*Knowledge for Growth – Industrial Research & Innovation (IRI)*

# Risk Factors and Mechanisms of Product Piracy - A First Empirical Approach

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**Contributed paper for the 2nd Conference on corporate R&D (CONCORD - 2010)**

## CORPORATE R&D: AN ENGINE FOR GROWTH, A CHALLENGE FOR EUROPEAN POLICY

## Session: Collaborating in corporate R&D: Empirical evidence, trajectories, and impact on innovativeness

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# Abstract

This paper examines the relationship of a firm's strategic framework and its business environment with the probability of becoming the target of product piracy. Using survey data, we empirically examine the role of firm's intellectual property protection strategy, its general strategic business alignment and factors exogenous to the individual firm. Furthermore, we discuss mechanisms of piracy and analyze how business operations induce “enabling” and “signaling” effects and how these influence the likelihood of being illegally imitated. We find that firm-exogenous factors (e.g. industry characteristics) are an important determinant and that successful protection strategies should show a strong complementary relationship between IP strategy and general business strategy. Paradoxically, “enabling” factors (such as information disclosure in patent documents) have a stronger effect on the counterfeiting of labels and brands than on the imitation of technological components. Market signals induced by trademark registrations or high research intensity equally affect both types of product piracy. Management implications for successful strategies against product piracy and counterfeiting are derived.

Key words: **Product piracy, Risk management, Counterfeiting, Rights violation, IP strategy**
JEL classification: **L10, O32, O34**

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# 1 - Introduction

Precious coins in ancient Rome, Chinese porcelain in medieval times, mp3 files with the latest U2 album or high tech car parts in the 21st century: Copying competitors' goods is by no means an exclusively modern phenomenon but it has received increasing public attention (and subsequently attention among policy makers) in recent years. Globalisation, highly dispersed value creation chains and distribution of goods in international markets are all partly responsible for a growing emergence of counterfeiting and product piracy. Part of the phenomenon is also related to the rise of emerging economies such as India and China, which are often blamed as the primary producers of goods infringing the intellectual property rights (IPR) of other (Western) companies. The OECD (2007) estimates a volume of up to 200 billion counterfeited goods.[1] In terms of the share of firms being affected by counterfeiting, data for German companies (including the data collected for this study) suggest that around two-thirds of German manufacturing companies have experienced illicit activities connected to their intellectual property.

All empirical studies in this field of research have one severe problem in common. The very nature of counterfeiting activities makes it hard to have access to reliable data. To overcome this problem, the OECD (2007) chose the approach of analyzing seizure rates at customs, thus catching only international flows of pirated goods. The problem with this approach lies in the fact that certain substantial assumptions have to be made e.g. concerning the percentage of pirated goods being detected. An alternative methodological approach is to analyze survey data collected among companies. A comparison of the two approaches once more highlights the measurement problems in this area. While customs seizure data suggest that most cases are connected with trademark infringement - which can be identified more easily by the authorities - firm responses in surveys also show the relevance of illegal imitation of patents and technological components in general, which are at best difficult to be spotted by customs officers.

This paper chooses the survey approach as it has the advantage that firm and industry characteristics can be analyzed with respect to their impact on the probability of being affected by piracy. A first glance at firm-level data reveals that there are certain factors

which seem to affect the incidence of counterfeiting. First of all, there are strong differences between industries. Mechanical engineering companies, for example, are more affected than the plastics processing industry. Industry characteristics thus seem to play a role. The severity of the problem also seems to vary within industries with medium-sized and big corporations being more affected than small firms. However, it is interesting to have a closer look at these firm-level characteristics. Are large multinationals more affected because they are more prominent in the marketplace, because they have larger distribution channels in emerging countries where IPR regimes are less developed, or because they have production facilities in these countries? Is a single firm simply at the mercy of these factors, because the industry in which it operates is targeted by pirates? What role do IP strategies play? Does a firm with a pronounced patenting (and enforcement) strategy deter piracy because of potential litigation procedures or does this strategy promote patent documents to be used as technological templates to copy know-how? What is the impact of the signaling effect of a patent application or brand to the market? The questions are manifold and are summarized in the following research questions: What factors influence the probability rate of being affected by product piracy? Which of these factors can be influenced by a single firm (firm-strategic factors), and which are exogenous to the individual firm (inter alia industry characteristics and technological aspects)? What is the role of formal intellectual property rights? And, lastly, can we even proxy the likelihood of becoming a victim of product pirates by showing the relationship between the originators' strategy and a subsequent observation of the incidence rate of counterfeiting?

The structure of the paper is as follows. The next section reviews literature related to this new field of research and section 3 addresses the theoretical framework. Section 4 comprises the empirical study, using firm-level data to evaluate the hypotheses derived. From the estimated model we move on to predicting expected piracy probabilities for specific firm position and their orientation in strategy space. Finally, we approximate piracy behavior and, hence, attempt to “look into Pandora's box”, based on the originators' implemented strategy and their effects on piracy entry. Section 5 discusses management and policy implications and concludes.

[1] At the same time the OECD acknowledges that it is very difficult to acquire sufficiently accurate data on a (more or less) secret and potentially undetected activity such as counterfeiting (see further down).

# 2 - Review of relevant literature

For an overview on the extent and the impact of counterfeiting and product piracy, the most frequently cited sources are industry reports (e.g. Business Software Alliance 2008), government reports (Kingston 2000, finding that 67 % of European SMEs think that own patented inventions have been copied) and the highly cited studies by the OECD (OECD 1998, 2007). The OECD is also the source of the often quoted figure of a 5 % to 7 % share of counterfeited goods. In terms of scientific standards, these studies (esp. the various industry reports) have a drawback in that they lack a transparent methodological setting as well as a comprehensive theoretical framework. Furthermore, especially in the case of industry reports, the views of the authors cannot always be considered completely neutral.

In the scientific literature on the effects of counterfeiting, Grossman and Shapiro (1988b) provide an theoretical analysis using a two-country model with imperfect information and brand-name reputations. They show harmful implications for the home-country (original producers) and report that overall welfare does not necessarily decline with the possibility of counterfeiting.[2] These potentially positive effects of counterfeiting have also been called the “piracy paradox”. In a recent paper Raustiala and Sprigman (2009) claim that in some industries such as fashion and music, piracy could promote innovation because imitation turns a formerly innovative design into a non-exclusive feature and demand for differentiated consumer goods then leads to even more innovative effort. The last argument holds particularly true for low investment industries. However, even in industries with substantial R&D expenditures, illegal imitation can have positive effects for the originator due to a faster diffusion of the imitated product. This is especially relevant when network effects are important (Conner and Rumelt, 1991; Givon, Mahajan and Muller, 1995), where the pirates thus create barriers to entry for competitors (Givon, Mahajan and Muller, 1995) and help the originator establish own technology as an industry standard with switching costs further cementing the originator's competitive position (Katz and Shapiro, 1994). The concept of signaling, which will play a role in the further course of this paper, has been discussed in the context of product piracy arguing that imitation signals

[2] Another important theoretical contribution by the same authors GrossmanShapiro1988a points out how the status and the quality characteristics of brand-name products are unbundled by counterfeiting.

the original product's high quality (De Castro, Balkin and Shepherd, 2008). This helps to overcome market information asymmetries and influences buying decisions.
Cordell, Wongtada and Kieschnick (1996) empirically study the determinants of buying decisions and willingness to pay for pirated goods and discuss the expected performance of the imitation relative to the original good, moral attitude and “investment-at-risk” of the purchased product.

The scientific literature on the risk factors of being attacked by product pirates - the focus of this paper - is by far smaller than studies on the counterfeiting demand side or on the impacts of product piracy, especially when the focus is not on brands or on digital piracy such as software but on imitation of technological aspects. Harvey and Ronkainen (1985) describe how pirates can obtain information, referring especially to the risk of information leakage from within the company. This process can also be seen as a special case of unwanted knowledge spill-over thus connecting to the large amount of empirical research on this topic (e.g. Jaffe, 1986). Inferences on the factors influencing the piracy rate can also be drawn from research on managerial implications of counterfeiting. Several authors (e.g. Olsen and Granzin, 1992) highlight the need for tight cooperation in sales channels to address the piracy risk for suppliers in product distribution in insecure markets. In a recent study among Australian inventors - maybe the one with an approach closest to ours – Weatherall and Webster (2009) survey inventors about their infringement cases. They report a 28 % rate and also find correlations between infringement rates and ex post estimates of patent value, export activities, and whether the patent covers a radical or incremental innovation.

Other relevant studies center on the appropriability of technical innovations which generally show a low effectiveness of patents and a high importance of lead time advantage (Blind and Thumm 2004; Blind et al. 2006; Harabi 1995) and on the relative importance of secrecy and patenting (Arundel, 2001; Denicolo and Franzoni, 2004).

All in all, literature on firm characteristics which influence product piracy incidence rates is virtually inexistent to our knowledge. The following analysis can therefore be a starting point to obtain valuable insights on a topic highly relevant for management professionals and policy makers alike.

# 3 - Theoretical framework and hypotheses

The terms counterfeiting or product piracy (as defined by the OECD or the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS)) usually refer to the infringement of trademarks and copyrights, patents and design rights, as well as to a number of related rights (OECD, 2007). In our analysis, we concentrate on two aspects only. We analyze i) whether technological elements of a firm's product are illegally copied by other players in the marketplace and ii) whether product names or labels are illicitly copied. This does not necessarily imply that these elements have been formally protected by patent applications or trademark registrations. If they are not formally protected, it is not considered to be "product piracy" as defined by the OECD and it might be more appropriate to refer to the "pirates" as legitimate imitators of a successful good. However, the economic implications in these two cases do not differ. In both situations the victim incurs the negative effects of piracy such as declining individual revenues (both by lower sales output and pressure on prices[3]), erosion of the brand value (as the product quality of a counterfeited good is usually lower than the original product[4]), costs for unjustified product liability claims caused by the lower quality of fake goods, and additional costs to reduce the danger of piracy. The only difference between counterfeiting of formally protected goods and copying of elements, for which formal IP has not been registered, is the potential risk for the pirate of being litigated for infringing the relevant right. Assuming a sufficiently high likelihood of successful prosecution, formal protection would thus have a negative impact on the probability of becoming a victim of product pirates.

When discussing legal protection of a product's elements and the consequences of this protection, it is necessary to distinguish between patent rights and trademarks. We will thus first address the situation for patents before turning to brands.

Firms bear certain costs in order to "buy" the option of suing illegal imitators for patent infringement. In the case of patents, the cost - apart from monetary aspects - includes the disclosure of a detailed description of the claimed inventive step.

[3] Recent work by Qian2008 and BelleflammePicard2007 emphasize the price dispersion effect of piracy entry, potentially enhancing long-run quality performance of genuine producers in the market.

[4] See discussion by Bosworth2006 on differences in quality of genuine and pirated goods, probability of perception by consumers and deception success.

These patent documents - although rather cryptic to read for non-patent lawyers - should in theory be understandable for a "person skilled in the art" (Article 56 of the European Patent Convention) and cases have been reported in which patents are used as "libraries of technological information" (Keupp, Beckenbauer and Gassmann, 2009).
A European Patent Office survey among both users and non-users of patents shows that more than 80 % of firms regard patent information as important or very important for their business. More specifically around 40 % to 50 % consider the technical information in patents as very important and especially in early phases of the product cycle, i.e. investigating and developing new product opportunities EPO2003. This shows that patent information disclosure helps potential (illegal) imitators to copy a successful product. We refer to this notion as the "enabling effect" of a patent document.

Before a product can be copied, it has to be identified by the imitators.[5] Again, the patent system can be useful for the pirate because patent applicants send a signal to society (and to their competitors) that a new process or product has been discovered[6], which can be used by everybody in the public domain after the patent has expired. This fact is inherent to the patent system and together with flaws such as like long pendency times, high costs and other uncertainty factors, lead companies to refrain from using official ways to protect their intellectual property. They want to avoid the signaling effect of a new patent application and to prohibit competitors from learning about their new research. An alternative strategy would be a strict reliance on informal protection models like lead time advantage and secrecy on multiple levels: strict confidentiality policy with employees, suppliers, or cooperating firms.

Our argumentation yields to the two following hypothesis on the relationship between the use of patents and trade secrets and the rate of being affected by product piracy.

[5] JonssonRegner2009 refer to this multi-stage understanding of the imitation process: identification of the product to imitate; willingness to imitate; ability to imitate. In our context, only the first and the last component are important although the willingness to imitate might be influenced by the use of IPR as well: a patent protection on an invention could lower the willingness to (illegally) imitate, due to the legal risk involved Somaya2003.

[6] There are numerous service providers and websites monitoring new patent or trademark applications and subsequent potential industry trends based on them (one example is *ipnewsflash.com* or The Trademark Blog on *schwimmerlegal.com* and (in German) *markenblog.de*)

**Hypothesis 1.** *Firms relying stronger on patents to protect their IP have a potential legal threat against infringers, but also cause a signaling effect (with respect to a new invention) and an enabling effect (through information disclosure). The effect on the rate of piracy is ambiguous.*

**Hypothesis 2.** *Firms relying stronger on trade secrecy to protect their IP incur neither a signaling nor an enabling effect. The effect of an explicit (successful) strategy focusing on secrecy on the rate of piracy is expected to be negative.*

It is obvious that a trade secret strategy is only relevant for the protection of technological elements of a firm and that this instrument is not adequate for product names and labels. A brand value entirely depends on its level of diffusion in the market and the brand awareness associated with it. A second differing aspect is that the registration of a trademark does not lead to the disclosure of relevant know-how. The "enabling effect" of a patent document does not exist here. However, the signal to market - or in other words the "assistance in identifying" a product worth counterfeiting - is analogous to the case of a patent application, indicating to the public that there is a brand premium to be earned. This is, after all, the basic concept of a branding strategy: a brand reputation inducing a favorable product quality leads to a higher willingness-to-pay and allows higher prices. Thus, a heavy use of trademarks can be understood as a signal to pirates of that there are relatively high profit margins which could be an incentive for potential pirates to enter the market.

**Hypothesis 3.** *Firms relying stronger on trademarks to protect their IP have a potential legal threat against infringers, but also cause a signaling effect (with respect to brand premiums). The effect on the rate of piracy is ambiguous.*

Various other measures can be taken to protect intellectual property. Firms are increasingly creating preventive technological barriers in their products to make reverse engineering by pirates more difficult. The rationale lies in raising the costs for potential pirates and making their cost-benefit ratio less attractive.[7] A relatively new strategy is the

[7] It should be noted that additional costs of this strategy, e.g. by using encrypted software product components or by explicitly de-standardizing mechanical product components away from industry standards may occur at the original manufacturer as well. These might be prohibitively high, so that the strategy might not be chosen by every firm.

implementation of management tools such as offering additional services for original goods. This bundling may help to protect products and enable (long-term) enforcement of related intellectual assets. In this way, the specialized know-how of the originator's (maintenance) staff may serve as a selling argument for the original product. Another measure could be the regular inspection of customers' facilities which may support detection of (unintended) piracy purchases.

**Hypothesis 4.** *Firms relying more on technological or management options to protect their IP cause neither a signaling nor an enabling effect, but increase pirates' copying costs. The effect of an explicit strategy focusing on technological or management tools on the rate of piracy is expected to be negative.*

A further strategy to secure a firm's freedom to operate in a certain technological area lies in deliberately refraining from keeping the latest research results secret. This strategy is known as defensive publication and aims at raising the "state of the art" in a specific field. As a consequence, competitors are prevented from patenting the same invention, as a patent will only be granted for new, previously unknown applications.[8] The down-side of this strategy is that relevant knowledge is disclosed (with the connected enabling effect) without the potential legal enforcement option.[9] Even though defensive publishing will never be a firm's sole IP strategy (a patent application will, of course, be filed for an important technological break-through), it increases the know-how of competitors and potential pirates about a company's technological developments. Together with signaling a relatively "open" company culture, we argue that firms which rely on defensive publishing worsen their situation with respect to piracy.

**Hypothesis 5.** *Firms relying stronger on defensive publishing to protect their IP cause an enabling effect (through information disclosure), without the legal value of a patent. The effect on the rate of (illegal) imitation is expected to be positive.*

[8] This is especially true for the European Patent Office (see Article 52 (1) EPC). In the US the legal situation is different as the patent can be granted even though the invention was patented or described during the last year (see 35 U.S.C. § 102).

[9] A considerable part of defensive publishing is also done via the patent system itself. HenkelPangerl2008 In this case, this last argument is not valid, as the patent application creating the state of the art might eventually turn into a valid grant.

The instruments above are the traditional methods of how firms try to protect their IP. This does not necessarily mean that they are the most efficient or effective ones, but are analyzed here since they are widely used in the market place. Not only do specific IP protection instruments play a role in securing appropriability but more general factors of the overall business strategy have to be taken into account as well.

An important driving factor of the probability of counterfeiting is related to the degree of a firm's involvement in operations out of the home market. We do not claim that copying of technological elements only exists outside a firm's home market, which in this case is Germany. However, every engagement in a foreign market leads to a loss of control and poses certain risks. The reason for this is that, despite conducting market research, management is unlikely to know the foreign market as well as it knows its home market. This knowledge gap will also include problems with recruiting reliable and trustworthy staff. Therefore we claim that an engagement in a foreign market raises the odds of being counterfeited. We furthermore assume that this probability increases when sensitive knowledge is transferred from the home to the foreign market. Only selling goods overseas does not bring the same risks as establishing production facilities. The relevance of this problem is even greater when research and development is also conducted in a foreign country, e.g. by staff fluctuation (Agarwal et al., 2009).

Similar to the diffusion of know-how outside the home market, knowledge can be at risk in inter-firm cooperations. If a firm cooperates with suppliers, competitors or customers, there is a good chance of benefiting from joint research efforts, but this could also lead to increased knowledge leaks. This is one of the reasons why firms often object to opening up their research labs (“open innovation”). There is a certain risk of giving away too much knowledge, although the benefits can be substantial as well Grant1996. We argue that firms which heavily cooperate - be it with universities, customers, suppliers or competitors - run the risk of a knowledge outflow and thus face a higher rate of piracy.

There is a possible alternative reasoning on the effect of cooperation, rejecting the argument of information leakage and instead focusing on the correlation of research cooperations and firm innovativeness (Becker and Dietz, 2004). If cooperative activities are thus seen as a signal that the originator's firm is highly innovative, the effect on the rate of piracy might also be expected to be negative. A similar effect could be expected for

the degree to which a firm engages in own (intramural) research and development (R&D intensity). We assume that pirates do no conduct state of the art research themselves. Therefore their absorptive capacity is somehow limited and they do not have the potential to reverse engineer high-end products on the market. A more relevant strategy would be to concentrate on low or medium tech products with a relatively steep learning curve. These products can be rapidly imitated and produced without too many sunk costs. Pirates always need to calculate the risk of being detected and consequently production facilities being shut down. It is therefore important to enter the market quickly, in which case the focus is not likely to be on products of a high-tech company.[10] A reputation of producing high-tech products might therefore be favorable to a firm's rate of piracy as this may generate technological barriers to imitation per se.

The competitive environment also plays an important role. If, as a result of competitive pressure, margins are low and a competitor is able to successfully raise its profit margins, a competing firm might try to imitate - legally or not - this successful product or product feature. Additionally, competitive pressure in the product market can coincide with higher competition in the technology market. A single firm's chances to be the first to make an invention and the first to file the connected patent decrease in constellations of strong competition. A similar situation occurs when technological interdependence among firms is high.[11] With a competitor holding a patent which potentially blocks the firm's own technological or commercial path - be it due to higher competition or to technological interdependence - a work around has to be attempted. In all three cases, this imitation strategy might not be completely successful and the relevant IP is still infringed.[12] The existence of patent thickets - situations where IP ownership is highly dispersed among a large number of IP holders - can even worsen the chances of unintentional infringement.[13] This is a somehow separate form of “product piracy” but still relates to our rather broad understanding of counterfeiting. We subsequently propose that a higher competitive pressure in a firm's industry and a higher interdependence in a firm's technological setting

[10]There is some evidence in EU customs seizure data (Blind et al., 2009) indicating that pirates increasingly violate patent rights and that this increase is higher than with trademarks. This partially implies a ``piracy shift'' to medium- and high-tech sectors -- even though the majority of seized counterfeits concerns trademarks.

[11]This is often the case in “complex” industries (e.g. semiconductors), where a single product consists of a significant number of separately patentable elements.

[12]There are, of course, many cases in which original and copying firm have substantial differences in their evaluation of this matter, ending before court.

will coincide with higher rates of piracy. Other “exogenous” firm characteristics can be seen in firm size and industry affiliation. Descriptive univariate analyses show a positive connection between firm size and the incidence of piracy as well as differences among industries. Multivariate regression in the empirical part will show whether these observations will also endure a more rigorous analytic approach.

So far we have discussed two groups of factors which potentially influence the probability to which a firm is affected by product piracy: the usage of traditional IP protection instruments and other more general components of a business strategy. Both groups are within the strategy space of the originator firm, i.e. can be influenced by the firm's management itself. However, a number of other factors might not be action parameters for an individual firm at all. Some of these are discussed in the next section and are addressed in the empirical part of this paper as (firm-)exogenous factors or control variables.

In closing the theoretical part, we refer once more to the two categories of mechanisms that determine the incidence of piracy: enabling and signaling factors. As put forward in the discussion of the risk factors (IP strategy and generic business decisions as well as the exogenous factors), there are several ways an unintended promotion of pirates' skills can occur: through disclosure in patent documents, defensive publication strategies, information leakage in production facilities abroad etc. Similarly, the signaling effect of the patent document (with respect to a new technology) or a registered trademark (with respect to new markets or brand premiums) can serve as an indication which products might be worth copying. Why can signaling matter in our setting? In a sense, compared with the originator producers, pirates face an information gap regarding market demand and consumer characteristics. One reason is that the originator has presumably been active in the marketplace for a longer time and has thus gained an informational advantage. Subsequently, pirates will be sensitive to any type of (legal) producers' behavior that may be interpreted as a market signal on demand, e.g. on the expected brand premiums by observing trademark registrations, as this may help to reduce the risks

[13] Situations of high technological interdependence lead to arrangements such as cross-licensing of whole patent portfolios or (implicit or explicit) agreements between firms to fully refrain from litigation relating to their patent rights.

associated with market entry.[14] An additional signal for an illegal imitator can be the competition intensity. Even though a dense market structure can reduce the expected profit margin of the individual firm, one can argue that higher levels of competition seem to signal an attractive market to outsiders. With many market players, and a potentially broader variety of products offered, this may also increase the (survival) probability of not being detected i.e. not prosecuted by authorities or competitors, or detected as „fake“ by customers.

As the imitation of technical components can naturally benefit more from an „enablement“ than from copying a brand name, we expect that the aggregate „enabling factors“ will have a stronger effect on the rate of being affected by illegal imitation of technical components rather than by counterfeiting of labels. Said differently, the enabling factors should not play a substantial role in the context of copying labels and names. Our expectations regarding the relative effect of signaling between both types of piracy are not as clear. Similarly, there is no clear theoretical hint on the relative effects within the two categories, although the signaling effect is perhaps likely to dominate the enabling effect when considering copying of brand names and labels only.

# 4 - Empirical part

In the following section, we present our sample and some descriptive results, before turning to our findings regarding the first question of risk factors for product piracy. We will also discuss whether the most significant factors are firm-strategic or exogenous to firm behavior allowing conclusions on the extent a firm can actually influence its exposure to pirates. Afterwards we turn to the mechanisms of product piracy concentrating on enabling and signaling effects.

[14] Note here that, interestingly, product pirates themselves can also be a substantial barrier to legitimate market entry, which can be in the competitive interest of the genuinely good producer (Balkin et al., 2004).

## *4.1 Descriptive statistics*

We have collected a unique data set by surveying patent active companies in Germany. All German companies with more than 10 patent applications between 2002 and 2004 were identified on the basis of applications at the German Patent Office (DPMA), the European Patent Office (EPO) and under PCT. In addition, a set of R&D active companies was randomly drawn from Hoppenstedt company database. Out of this database, around 3,000 companies received a paper questionnaire with the additional possibility of accessing the questionnaire on the web. Due to the high level of detail with numerous IP and counterfeiting related questions, our analysis involves 217 observations. Although the level of detail of the subsequent analysis resulted in a limited number of cases, our survey covers a broad range of firms and industries which is conductive to the originality of the data - product piracy has not been integrated in many surveys of satisfying scientific quality.

An crucial feature of our data is that the unit of observation is on the company level - not on product level. It can be argued that the latter might be the dominant pattern for infringement on technical product components as copying often refers to an imitation of specific products rather than whole product portfolios, business models or organizational schemes (but maybe processes in manufacturing). Still, we suggest that our data quite nicely reflects average product incidence of a company. Additionally, In contrast to this, analysis on the company level seems to be more adequate in the case of trademark infringement or free-riding on brand premia as a singular infringement potentially exercises strong externalities on all company products associated with one infringed (umbrella) brand or one level of product quality.

As Table 1 shows, both small and medium sized firms as well as large corporations are represented in the sample. The industries with highest numbers in the sample are Mechanical and Electrical Engineering. Table 1 additionally allows a closer look at the extent to which companies are actually affected by product piracy. The share of companies reporting at least one case of illegal imitation of technological components is stunningly high: around 75 % of all surveyed companies are affected. Small firms with fewer than 250 employees report significantly lower piracy rates than their larger

counterparts. This first look at size effects thus suggests that larger firms run a higher risk of being affected. This holds true for both types of piracy (of technological components and of brand names and labels). With respect to industry affiliation, firms in Metal Processing report the highest piracy rates for technological goods, whereas Chemicals/Pharmaceuticals and Consumer Goods have the highest rates for the imitation of brand names. Firms in the Plastics industry seem to be among the least affected manufacturing companies.

Table 1: Number of observations by firm size and industry affiliation and mean piracy incidence (share of firms reporting to be affected by an illegal imitation in 2007; first value refers to piracy of technical components, the second one to piracy of product names/labels)

| | | Number of observations (over firm size in employees) | | | | Rate of piracy |
|---|---|---|---|---|---|---|
| | | < 249 | 250 ≤ 999 | ≥ 1000 | Total | |
| Industry | Chemicals and Pharmaceuticals | 5 | 4 | 10 | 19 | 78.95 % ; 73.68 % |
| | Plastics | 5 | 3 | 3 | 11 | 63.64 %; 30.00 % |
| | Mechanical engineering | 16 | 26 | 32 | 74 | 78.38 %; 54.29 % |
| | Metal processing | 6 | 6 | 13 | 25 | 96.00 %; 60.00 % |
| | Electrical engineering | 28 | 9 | 22 | 59 | 67.80 %; 48.21 % |
| | Consumer goods | 5 | 8 | 6 | 19 | 73.68 %; 68.42 % |
| | Other manufacturing | 3 | 2 | 5 | 10 | 70.00 %; 44.44 % |
| | Total | 68 | 58 | 91 | 217 | 76.04 %; 54.81 % |
| Rate of piracy | | 64.71 %; 34.38 % | 86.21 %; 65.45 % | 78.02 %; 62.92 % | 76.04 %; 54.81 % | |

Table 2: Summary statistics of regressors (N=217)

| | Variable | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| IP strategy | Importance of patents | 3.419 | 1.099 | 1 | 5 |
| | Importance of brands | 3.12 | 1.172 | 1 | 5 |
| | Importance of trade Secrects | 3.409 | 0.915 | 1 | 5 |
| | Importance of other informal protection methods | 3.097 | 0.875 | 1 | 5 |
| | Importance of defensive publication | 2.641 | 1.182 | 1 | 5 |
| General business strategy | Foreign sales | 0.959 | 0.2 | 0 | 1 |
| | Foreign manufacturing | 0.724 | 0.448 | 0 | 1 |
| | Foreign R&D | 0.622 | 0.486 | 0 | 1 |
| | Participation in formal standardization | 0.627 | 0.485 | 0 | 1 |
| | Cooperation intensity | 0.599 | 0.491 | 0 | 1 |
| | R&D intensity | 0.109 | 0.138 | 0 | 0.786 |
| Exogenous factors | ln(employees) | 6.406 | 2.146 | 1.099 | 11.622 |
| | Competition intensity | 4.3 | 0.774 | 2 | 5 |
| | IPR dependency | 2.806 | 1.284 | 1 | 5 |

## *4.2 Regression results*

We use a probit regression model to estimate the probability of being affected by product piracy - i.e. in terms of “technical components” being copied and separately “product names or labels“ being imitated - depending on a broad set of independent variables (see

Table 2 for summary statistics). The dependent variables are based on company responses on a 6-point Likert scale ranging from no to very frequent incidences of infringements both inside or outside the EU. These answers were transformed into binary sets (no incidence vs. incidence). This may include infringement of legally protected intellectual property as well as secrecy leakage. For the sake of theoretical framework's consistency it is reasonable not to adopt a (strictly) legal definition of piracy incidence, i.e. explicit infringement, but to broaden the conception.
This would otherwise preclude some cases of a trade secret strategy or strategies applying complex security technology and associated failure risk as well as cases of copying non-patentable IP.

In the construction of the explanatory variables, we had to deal with a possible endogeneity problem as the both the importance of patents, trademarks etc. and the questions on the incidence of product piracy were obtained in the same survey. Thus, it cannot be ruled out that the evaluation of the importance of patents is influenced by a previous piracy case. This would mean a reverse causation problem in the regressions. We thus derive “time-lagged” values for all firm-endogenous strategic variables inserted in the model. Using the firm's assessment of the development over the last five years, we simulate the answers the companies would have given five years ago. This procedure tries to assure that the incidence of piracy is indeed caused by the relevant strategic factors (e.g. the use of patents) and not vice versa.

To allow straight-forward interpretation of these estimation results, in what follows, we will concentrate on the marginal effects presented in Table 3.

A first interesting observation is that in the category of IP strategy factors as explanatory variables for piracy of technical components, a significant coefficient is obtained only for defensive publication. This means that there is support for Hypothesis 5 suggesting that a strategy of defensive publication can cause higher risks of being imitated. Hypotheses 1 through 4 on the enabling and signaling effects of patents, brands, trade secrets, and other informal protection methods do not find sufficient statistical support. The coefficient estimates are too imprecise to allow definite conclusions on the basis of our dataset. However, coefficient signs for patents and brands suggest that a signaling effect of their use is conceivable to some extent. For piracy of names and labels, the coefficient for the

variable “Importance of Brands” is statistically significant. This means that firms which use trademarks should be aware that the benefits of registering a trademark can be accompanied and even dominated by signaling phenomena.

Table 3: Marginal effects after probit regression

| | (1) Piracy of technical components | | (2) Piracy of product names/labels | |
|---|---|---|---|---|
| Importance of patents | 0.0164 | ( 0.61) | −0.0287 | (−0.74) |
| Importance of brands | 0.0315 | ( 1.26) | 0.102*** | ( 2.88) |
| Importance of secrecy | −0.0310 | (−0.86) | −0.0890* | (−1.80) |
| Importance of other informal protection | −0.0258 | (−0.69) | −0.0404 | (−0.76) |
| Importance of defensive publication | 0.0513** | ( 2.05) | 0.0915** | ( 2.56) |
| Foreign sales (d) | 0.219 | ( 1.05) | 0.130 | ( 0.62) |
| Foreign manufacturing (d) | 0.0901 | ( 1.00) | 0.0213 | ( 0.19) |
| Foreign R&D (d) | 0.134* | ( 1.69) | 0.176* | ( 1.83) |
| Participation in formal standardization (d) | 0.0905 | ( 1.44) | 0.134 | ( 1.56) |
| Cooperation intensity (d) | −0.130** | (−2.36) | 0.0146 | ( 0.18) |
| R&D intensity | −0.737*** | (−3.06) | −0.475 | (−1.46) |
| ln(employees) | −0.0299* | (−1.71) | 0.00926 | ( 0.39) |
| Competition intensity | 0.0556 | ( 1.60) | −0.00483 | (−0.09) |
| IPR dependency | 0.0539** | ( 2.19) | 0.0211 | ( 0.65) |
| Plastics | −0.280 | (−1.24) | −0.477*** | (−4.04) |
| Mechanical engineering | −0.0590 | (−0.51) | −0.254* | (−1.71) |
| Metal processing | 0.169*** | ( 2.74) | −0.172 | (−0.99) |
| Electrical engineering | −0.0901 | (−0.71) | −0.299** | (−2.05) |
| Consumer goods | −0.0901 | (−0.55) | −0.0773 | (−0.40) |
| Other manufacturing | −0.316 | (−1.33) | −0.382** | (−2.35) |
| Observations | 217 | | 210 | |

Marginal effects; $t$ statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Within the group of general strategic aspects, we see that there are more significant factors for piracy of technical components than for brand names. In terms of firm internationalization, the analysis shows that effects strongly depend on the extent of foreign activities. While foreign sales and manufacturing have no statistically significant impact, the effect of having R&D facilities abroad is positive in both dimensions. Furthermore, the size of the marginal effects suggests that once a firm distributes its products abroad, it should anticipate the threat of piracy. The next step of establishing manufacturing facilities does not seem to imply a growing risk, but this is clearly the case for research and development activities abroad. In this case, keeping firm knowledge and competences intra-mural in a global network may become a very difficult management task. Interestingly, when it comes to effects from cooperation, we find a relatively strong negative effect on increased risk of information leakage for piracy of technical components.[15] Rethinking the issue, and given that our control variable fully reflects the overall variety of cooperation types and motivations, this may lead to the conclusion that some cooperations may succeed in internalizing some potential piracy and, hence,

[15]Marginal effects from participation in formal standardization is weakly statistically significant, and therefore supports the information leakage argument to some extent.

legalize the external use of IP by setting up a joint-conduct or joint-property environment for future research (e.g. by pooling IP assets in complex technologies). This may be true for some cooperations but surely not for all. The alternative interpretation of cooperation as an indicator for innovativeness might therefore be more adequate as the effect of research and development intensity shows a very high and statistically significant estimate. High R&D intensity seems to be a dissuasive sign of high entry costs for pirates.

Several observations can be made about the different risk factors of piracy outside the firm's strategy space. We find a small, but significant size effect showing that once controlling for other variables, larger firms are not per se more affected by product piracy. In fact, they are slightly less vulnerable. This could be because large multinationals are capable of building up credible threat of legal disputes, while smaller firms will often avoid legal actions over IP especially when the location of trial is abroad. Contrary to what customs seizure data suggests, in our sample the Consumer Goods industry is not strongly targeted by pirates. In terms of technical components, firms in Metal Processing report a significantly higher incidence of piracy. The Chemicals and Pharmaceuticals category (the reference category for the industry dummies) seems to be affected quite heavily with respect to product names and labels, as industry dummies for a number of other branches show negative signs significantly different from zero. The coefficient for the level of competition between firms and inter-firm dependencies in the market for technology suggests that there could be a certain degree of unintentional infringement for copies of technical components. This may stem from a limited “freedom to operate” or “freedom to research” in very complex and fragmented markets for technology. A possible explanation for the positive influence of competition intensity on the rate of piracy could be an indirect effect of the competitive pressure. Hard-pressed firms in hotly contested markets are more likely to make illegal use of a competitor's IP, just because the competitive environment removes possible (ethical) barriers / “rules of conduct” that would normally prevent a firm's management from illegally copying.

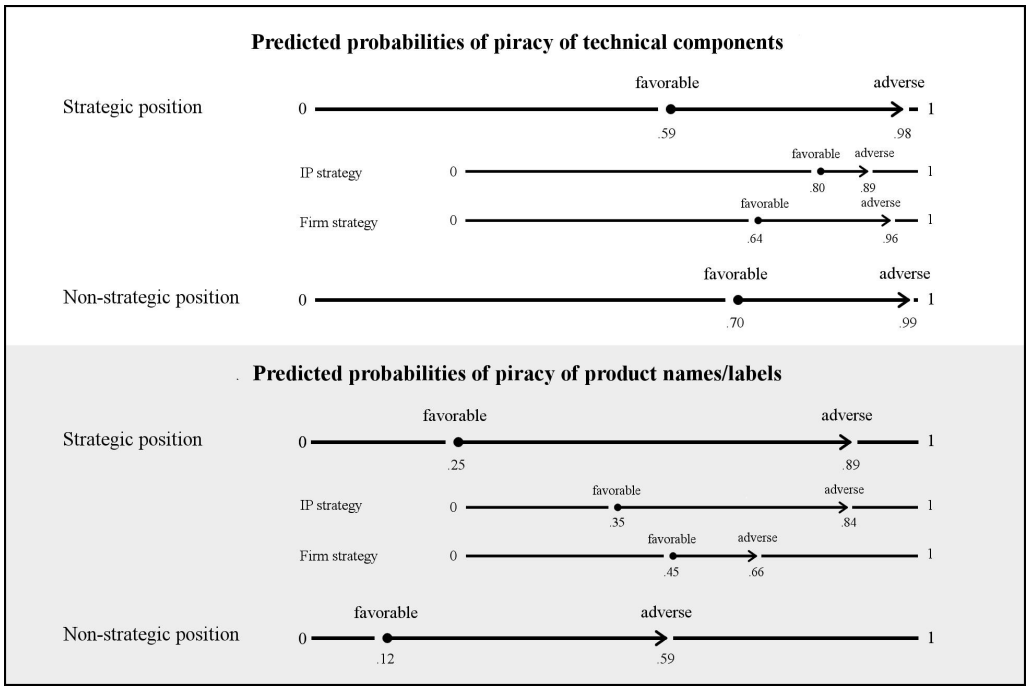
## *4.3 Predictions from the model*

Within the framework of IP strategy, business strategy and exogenous factors, it is clear that there are more IP strategic factors that are significant for piracy of names and labels whereas imitation of technical components depends more on the general business strategy and on exogenous factors. To avoid “patent infringement”, the strategy space for

IP instruments therefore seems to be rather limited. Effective IP protection should be accompanied by overall strategic orientation which may not be adjustable in short or medium term (e.g. industry affiliation). These insights are highlighted and exemplified using predicted probabilities in Figure 1. Based on the estimation results, we simulate the incidence rate of piracy for different hypothetical strategic frameworks (see Appendix). From this we can conclude the probability of being the victim of counterfeiting with an advantageous ("favorable") IP strategy or exogenous constellation (e.g. emphasis of trade secrets, no defensive publication, high R&D intensity etc) compared with a disadvantageous ("adverse") strategy (no emphasis on trade secrets, active defensive publication, low R&D intensity). The results are intriguing. Varying the strategic factors from a favorable to an adverse position increases the probability of piracy to a similar extent as a change in the exogenous dimensions for the piracy rate of technical components (similar length of arrows in Figure 1), while strategic factors have a stronger influence on piracy of names and labels compared to the exogenous ones. One could thus assume that management has a stronger influence on the situation when it comes to mere copying of labels than when technical components are concerned.

In a subsequent step, we contrast IP strategic factors and firm strategy as subsets of the overall strategic position of the business. Both dimensions of governance play a role in technical piracy but from our model we find that firm strategy has a much higher leverage than IP strategy. To conclude, IP strategic factors have a much stronger effect on the imitation of names or labels, while a complementary IP and business strategy is fundamental in the case of technical components.

Figure 1: Predicted probabilities of piracy of technical components and piracy of product names/labels (given a hypothetical firm with a specific strategy set or non-strategic characteristics)

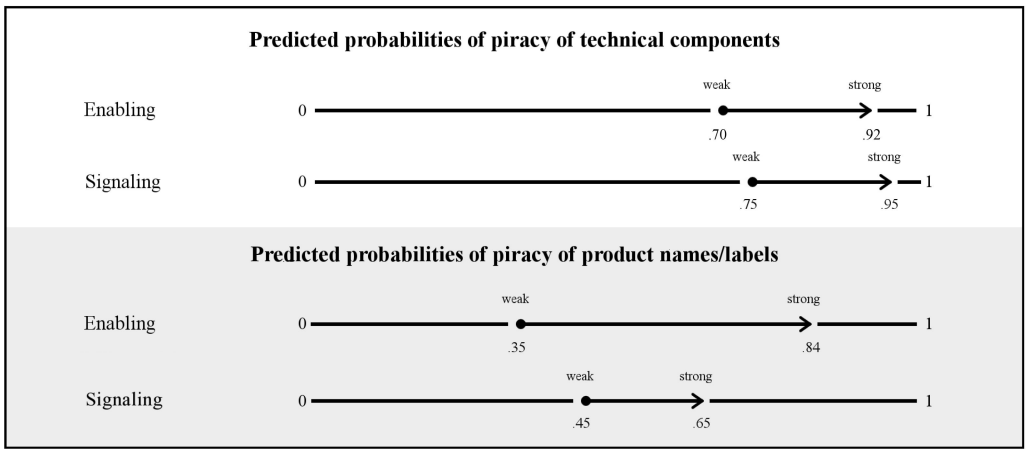



We will now proceed with the final question of our analysis and examine whether firms can "proxy" and, thus, potentially anticipate piracy behavior by concentrating on the signaling and enabling effects caused by a firm's strategic or exogenous situation. We regroup our variables along the categories "signaling" and "enabling" and calculate the effects on the incidence of piracy on the basis of significant variables and the observed direction of marginal effects from Table 3.[16]

When we look at piracy of technical components and names or labels in Figure 2, we find strong differences in predicted probabilities depending on the extent of the signaling and enabling sources being available. Paradoxically and against our theoretical argumentation, the likelihood of names or labels being copied - in our example - will increase with stronger "enabling factors" by a factor of 2.4 (i.e. .35 to .84), while for technical components this rate is only at 1.3 (i.e. .70 to .92). We had expected the relation to be the other way round, since the imitation of a technological component requires more technological know-how than the copying of a brand name or label. There are similar effects on piracy probabilities for signaling, i.e. an approximate increase of 20 percentage points. Thus, when we

compare the size of the effect of signaling and enabling along types of piracy, our simulations suggest that for technical components we do not observe any significant differences between the two categories, graphically expressed in the two equally long arrows. However, we find that enabling sources clearly dominate signaling sources for copies of names or labels.

Figure 2: Predicted probabilities of piracy of technical components and piracy of product names/labels (given a hypothetical firm's activities enabling piracy or signaling to pirates




# 5 - Summary and conclusion

We have examined the relevance of different factors of a firm's IP strategy and business strategy on the incidence of product piracy. We find that traditional (formal and informal) strategies of IP protection are relatively more effective against piracy of names or labelling, while they there seems to be only a minor effect on the probability of technical components of products being copied. The latter are more strongly dependent on general business strategy aspects such as internationalization decisions or cooperation behavior as well as factors which cannot - or only to a minor extent - be influenced by the individual firm (e.g. industry affiliation, firm size etc.). We furthermore revealed that trademarks may have adverse effects on piracy of names or labels by signaling new products or expected brand premiums to pirates. In general, we do not find any evidence that patents or trademarks

[16] More precisely, we now analyze piracy rates as behavioral "reaction"' functions of pirates where the latter will choose among different, uncertain market environments depending on (entry) incentives, rather than applying our results as an evaluation scheme for (non-)strategic positioning of originator producers as we did before.

successfully pose a legal threat to pirates, but the disclosure of information in patent documents does not worsen IP appropriation either. Furthermore, from proxying piracy behavior we have encountered a paradox that enabling pirates by giving away technical information to the public domain has a relatively stronger impact on the copying of names or labelling than it has on technical components. The effect of signaling to pirates generates similar effects in the two categories.

A number of managerial implications can be drawn from our analysis. As IP strategy factors were found to be especially relevant for the imitation of names and labels, firms confronted with the threat of brand counterfeiting should be particularly aware of their strategic position in this area. An example is the signaling effect of a brand registration to potential imitators. However, this does not imply that management should abandon trademark registration, but managers should consider carefully whether the benefits of an additional registration outweigh the potential downside of piracy. More articulate decision on which brand aspect should be registered and which not might be worth considering. In general, it should be clear that any anti-piracy strategies for different IP types should be seen as interdependent e.g. when it comes to establishing R&D facilities abroad and the associated piracy risk. Since an IP strategy detached from the general business framework can be expected to have only limited success (especially for piracy of technological elements), an integration of IP and overall business strategy is needed. This is particularly important for companies active in the international market since internationalisation (especially of sensitive units such as research and development staff) is shown to be a significant driving factor of piracy. Contrary to our assumption, extensive cooperation does not seem to have detrimental effects, but the articulation of a strict trade secret strategy becomes even more important here. Lastly, the negative signaling effect of high research intensity can be exploited even by companies which are not at the forefront of innovation. Using technological means of protection, e.g. IT-security technologies, may offer an alternative way to successfully prevent product piracy.

With respect to future research and the potential limitations of our approach there is a basic need to link up insights on the supply side to demand activities, e.g. by surveying purchasing consumers, in order to create an overall piracy and (legal and black) market framework of analysis. This becomes particularly evident in the case of piracy on labels and names and the related creation of brand premium. In addition, it is not clear at this

stage how much firms themselves are aware of the phenomena and risk factors associated and if they are willing to adopt anti-piracy consideration into their risk management operations. In this way, we do neither know if and how product and brand pirates will respond to such strategies - and it seems impossible to survey here -, nor can we assess yet the overall behavioural effects on market dynamics and competition. There are thus important paths to address in the future.

# 6 - Appendix 1

Table 4: Inserted variable values for predicted probabilities

| | | | Inserted variables (values): predicted probabilities* | |
|---|---|---|---|---|
| | | | **Piracy of technical components** | **Piracy of product names/labels** |
| Figure 1 | Strategic position (favorable : adverse) | IP strategy | Importance of defensive publication (2 : 4) | Importance of brands (2 : 4)<br>Importance of secrecy (4 : 2)<br>Importance of defensive publication (2 : 4) |
| | | Firm strategy | Foreign R&D (0 : 1)<br>Cooperation intensity (1 : 0)<br>R&D intensity (.13 : .02) | Foreign R&D (0 : 1) |
| | Non-strategic position (favorable : adverse) | | ln(employees) (7.7 : 4.5)<br>IPR dependency (2 : 4)<br>Metal processing (0 : 1) | Plastics (1 : 0) |
| Figure 2 | Enabling (weak : strong) | | Importance of defensive publication (2 : 4)<br>Foreign R&D (0 : 1) | Importance of secrecy (4 : 2)<br>Importance of defensive publication (2 : 4)<br>Foreign R&D (0 : 1) |
| | Signaling (weak : strong) | | Cooperation intensity (1 : 0)<br>R&D intensity (.13 : .02) | Importance of brands (2 : 4) |

* All other variables set to mean.
Variable specifications are selected as mean values of the samples 1st, respectively 4th quartile, while being 1/0 for dummy variables.

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