an analogy from soccer, where a yellow card constitutes a reprimand by the referee, one interviewee stated:

(g) "Almost every day we show each other the yellow card. Manroland, KBA, WIFAG—day-to-day it is the same discussion".

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[21] See, e.g. http://www.kba-print.de/de/investor/berichte/06.html or http://www.manroland.com/com/en/press_releases_company_3163.htm (accessed 18 May 2010).

[22] We used the LexisNexis database for a systematic search of reports on such conflicts. Further, we inquired about such conflicts at German district courts. Finally, all interviewees were asked whether they knew about court-level conflicts.

In such a situation, patents fulfill an important function as “bargaining chips”. Such strategic use of patents creates an incentive to grow patent portfolios in order to improve one’s bargaining position, and finally reinforces the patent portfolio race that we observe.

4.5. Effectuating rapid increases in patenting

An important question to be resolved is how the firms in our sample were able to effectuate such dramatic increases in patenting over such a short period of time. We identify the patenting of previously unpatented inventions, the filing of more patents per invention, and combinatorial patent applications as major drivers.

First, patents were filed on inventions that would not have been deemed worth patenting some years ago. Thus, part of the increase in patenting is attributable to minor inventions. Commenting on why his firm did not increase patenting earlier, an interviewee stated:

> *(h) “It was somewhat depending on the self-conception of the engineers who did not file [patent applications for] each bagatelle that you have developed, reconfigured or implemented”.*

Another interviewee stated that it has become common to file rather trivial patents:

> *(i) “Today, if they draw a line on a paper, they would patent it”.*

Second, patents were filed on different versions or layouts of the same invention, creating so-called “patent fences” (Granstrand, 1999). In addition, inventions were protected by multiple “smaller” patents rather than one “big” patent. Such dual strategy of “more patented inventions” and “more patents per invention” is the central driver of the strong increase in patenting that we observe.

Concrete examples of the functioning of this strategy are “divisional applications”. European patent law allows applicants to split up one patent application into two or more applications as long as subject matter is not extended (Article 76 European Patent Convention). Similar procedures are available at the GPTO (§39 PatG, German Patent Code) and the United

States Patent and Trademark Office. We find that divisional applications were often used to establish dense networks of smaller patents covering various features of the initial, sometimes very voluminous, application. For example, the application EP1233864 led to 10 divisional applications. A closer analysis reveals that out of KBA's European patent applications in 2002, 32 percent resulted from splitting up other patent applications (as opposed to 6 percent in 1992). For comparison, divisional applications currently make up around 5 percent of all European patent applications (EPO, 2009, p. 5).

Third, the results of our interviews suggest that patents covering combinations of inventions were filed. Given two inventions, one patent would be filed for each invention separately, and a third one for a combination thereof. In some cases, it seems that even patents on new inventions in combination with state-of-the-art technology were filed. Printing cylinders seem to be an example. One important design change was an increase in the breadth of such cylinders at the end of the 1990s. Whereas the new format did not change the technical mode of operation of printing machines in principle, existing components (such as drive systems) underwent adaptations. While many engineers believed that those two elements (the broader printing cylinder and the modified drive system) were not inventive enough to be patentable (see quote *(h)* above), KBA succeeded in securing patents on the combination of the two elements. Combining the broader printing cylinder with existing components, they were even able to build a thicket of patent rights covering the new cylinder format—which in the meantime was used by other firms as well. This approach put KBA—at least temporarily—into a powerful position toward its competitors. One interviewee commented on the effects of KBA's strategy:

> *(j) "[…] as a consequence, this was often hindering to us, since they simply blocked a product line which we are also active in, with patent applications first, and then to an increasing degree with a multitude of patents"* .

The situation that the interviewee describes effectively amounts to holdup. Since these patents partially cover technology that firms have already made investments in, inventing around may be very costly. These costs rise further since the alleged infringer would not only have to invent around a single patent, but a multitude of them—a patent fence. This fact allows the patent holder to extract rents from other firms, either through licensing or indirectly by creating higher costs for competitors.

In addition, we find examples where new inventions were not only combined with other technology, but with known machine parameters such as temperature. For example, in a patent application on a new mode of utilization of printing ink (patent number EP1446290) the minimum temperature of 30°C of the plate cylinder of a printing machine was added to the claims. Interviewed engineers told us that 30°C is somewhat the standard operating temperature of such cylinders. However, this is common knowledge rather than documented information, and was thus not identified by the patent examiner as belonging to the state of the art.

This patent application was opposed after grant, with the outcome of the opposition still pending. But even if the patent is revoked, the opponent will be worse off than the applicant due to the period of uncertainty and the cost of opposing a patent. One interviewee estimated that preparing an opposition or appeal[23] takes one man-week, whereas filing a patent takes only one man-day. Filing more than one patent application on an invention multiplies the cost of opposition and allows diversification of opposition risk. Actually, the above–mentioned temperature patent has three European divisional applications.

4.6. Timing and trigger events

Having established the reasons for the increase in patenting, we turn our attention to the question of why it happened in 2000 in the case of KBA, and around 2004 for Manroland.

[23] An appeal aims at invalidating granted patents after expiry of the nine-month opposition period.

In the case of Manroland, we know that the increase in patenting is firstly due to the perceived threat from KBA's growing patent portfolio. Second, it is due to concrete, holdup-like threats from some particularly dangerous groups of patents, such as the above-mentioned patent fence around the new cylinder format. The lag between the increase of KBA's and Manroland's filing numbers can be explained by the 18-month publication lag and the time it took Manroland to prepare its reaction. We would also assume a further year to lapse until Manroland realized that the increase is sustainable and not a singular "outlier".

In the case of KBA, the major trigger was the development of new product features and versions. While these inventions by themselves did not warrant a strong increase in patenting—let alone a tripling of application numbers—they offered a good opportunity to establish the new strategy of building patent fences around them. Among them were new product variations (see Section 4.2.1) such as Commander 6/2®, a printing machine based on the above-mentioned larger printing cylinder format.

Finally, we have anecdotal evidence that the printing industry's most important trade fair, the DRUPA, which is held every four years in Düsseldorf (Germany), might trigger patenting. Industry incumbents tend to file more patents before the trade fair takes place. The rationale is that the exhibition of innovations at a trade fair reveals inventions to the public, which may preclude future patenting. So, it may not be incidental that the sharp patenting increases of KBA in 2000 and Manroland in 2004 fall in years when the DRUPA was held. After these respective years, however, both firms kept their elevated patenting level.

5 Discussion

5.1. Summary

Given the scarcity of existing research and the high degree of concentration of the market under study, we employed case study methods. Starting from a patent data analysis we in-

clude qualitative evidence from press articles and other documented sources, and use interviews to enrich and interpret our findings.

What we observe is a patent arms race in the printing machines oligopoly—an industry that existing theory would have predicted to be immune to such development due to its high concentration of intellectual property ownership. We can exclude higher innovative output, increased inputs to R&D, growth with the average, major M&As, and collusive behavior as significant drivers of the patenting increase. Rather, it was driven by a patent strategy change of the first mover from filing individual patents to building patent fences and thickets, motivated by the perceived invectiveness of individual patents. The patenting increase by the second firm was clearly a reaction to the first firm. It was motivated by the perceived threat through the competitor's larger patent portfolio, and by concrete holdup-like situations. The latter finding is particularly interesting since we would have expected holdup risk to be less present in a highly concentrated market. Yet, we find that through sophisticated filing strategies, and presumably shortcomings of the examination process, firms are able to create such situations.

We thus contribute to the theory on motives to patent by showing that, while literature predicts that high dispersion of patent ownership and high industry dynamicity are the major drivers of patent portfolio races, the absence of these drivers does not prevent strong and swift increases in patenting. Even under highly concentrated patent ownership and product life cycles of 10 to 20 years, a more than tripling of patent applications numbers within only three years was observed.

5.2. Welfare implications

The welfare implications of a patent arms race are unfavorable. While the increase in patenting may have yielded temporary advantages for the first mover, in the long run a patent arms race reduces efficiency for all parties involved. In this vein, Cohen et al. (2000, p. 28,

emphasis added) critically note that *"[…] patent portfolio races […] reflect excessive patenting from a social welfare perspective (as would typify a [p]risoners' [d]ilemma-like situation), and are thus raising the cost of innovation unduly"*. Guellec and van Pottelsberghe (2007, p. 81) characterize excessive use of patents as a zero- or negative-sum game and Jaffe (2000) argues that at the end, none of the firms increases its returns to innovation. In fact, innovation might even be hampered if engineers dedicate time to reading, writing, and enforcing patents at the expense of inventing and constructing new products.

Structurally, a patent arms race is similar to a price war. According to the folk theorem in game theory (e.g. Tirole, 1988, p. 246), in an oligopoly any pricing level within a certain range is sustainable as the equilibrium of a repeated pricing game. Unilateral deviation from this equilibrium yields short-term advantages for the deviating firm, but would trigger retaliation strategies that could bring down the entire industry to a new equilibrium with reduced prices and profits. A patent arms race is even more precarious than a price war, for two reasons. First, the 18-month publication lag restricts observability of competitors' actions, which makes a unilateral breach of an implicit collusion (i.e. low levels of patenting) more attractive (e.g. Tirole, 1988, p. 248). Second, while price wars may be welfare enhancing overall since they benefit buyers, excessive patenting constitutes wasteful expenditures from a societal point of view.

5.3. Possible long-term outcomes

Possible long-term outcomes of a patent arms race are a cooperative contractual solution, an outright patent war, and a leveling-off at higher patenting rates. As to contractual solutions to resolve mutual blocking with patents, patent pools and cross-licenses are common in the semiconductor and electronics industry (Shapiro, 2001). In a highly concentrated industry, however, patent pools would likely create antitrust issues. A limited cross-license would avoid antitrust problems, but would have to be renegotiated after a certain period and would,

thus, not solve the problem. Since balancing payments are typically negotiated on the basis of patent counts, they create incentives for further patenting.

An outright patent war would be the most aggressive outcome, with juridical assertion of all conflicting patents and steadily growing patent portfolios. Such a situation, which would nearly amount to a mutual destruction of the opponents, is not observed in our study. This is in line with the folk theorem, according to which an equilibrium outcome is more stable the lower the temporary advantages from unilateral deviation (e.g. Tirole, 1988, p. 248). Since the benefit-cost ratio of a unilateral increase in patenting will become more unfavorable the higher the current patenting rates, one would expect a "truce" at some elevated level of patenting.

Such leveling-off at higher patenting rates is indeed what we observe. Manroland's managers were aware of the prisoner's dilemma-like situation, and felt forced into the arms race. They would likely not increase patenting further than necessary, i.e. until being on an eye level with KBA. Manroland's patenting at the GPTO indeed remained stable between 2004 and 2006, equal to KBA's prior level between 2000 and 2005. KBA, in turn, has not increased patenting since 2002 (but seems to have shifted some of its patenting activity from the EPO to the GPTO in 2006). Thus, it seems that some kind of "tacit collusion" evolved that helped avoid a further escalation. Even explicit coordination would theoretically have been possible (though we have no indication that it took place), since our interviews suggest that intellectual property and R&D executives of all involved firms know each other well and meet regularly.

6 Conclusions

Our study provides a number of insights for managers. It demonstrates how patent strategies such as fencing work concretely. It analyzes what may cause a patenting increase by a competitor and what effects an increase of own patenting may have on others. Further, our article suggests that such patent strategies, while yielding temporary advantages for the first

mover, are likely suboptimal in the long run. Managers should, thus, think twice before initiating a patent portfolio race.

On the policy level, our findings suggest that the patent system was fueling the arms race. The ability to obtain patents on minor inventions, combinations of state-of-the-art or machine parameters with new inventions, and the availability of divisional applications were central elements in the strong increase in patenting that we observed. These possibilities led many of our interviewees to perceive the patent offices' grant policy as "lax", in particular at the EPO (compared to the GPTO). Not surprisingly, firms' perception of being able to obtain patents quite easily constitutes an additional incentive to file more patents. This finding implies, once more, that patent offices should consider raising the patentability threshold. Furthermore, it supports existing criticism that rising patent application numbers should not be celebrated as signs of increasing innovativeness, but rather should be closely scrutinized as indications of problems in the patent system.

Our study has a number of limitations and suggests avenues for future research. First, since we focus on the machinery industry and identify differences to the semiconductor, electronics, and software industry, further studies on other industries such as pharmaceuticals or biotechnology are needed to draw a complete picture of causes and effects of patent portfolio races.

Second, we could clearly show that the observed increases in patenting were not mainly driven by heightened inventive activity and that patenting rates are, within boundaries, somewhat arbitrary. However, we did not precisely identify what share of patent applications was attributable to the strategy of harvesting more patents from a given number of inventions. Thus, an avenue for future research would be to measure the extent of such strategies more precisely. Our analysis of divisional applications, combinatorial patents, and multiple filings constitutes a starting point to such analysis. Recent changes in European patent legislation to

limit the abuse of divisional patent applications underline the need for action in this field.[24] Further studies should be undertaken to supply policy makers with the relevant information.

[24] Decision of the Administrative Council of 25 March 2009 amending the Implementing Regulations to the European Patent Convention (CA/D 2/09): http://www.epo.org/patents/law/legal-texts/decisions/archive/20090325.html (accessed 18 May 2010).

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Figures and Table

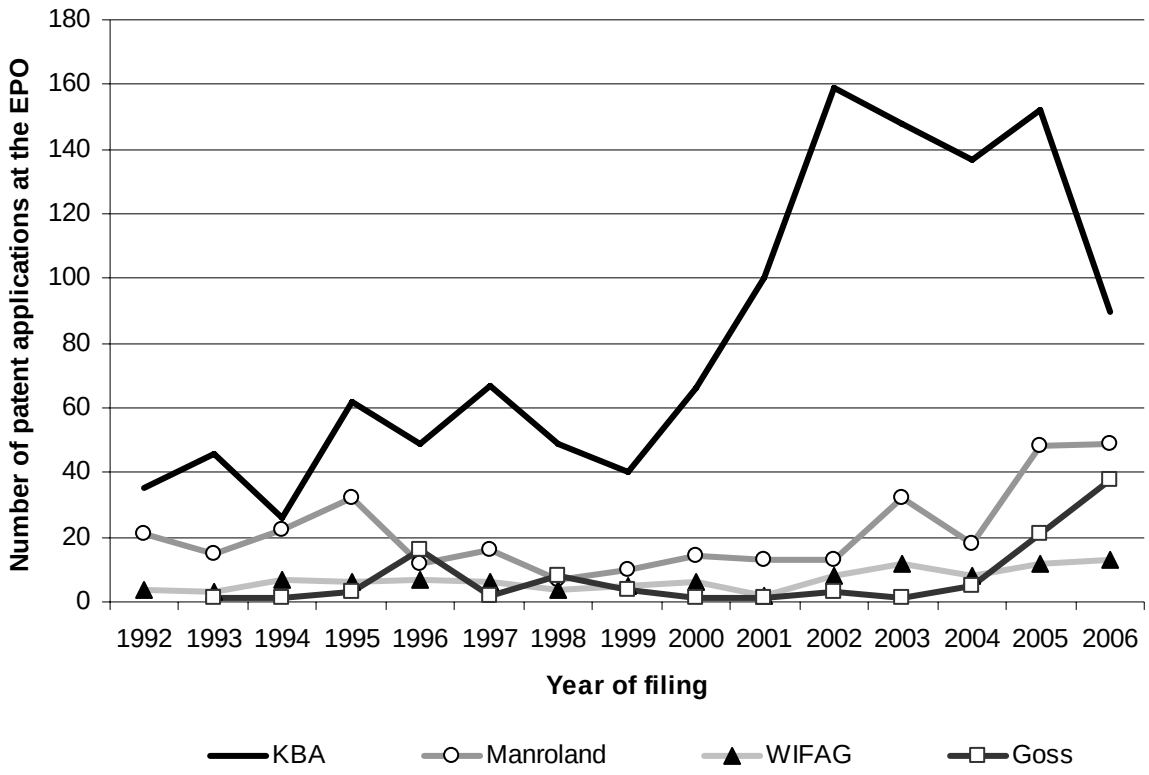

Fig. 1: Number of newspaper printing machines related patent applications at the EPO by manufacturer (1992 to 2006)

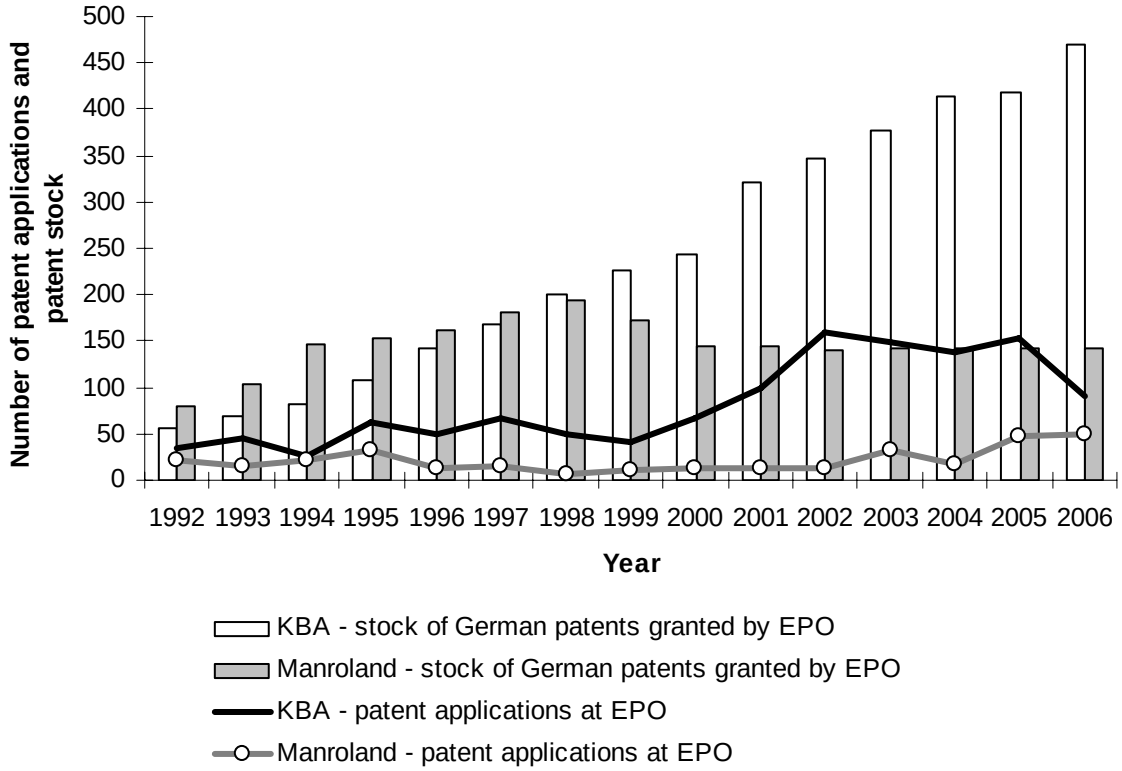

Fig. 2: Stock of active German newspaper printing patents (granted by the EPO) and patent applications (at the EPO)

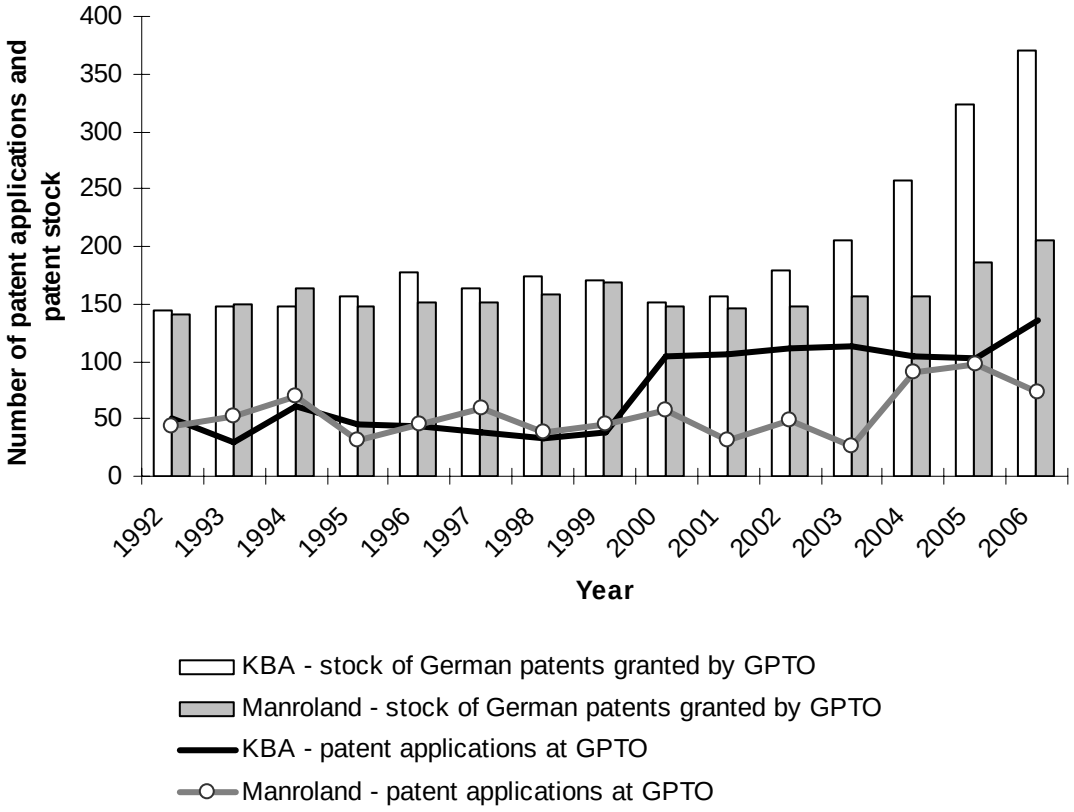

Fig. 3: Stock of active German newspaper printing patents (granted by the GPTO) and patent applications (at the GPTO)

Table 1: R&D headcount (source: annual reports of KBA and Manroland)

Year:	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
KBA:	--	735	775	802	866	890	--	--	--	800
Man-roland:	1200	1050	804	1126	1183	1096	1022	901	--	--