Paper to be presented at

DRUID15, Rome, June 15-17, 2015

(Coorganized with LUISS)

Different Rules, Different Behaviors, Same Performance: The Use of Intellectual Property Rights by German and UK Firms

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Abstract

This paper examines differences in the use, and extent of use, of registered intellectual property rights (IPRs) by German and UK firms. Specifically, we match German firms to their closest UK counterpart on observed characteristics, and examine differences in the extent to which German and UK firms apply for patents, trademarks and registered designs. For each type of registered IP, we do this at three levels: national, European and international. We find that German firms are more likely to register IPRs, but argue that this is at least partly because German firms have stronger incentives to do so. After controlling for observed characteristics, most differences between German firms and their UK ?twins? are modest, being greatest for national patenting, in high-technology sectors. Interestingly, the behavior of German and UK firms is most similar in the use of Community Trade Marks and Registered Community Designs, two ?harmonized? instruments intended to encourage the development of the single European market.

Jelcodes:K40,-

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Keywords: intellectual property rights; cross-country comparison; matched pairs; institutional harmonization

1. Introduction

The system of intellectual property rights (IPRs) is an important element of an economy's institutional structure (e.g., Barbosa and Faria, 2011; Nelson, 2008), as IPRs affect the rate of production and diffusion of innovations, and the allocation of returns to innovations. With innovations being difficult to identify and quantify directly, IPRs are often used as proxy indicators of a country's fecundity for innovation (see e.g., OECD, 2005; WIPO, 2014). For the UK, such indicators can make distressing reading because the UK number of patents, trademarks or registered designs per head (or relative to GDP), lags significantly behind those of other "rival" countries, such as Germany. Such comparisons are, however, much more problematic than many seem to realize. Arguably, because countries are "playing the game" by (slightly) different sets of rules, which can have substantial effects on revealed behaviors.

By analogy, the game of rugby is played according to two codes: rugby union and rugby league, which split from each other in 1895. The two codes have many things in common including the ovoid shape of the ball, the duration of the game (80 minutes), rules concerning how the ball can be moved (e.g., no forward passes), and there being four different ways to score: tries, conversions (or goal kicks), penalties and drop goals. But there are also differences. A union team has 15 players while a league team has 13. Moreover, and with one exception, the points awarded for each way of scoring is different. In the 2013/14 season, the average number of points per game in union's English Premiership (the top professional league) was 41, with an average of 4.3 tries per game. In the corresponding Super League, 50 points were on average scored per game in the 2013/14 season, with roughly twice as many tries per match. Advocates of league might see this as indicating their code is more "productive," while advocates of union would say nonsense, all it shows it that it easier to score points and tries in league. The argument is likely to be endless, but might just be settled if (i) the teams were playing by exactly the same rules; and (ii) the teams were permitted to field the same quality of players.

The same logic can be applied when comparing the "performance" of German and UK firms with regard to their registration of IPRs. To do this we need to (i) appreciate the differences in the "rules of the game" between the two countries (even if the "harmonization" of some of the IPRs available in Europe has levelled the playing field to some extent); and (ii) compare like with like in terms of the quality of the firms compared, at least on observed characteristics.

This paper undertakes this exercise, by drawing on a novel database that integrates information on a variety of registered IPRs at the firm level: patents, trademarks and registered designs – each of which may be filed at the national, European or international office. To separate cross-country variation in IPR usage due to differences in industry and firm demographics from differences attributable to the national environment, we apply an econometric matching method. Adjusted differences are quantified for nine types of IPRs over a period of up to eight years (2004-2011), both in terms of activity and count gaps. Activity gaps capture the difference in the proportion of German and comparable UK firms with at least one filing in a year, count gaps examine the difference in average annual filing numbers. An interesting aspect of our study is that we include both "established" and "new" IPRs; the new rights being the relatively recently introduced Community Trademarks and Registered Community Designs.

Our results suggest that on average German firms generally "outperform" their UK counterparts in their propensity to use IPRs and in the extent of their use (i.e., average number of filings), but interestingly the magnitude of these differences are rather modest. And moreover, the activity gaps for Community Trademarks and Registered Community Designs are not significant after controlling for industry and firm characteristics. This appears to support the idea that once we control for the quality of the players and have them play according to the same rules, German and UK firms differ little in their IPR "performance" or behaviors.

The remainder of the paper is structured as follows. Section 2 briefly outlines how the incentives to register IPRs differ between Germany and the UK, and how the European Union has sought to harmonize some of the IPR instruments available in Europe; Section 3 introduces the database of firms; Section 4 presents the methods, and Section 5 the results. Section 6 discusses the findings, while Section 7 concludes the paper.

2. Understanding the Incentives to Register Intellectual Property Rights in Germany and the UK

Germany and the UK share three different types of registered IPRs: patents, trademarks and registered designs. However, the incentives to register intellectual properties differ between the two countries.

2.1. Patents

When considering whether or not to take out a patent, the prospective applicant should consider the cost of obtaining (and maintaining) protection, relative to both the effectiveness of the protection provided and the value of the invention for which protection is sought.

The cost of obtaining a patent involves the fees payable to the patent office and professional fees to patent drafters, which are considerably larger. In Germany, fees tend to start around €2,500 euro for the simplest patents, while in the UK they tend to start around £3,000 (circa €4,500). In part, the difference is likely to reflect the size of the market for patent drafting services, which is much larger in Germany. This cost difference may have some influence on the extent of patenting, because (i) it is only rational to obtain patents the value of which exceeds the cost of obtaining them; (ii) the distribution of patents by value is understood to be extremely skewed with many low value inventions and a few high value patents (Gambardella et al., 2008; Scherer and Harhoff, 2000); (iii) if higher costs deter patent filing, then the cost to rivals of searching through patent information is lower, increasing the true cost of disclosure. Relatively small differences in the cost of obtaining patents may therefore have a substantial impact on the extent of patenting activity.

This said, firms should not only consider the cost of patenting, but also the effectiveness of the protection provided. Ultimately, any right is only as effective as the ability of the holder to assert it. This has to do with (i) the cost of defending a patent considered to have been infringed; and (ii) the likelihood of winning a contest against an alleged infringer. Here, Germany has two significant advantages over the UK (or more specifically, England and Wales): first, the cost of litigation is substantially lower; second, the likelihood of the patentee winning is significantly higher.

With regard to costs, Graham and Van Zeebroeck (2014) state that the average cost of litigation in Germany ranges between €50,000 and €250,000, whereas in the UK the typical range is €150,000 to €1.5m, that is, between three and six times that in Germany. Unlike the UK system, the German system cannot award punitive damages, however. But while the prize for winning may be lower, the chances of the patentee winning are significantly higher in Germany. This is partly because Germany operates a dual (or bifurcated) system, with invalidity challenges brought before the Federal Patent Court, while infringement cases are brought before any of twelve competent district courts. This gives the patentee two advantages: first, he/she can choose

the court most sympathetic to his/her case; and second, and more significantly, the split between courts in responsibilities for infringement and validity allows the patent claims to be interpreted differently. According to Cremers et al. (2013), the district courts tend to interpret the claims generously, increasing the probability of infringement, whereas the Federal Patent Court tends to interpret the claims narrowly, reducing the chances of revocation. Furthermore, possible invalidity is not a defense in the district court; defendants who wish to overturn the validity of the patent they are accused of infringing must take a separate action to the Federal Patent Court. Only about a third of alleged infringers take this course of action in Germany (Cremers et al., 2013). It is possible for the district court to find that the defendant has infringed a patent which the Federal Patent Court later finds invalid. District court proceedings are also typically fairly quick, with expert opinions being ordered only in exceptional cases, and there is a tendency to trust the judgment of the patent examiner (Cremers et al., 2013). These features make it harder for the defendant to disprove infringement, or to invalidate the patent.

The setup in the UK is rather different. During the period of our study England and Wales had two specialist courts for IP matters: the then Patents County Court (for simpler, lower cost cases), and the Patent Court, a division of the High Court. In practice, the overwhelming majority of cases were heard at the High Court. Significantly, both courts could hear infringement and validity issues in the same action, and in more than half the cases of alleged infringement the defendant counter-claims for invalidity (Helmers and McDonagh, 2013). The UK courts also have wide ranging powers to obtain evidence and hear from witnesses, which leads to longer cases and escalating costs: cases typically last several days or even weeks, much longer than in Germany. And if infringement is established in a first trial, a second trial is required to assess damages.

Although many disputes are settled privately before judgment is reached, both Graham and Van Zeebroeck (2014) and Cremers et al. (2013) find that the patentee is much more likely to win in Germany than in the UK. Graham and Van Zeebroeck (2014, p. 695) report that "Among infringement actions […] German courts find significantly more in favor of the patentees (52%) than in favor of the defendants (44%)," whereas in the UK the outcome is more even, with 45% found to be infringed, 43% not infringed, and 12% ambiguous outcomes. In validity actions, the German courts revoked patents in 37% of cases, but upheld validity in 43% of cases, with 20% having ambiguous outcomes. These outcomes were more favorable to the patentee than those in

the UK, where Graham and Van Zeebroeck (2014) found 35% were upheld and 33% revoked, with 32% ambiguous outcomes.

Cremers et al. (2013) show that when the courts settle cases, the outcomes in Germany tend to be much more favorable to the patentee than the outcomes in the UK. Indeed, the most likely outcome for a German patentee in an infringement case that goes to judgment is that the patent is found to have been infringed. The least likely outcome is that the patent will be revoked. By contrast, the most likely outcome for a UK patentee in an infringement case is that the patent is revoked, with this outcome being almost twice as likely as the patent being found to be infringed. In other words, the most likely outcome for a UK patent holder alleging that someone else is using his/her property is the finding that he/she does not have any property! Among invalidity cases that reach a verdict, 42% end with patents being revoked in the UK, which is more than twice the share in Germany.

All this suggests that for any particular invention, German firms are much more likely to seek domestic patent protection than their UK counterpart. Because European patents are essentially bundles of national patents (subject to national rules of the contracting states designated in the application), these same arguments also apply at that level.

2.2. Trademark and Design Protection

With both trademarks and design rights, the European Commission has made greater, and considerable progress towards the "harmonization" of protection across Europe. Harmonization of regulations is an important objective of the European Commission because it recognizes that the objective of a single market cannot be achieved if every country is playing by a different set of rules.

Trademarks were the first of the IPRs to be harmonized in the European Union, with the Trademark Directive of 1989 leading to the introduction of Community Trademarks in 1996. However, a parallel system of national trademarks and their registration also exists. In Germany, around 60,000 applications are still made for national trademarks annually (reference year: 2011). Although this number has been declining in recent years, it is higher than the number of domestic trademark applications submitted in the UK, which is around 35,000 per annum. German-based applicants also apply for far more Community Trademarks than do UK applicants (16,000 vs. 8,000 in 2011).

With regard to designs, the Commission's Design Directive of 1998 required that all Member States provide harmonized national protection of designs through national registration procedures. Then the Community Design Regulation of 2002 created two EU-wide design rights: the Registered Community Design (RCD), which corresponds to the national right specified previously under the Design Directive, and the Unregistered Community Design (UCD), which provides automatic protection of any new and individual design against copying for three years from the date of disclosure in the EU. Since the introduction of the RCD, the total number of designs registered by UK-based registrants has remained stable, but half are now registered in Europe (BOP, 2011). However, German based registrants submit around seven times the number of designs, with approximately three-quarters of these being domestic registrations.

While the basic setup is similar in Germany and the UK, the incentives for registering trademarks and designs are not the same, especially for businesses that are only active in their domestic markets. This is because the UK common law provides protection against "passing off," which protects goodwill, something that does not necessarily accrue to registered trademarks. Germany, meanwhile, has laws against unfair competition, which are not available in the UK.

Aside from the much lower cost of litigation than in the UK, according to Cohen et al. (2004), an advantage to the plaintiff of the German system is that he can choose the forum, and "Plaintiffs tend to gravitate to the court having the strictest view on companies that attempt to exploit their competitors' goodwill." A disadvantage is that only "reasonable damages" and not punitive damages can be awarded in Germany for infringement cases. Also notable is that if proven, infringements are a civil offence in the UK, but may be a more serious criminal offence in Germany.

Although we are not aware of any studies which have systematically examined infringement and revocation cases with regard to either trademarks or designs in Germany and the UK, the UK legal system should be most favorable to very high value trademarks (and designs), whereas the cost of defending a low value trademark or design is prohibitive. The German system, by contrast, is more favorable to owners who wish to assert their rights with respect to trademarks and designs of modest value. These differences in the legal setup suggest that overall the incentives to register trademarks and designs are greater in Germany than the UK. In other words, for any potentially registrable trademark or design, owners in Germany have greater incentives to register than do owners in the UK.

Having established that overall the "rules of the game" are slightly different in the UK and Germany, we now aim to shed light on the extent of any behavioral differences between German and UK firms by undertaking a detailed comparison of their IPR application activities. To do this, we draw on a novel database which is discussed in Section 3 below.

3. Construction of the Dataset: Comparing Apples and "Äpfel"

To allow for a detailed comparison of firms' IPR choices with regard to registrable rights in Germany and the UK, we compiled a dataset by integrating observable company data and a variety of IPR sources. Company data was obtained from Bureau van Dijk's ORBIS database (August 2014 version) which contains basic information on all firms recorded, including name, ownership, and industry. Availability of financial and accounting data, such as revenues, profits and number of employees, varies substantially however. Because of this, we included only relatively large firms, with annual revenues ≥10 million EUR[1] in at least one year of the 2004-2012 period. This provided a total of 47,856 German and 47,832 UK companies.

Patent data was extracted from PATSTAT (October 2013 version), the worldwide statistical patent database of the European Patent Office (EPO). PATSTAT provides, amongst others, standardized access to patent applications submitted to the German Patent and Trade Mark Office (DPMA), UK Intellectual Property Office (UKIPO), EPO, and the International Bureau of the World Intellectual Property Office (WIPO), including filings under the Patent Cooperation Treaty (PCT). Information on national trademarks and design registrations was taken from the registries maintained by the DPMA and UKIPO, while data on Community Trademarks and Registered Community Designs was supplied by the European Commission's Office of Harmonization for the Internal Market (OHIM). Finally, data on international trademark and design registrations (filed respectively under the Madrid and Hague systems) were obtained from the WIPO databases. All IPR databases other than PATSTAT were last updated between December 2013 and April 2014.

We restrict our analysis to 2004 to 2011, as 2004 was the first year for which financial data is available and 2011 is used to allow for the delay in the publication of patents. IPR data is

[1] Historical currency rates were used to generate consistent Euro values for financial variables.

assigned to firms in the year of filing. Using a longitudinal approach increases the robustness of the findings, and allows for the identification of potential changes in firm behaviors over time.

The assignment of patents, trademarks and registered designs to individual firms in a particular year involved a major challenge: Firms file IPRs under a variety of names, and there is no unique identifier that can be used to link the datasets. Consequently, major efforts have previously been undertaken to harmonize the names in IPR databases and match them to entries in business registers, such as the NBER patent data project (e.g., Hall et al., 2001). Building on the methods of those studies, and for both countries, we implemented a three-step procedure to consolidate IPR data at the firm level. First, we extracted all applicant names associated with filings between 2004 and 2011 from the various IPR databases and removed those applicants that could be identified as non-legal entities. Second, we applied a set of automatic cleaning algorithms, originally developed by Magerman et al. (2009), to reduce variations in name spellings. The final phase involved matching cleaned applicant names to cleaned company names extracted from ORBIS using a token-weighted approximate string matching technique. Perfect matches were accepted; matches below a certain similarity threshold were disregarded. Matches in the grey area – more than 30,000 for each country – were manually verified with the help of research assistants. The advantage of this semi-automated procedure is that both high levels of accuracy (correct allocation) and completeness (extent to which a firm's different name variants are captured) can be achieved.

4. Methods

Here, we first explain our rationale for applying econometric matching estimators, before introducing the variables of the model and the actual matching protocol. We conclude with a description of the baseline sample.

4.1. Matching Approach

Our two-country comparison is based on an econometric matching method which seeks to estimate the difference in IPR behaviors between German and UK firms controlling for all observable factors except country location. In other words, by finding its UK "twin," we can estimate the extent to which a German firm would have behaved differently if they were in the UK. We define the activity gap of an IP instrument to be the average difference in the proportion

of German firms making at least one filing of a particular instrument in a particular year against the corresponding proportion of comparable UK firms. Analogously, the count gap of an IP instrument is the average difference in the average number of yearly filings made by German firms compared with the average number of filings made by their matched UK counterparts. Positive gaps indicate, respectively, higher propensities to file, and greater average filing numbers by German firms.

Matching techniques have been developed to replicate randomized experiments in observational studies, where the treatment status is confounded by systematic differences in covariate distributions between the treated and control groups (e.g., Heckman et al., 1998; Rosenbaum and Rubin, 1983). The two groups are first balanced on a set of a priori defined and observable covariates, before the outcomes of the two sets are compared. Observed differences in the outcomes between treated subjects and their matched controls are attributed to the treatment. In our case, "the treatment" is being based in Germany, relative to being located in the UK.

While matching is typically used to estimate causal effects, recent studies have demonstrated its usefulness for investigating inter-group disparities (e.g., Aggarwal et al., 2010). In this paper, we follow the latter approach, applying matching estimators to adjust for observable differences in the characteristics of German and UK firms (e.g., industry, size, and productivity). In analyzing the residual differences at the population level we focus on activity and count gaps of the various IPRs defined above. Formally, these gaps are described by $E(Y_1\text{-}Y_0 \mid S = 1, X)$, where Y is the outcome measure of the IP instrument (either as a binary variable indicating at least one filing in a particular year, or as a continuous variable denoting the number of annual filings). S refers to the country status (S=1: DE, S=0: UK), and X to the vector of measured covariates. While the mean $E(Y_1 \mid S = 1, X)$ can be identified from the data collected for German firms, $E(Y_0 \mid S = 1, X)$ corresponds to a hypothetical situation which cannot be observed and thus is approximated by $E(Y_0 \mid S = 0, X)$, the mean outcome in the control group of matched UK firms.

We employ matching techniques instead of multivariate regression models for several reasons. First, matching is a non-parametric approach and, therefore, the actual relation between firms' IPR choices and potential covariates does not need to be specified. Explicitly estimating IPR choices would require functional and distributional assumptions that are difficult to justify. Secondly, matching avoids comparing incomparable subjects (on observed characteristics) by highlighting areas of the covariate distribution without sufficient overlap between groups.

Regression analysis, in contrast, does not provide standard diagnostics to assess this overlap, and would therefore rely heavily on extrapolation given marked inter-group differences in firm characteristics. Finally, when outcomes are binary, matching allows estimation of absolute differences in proportions.

While differences may arise in the behavior of matched German and UK firms, we cannot know exactly why these differences arise. Strictly, causality would imply that the outcome variables are statistically independent of the treatment assignment (here: country status) once German and UK firms have been balanced with respect to X. As we cannot entirely preclude that the observed covariates are independent of national parameters and, moreover, there might be other (unobserved) variables that either or both differ between countries and relate to firms' IPR choices, we cannot be certain that any differences that arise are due to "real" national difference. This said, it is normal to draw inferences from results of statistical modelling; inferences that the reader may accept or reject based on the quality of the argument, data and modeling.

4.2. Variables

We evaluate cross-country differences in IPR filings along 18 outcome variables – two for each individual IP instrument. The dual approach of characterizing firms' IPR behaviors by the probability of at least one filing and the number of applications is in line with prior research (e.g., Brouwer and Kleinknecht, 1999). For all three types of IPRs – patents, trademarks, and registered designs – we consider filings at (i) the respective national office (i.e., DPMA or UKIPO), (ii) the European office (i.e., EPO or OHIM), and (iii) WIPO's International Bureau.

To avoid double counting of patents in the same family, we use a classification based on priority filings and transfer histories. Specifically, any priority filings at the national office not subsequently transferred to the EPO or PCT route are coded as "national filings." National priority filings transferred to the EPO (but not to the PCT), and filings at the EPO not transferred to the PCT, are identified as "European filings," while "international filings" include all priority filings made via, or transferred into, the PCT route. Since trademarks and design rights families are relatively rare, we do not restrict their analysis to priority applications but account for first and second filings – those at the domestic office are considered "national filings," OHIM applications are designated as "European filings," and WIPO applications correspond to

"international filings." For simplicity, full ownership is attributed to every applicant associated with a particular IPR. In other words, we do not adjust for partial or co-ownership.

We balance German and UK firms on a set of key covariates known to affect IPR choices and essentially independent of a firm's national environment. While the determinants of patenting have been studied extensively in theoretical and empirical contributions (for a recent review see Hall et al., 2014), research on the drivers of trademarking (e.g., Mendonça et al., 2004) and design registrations (e.g., Filitz et al., 2015) is relatively scarce.

First, differences in the industrial mix of firms are captured by standard industrial classification codes (here NACE codes) at the 2-digit level (note that, as a robustness check – reported later – we also matched firms by their 3-digit classification). Since the seminal studies by Levin et al. (1987) and Cohen et al. (2000) it is well established that the use and perceived effectiveness of different protection mechanisms varies significantly across industries, with patents known to be particularly effective in "discrete" technology industries, such as pharmaceuticals or chemicals. For strategic reasons, the use of patents is also high in "complex" technological fields, including telecommunications equipment and semiconductors. Heterogeneous filing motives across industries are closely linked to the sectoral variation in firms' propensity to patent (e.g., Arundel and Kabla, 1998). Not surprisingly, patenting is particularly widespread in sectors characterized by high R&D intensities (e.g., Brouwer and Kleinknecht, 1999). More surprising is that trademarks are also more heavily used in "high-tech" rather than "low-tech" industries (Greenhalgh and Rogers, 2006; Mendonça et al., 2004), yet, in contrast to patents, they are also widely used in service sectors (Amara et al., 2008). Finally, there is some evidence that design registrations are concentrated in a limited number of design-intensive sectors, which includes some R&D-intensive and some traditional, "low-tech" activities (Filitz et al., 2015).

Second, we use two measures to control for differences in firm size – the log of the number of employees (LEMPL), and the log of revenues (LREV). Most studies have reported a positive relationship between firm size and the use of patents (e.g., Arundel and Kabla, 1998), trademarks and registered designs (Amara et al., 2008; Gallié and Legros, 2012). Explanations usually include scale advantages of large IPR departments, and the financial barriers to filing and enforcing legal protection mechanisms faced by smaller firms. By matching on both the number of employees and revenues, we effectively control for firm-level differences in labor productivity

or "the quality" of firms. Some of the variation due to unobserved covariates correlated with productivity is therefore captured as well. For example, productivity is a strong predictor of firms' degree of internationalization (e.g., Helpman et al., 2004) – a variable also shown to be positively related to the use of IPRs (Hall et al., 2014).

In addition, we adjust for differences in company age, measured by the log of years (plus one) since incorporation (LAGE), and external ownership or group affiliation, as captured by a dummy variable (GROUP). Both variables are standard in studies modelling IPR choices. As regards firms' R&D expenditures, an important determinant of patenting (e.g., Hausman et al., 1984) and – potentially – the use of other registered IPRs as well, we had to resort to the differences captured by industry dummies, as coverage of R&D spending is poor in company accounts data (and ORBIS in particular). As a robustness check, we re-ran the matching for the small sample of firms for which R&D data is available (see Section 5.2).

4.3. Matching Protocol

The matching procedure described in this section was chosen as the result of an iterative process that aimed to minimize systematic differences in the distribution of observed covariates between German and UK firms (cf. Austin, 2011). We combine three distance measures to decide whether a UK firm from the pool of potential matches is a good match for a particular German firm.

First, we applied exact matching by industry by implementing the matching separately within subgroups of industries and then aggregating industry-specific effects to estimate an overall effect. This approach puts greater emphasis on one or more specific covariates – here principal activity, or industry.

Second, propensity scores are estimated to define the region of common support, that is, the subset of firms for which at least one sufficiently similar observation in the comparison group is available (e.g., Dehejia and Wahba, 1999). In our application, the propensity score is the probability that a firm with given characteristics is a German firm. This probability is calculated using the measured covariates of both German and UK firms in a probit regression. Conditional on the propensity score, the distribution of observed covariates is similar between firms in each

group (Rosenbaum and Rubin, 1983). We discard observations with propensity scores for which there is no good match in the comparison sample.[2]

Third, we perform one-to-one nearest neighbor matching within subgroups of industries based on the Mahalanobis distance. The latter metric defines the distance between two subjects i and j as $d_{i,j} = (X_i - X_j)D^{-1}(X_i - X_j)^T$, where X_i and X_j are covariate vectors and D the corresponding covariance matrix based on the sample of potential controls. Mahalanobis matching works particularly well where there are few (<8) matching arguments (Zhao, 2004). For each German firm we select the most similar UK firm according to the lowest Mahalanobis distance. UK firms may be matched to more than one German firm; that is, we perform matching with replacement.

Once the matched sample has been formed, activity gaps (i.e., the inter-group difference in proportions of firms with at least one filing) and count gaps (i.e., the average difference in the mean number of filings) are estimated. To account for the matched nature of the data, we use McNemar's test on the (binary) activity gaps and paired t-tests on the (continuous) count gaps to assess the statistical significance of the outcomes (Austin, 2011). Our matching protocol is summarized in Table 1 (for similar approaches see Czarnitzki et al., 2007 and Czarnitzki et al., 2011).

Insert Table 1 about here

4.4. Baseline Sample and Descriptive Statistics

In the baseline model, we apply matching estimators to six cross-sections of our integrated dataset for the period 2006-2011 and a subsample of 9,696 DE and 14,547 UK firms. Three criteria led to the trimming of the initial data.

First, most of the literature on matching assumes fully observed covariates and, therefore, observations with missing data had to be excluded. To draw from constant pools of DE and UK firms in each cross-section, only observations with complete time-series data were considered.

[2] In other words, for each observation in both groups we calculate propensity scores, the summary measure of similarity incorporating all covariates into one scalar. We then discard German firms with propensity scores that are smaller (larger) than the minimum (maximum) in the UK comparison group – i.e., those for which there is no good comparator. We then also do the same for UK firms. This is a standard approach to define the region of common support.

Note also that the actual pairings of firms may differ across years. As coverage of financial and accounting data of German firms was substantially expanded from 2006 onwards, we decided to initially drop 2004 and 2005 from the analysis. In a robustness test reported later, we relax the requirement of complete time-series data and match all firms with fully observed covariates in a particular cross-section, including the years 2004 and 2005.

Second, further loss of observations was due to the exclusion of three non-activity specific NACE classes that reflect the practice of concentrating IPR registrations at head offices. Where possible, companies were reassigned to the distinctive NACE class that occurred most frequently in their corporate group. Third, only NACE classes with at least 20 observations for each country were included, leaving us with a total of 61 2-digit industries.

Table 2 provides descriptive statistics of the baseline sample, averaged over the period 2006-2011. The German firms exhibit statistically significantly higher filing probabilities for each type of IPR, and dividing the German propensity to register IP with the corresponding UK propensity shows that overall German firms were about three times more likely to apply for national patents, international (Madrid) trademarks and to register designs nationally, twice as likely to apply for international (PCT) patents, and six times more likely to apply for European patents. Only with national and European trademarks, and European designs, was the overall propensity to register IP by German firms less than double that of the UK firms. Furthermore, when it comes to average number of filings, overall the German firms had a significant lead, most especially in patents.[3] Overall, the average German firm was likely to register almost 15 times as many patents nationally, 10 times as many patents at the EPO, and seven times as many patents internationally as the average UK firm. German firms also typically registered almost 8 times the number of designs nationally and nearly 5 times the number of designs in Europe with OHIM as the average UK firm. The pattern is similar but less pronounced with trademarks. Relative differences – both in terms of the probability to file and application numbers – are largest for international (Hague) design registrations, as this instrument is extremely rarely used among UK firms.

However, as noted earlier, there is an obvious problem when simply comparing country averages – we are comparing firms with different characteristics, that is like comparing two

[3] The significance of the differences in annual filing numbers was confirmed by two alternative tests – a two-sided t-test based on the geometric means of the log (plus one) of the variables (all p-values < 0.001), and a non-parametric Wilcoxon rank-sum test (all p-values < 0.05).

different baskets of fruits, rather than apples with apples. Some of these differences in firm characteristics may reflect structural differences between the two countries, while other variation may be due to the fact that the coverage of UK firms is broader and, therefore, a more diverse set of firms is included in our dataset. The analysis presented below will shed light on the question whether the marked cross-country differences in IPR usage persist when controlling for observable company characteristics.

Insert Table 2 about here

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5. Results

We begin by presenting the matching results for the baseline model. Subsequently, we report various robustness tests and then explore potential sources of heterogeneity in the distribution of gaps in more detail.

5.1. Baseline Model

Before turning to the outcome measures of interest – the activity and count gaps of the various IPRs – we demonstrate that the matching routine as described in Table 1 has indeed been adequately specified. Table 3 shows that the number of matched pairs formed in each cross-section ranges between 9,487 and 9,546. Accordingly, for a small percentage of the 9,696 German firms in the baseline sample no suitable UK "twin" could be identified, owing to propensity scores outside the value range of the potential control group. As the lost observations amount to only about 2% of the German sample, there is sufficient overlap between groups to apply matching estimators (Dehejia and Wahba, 1999). Moreover, we can assume that the impact of the common support restriction on our results is fairly low (e.g., Czarnitzki et al., 2011).

Table 4 reports the "standardized bias," a common measure of covariate balance, before and after matching. For each covariate, this is defined as the inter-group difference in means, divided by the square root of the average of the sample variances in both comparison groups. Matching reduces in each instance the standardized bias to an acceptable difference of below 10% (Austin, 2011), indicating that the whole matched sample is well-balanced with respect to the observed covariates (see Table 4). Since we imposed an additional restriction, namely exact match by

industry, covariate balance within subgroups of industries was also examined. This was done by estimating propensity scores as outlined in Section 4.3, yet on the matched sample and separately for each NACE class and cross-section. The requirement for successful balancing is that the likelihood ratio test on the joint significance of all regressors in the probit model is rejected after matching (e.g., Czarnitzki et al., 2007). This condition was ultimately met in 97% of all cases. Taken together, the applied balancing diagnostics suggest that systematic differences in observable covariates have been greatly reduced between comparison groups. Hence, we can now proceed with an outcome analysis based on the assumption that the country-specific industry and firm mix is controlled for.

Insert Table 3 and Table 4 about here

The matching results are presented in Table 5 (activity gaps) and Table 6 (count gaps). It is immediately clear that matching has an impact on the size of the cross-country differences in IPR indicators, since the adjusted gaps are generally smaller than the unadjusted, time-averaged differences reported in Table 2. Indeed, even the maximum absolute values of 4% higher propensity to register (EUR-PAT-ACT_{2008}) and 0.493 filings per year (NAT-PAT-CNT_{2010}) could be considered relatively modest. However, with some notable exceptions (discussed below), most gaps remain positive and statistically significant, suggesting that variation in firm demographics can partly, but not fully, explain German firms' higher preference for registered IPRs.

With regard to the activity gaps, the following results stand out:

- First, German firms are more likely to file (1+) patents than similar UK firms, independent of application path or year. The stronger proclivity for patent protection across German firms has been reported in prior work and is likely to be related to Germany's patent-owner-friendly legal system which we discussed earlier (Cremers et al., 2013; Graham and Van Zeebroeck, 2014), as well as its generally pro-patent business culture, and high-levels of R&D productivity (Arundel and Kabla, 1998). Interestingly, the patent activity gap is not largest for national patenting, but for European patenting, with the gap peaking at 4% in 2008; this is almost twice the gap of national (2.4%) and international filings (2.1%) in that year. Possible explanations for this include a home-bias effect since the EPO is located in Germany and that the non-unitary character of European patents still reflects national

differences because EPO patents are essentially bundles of national patents subject to national rules of the contracting states designated in the application.

- Interestingly, the situation is different for trademarks and design registrations. For these, the European route features nearly identical filing propensities in Germany and the UK, whereas differences in national and international filings tend to be more pronounced, with German firms more likely to use these routes. Strikingly, over the whole period, a statistically significant activity gap is not found for European trademarks, and, with the exception of 2008 and 2009 – years of financial crisis that may have induced some variation – the same is true of European design registrations. These findings are notable, because Community Trademarks and Registered Community Designs constitute the most "unified" forms of registered IPRs available in Europe. They provide EU-wide protection with one application, and may only be granted, transferred or declared invalid for all Member States at the same time, according to the same rules. Moreover, the administering office (OHIM) is on neutral ground, being located in Spain.
- The evolution of the activity gap in national trademarking is also interesting. While most activity gaps are relatively stable over time, that for national trademarking drops from a level above 2% in favor of German firms between 2006 and 2009 to almost zero in 2010 and 2011. One explanation for this is that the substantive amendments to UK trademark law in 2007/2008, which included the introduction of a fast-track application process and less restrictive examination procedures, have increased the attractiveness of UK trademark filings. Similar features had previously been incorporated into German trademark law in the mid-1990s, and therefore UK and German national trademark systems have converged to some extent.

So far, we have considered disparities in the proportions of firms with at least one filing of each particular IPR in a given year. We now turn to the mean differences in number of annual filings between German and matching UK firms (Table 6).[4] Here, we find that:

[4] Two alternative tests were performed to double-check the statistical significance of the count gaps reported in Table 6. Paired t-tests based on the geometric mean of the log (plus one) of the variables yield very similar results (exception: insignificant gap – i.e., p-value > 0.05 – for EUR-TM-CNT_{2008}). Wilcoxon signed-rank tests produce more conservative results, with additional insignificant gaps for NAT-TM-CNT_{2010}, EUR-TM-$CNT_{2008\text{-}2011}$, NAT-DES-CNT_{2010} and EUR-DES-$CNT_{2006,2007,2010}$.

- With regard to patents, the evidence is clear: each count gap – independent of application path and year – remains positive and statistically significant after adjusting for company characteristics and industry of activity. Absolute differences are largest for national patents, with an average German firm in the sample outperforming its UK counterpart by almost 0.5 filings per year. European patent filings, for example, just differ by roughly 0.2 filings per year, despite markedly higher activity gaps. Because only a minority of firms patent at all, another way of viewing this is in relative terms; in relative terms, German firms apply for between twice and nine times as many patents, with the largest difference being for national patents, followed by European patents. However, later we will show that the count gap in national patenting is essentially driven by a subgroup of large companies in the medium high-tech sector (see Section 5.3).
- Also notable is the magnitude of count gaps for national and European design filings, given the relatively low prevalence of these protection mechanisms. While both comparison groups have a similar propensity to use European design registrations, German firms file more designs. A similar pattern applies to European trademarks, although absolute differences in filing numbers are smaller in this case. Indeed, among the matched pairs of companies where both file at least one European design, 65% exhibit greater annual filing numbers for the German firm, with the corresponding figure for European trademarks being 60%. That is, even if a German and a comparable UK firm both decide to use these EU-wide instruments, the German firm will generally register more designs or trademarks.

We interpret the above findings as showing evidence that even when matched to their UK "twin," German firms tend to compile larger portfolios of IPRs, although the magnitude of the differences are in general much more modest than when the overall samples are compared. While it is possible that this is because German firms are more productive in terms of producing a higher number of protectable "pieces" of intellectual property than their UK counterparts, we consider this to be at best only part of the explanation. For the reasons discussed in Section 2, German firms are more likely to seek formal protection for any given piece of protectable IP, because they have stronger incentives to do so.

Insert Table 5 and Table 6 about here

5.2. Robustness Checks

To examine the robustness of the results, we conduct a variety of tests, considering alternative assumptions and additional covariates. To improve clarity, we aggregate gaps over time. The pooled estimates of the baseline model serve as a comparison standard (we do not show the results for brevity).

First, to address the concern that the impact of sectoral differences on firms' IPR behaviors is not adequately captured by 2-digit industry (NACE) codes, we re-ran the matching on the baseline sample using the more refined 3-digit NACE codes. Because the exclusion criterion requiring at least 20 observations per industry and country applied more frequently, the total number of matched pairs formed over the period 2006-2011 is somewhat smaller (47,865 vs. 57,123). However, the results, both in terms of the magnitude and the statistical significance of gaps, are very similar, suggesting that the 2-digit classification is sufficient for our purpose.

Second, we aimed to expand the generality of our findings (column 4). In this specification, we included all firms to a cross-section (2004,…, 2011) for which we have complete data in any particular year, and thereby more than triple the total number of matched pairs (173,210 vs. 57,123); in other words, this relaxes the requirement of full time-series data and extends the time-period covered by two years. This widening of the net reduced the average size of the firms being compared, and therefore the inclusion of a broader set of firms could be expected to reduce the size of most activity and count gaps. While this was indeed the case, the absolute reductions in gap sizes are small and the significance levels remain unchanged, so we can infer that our findings also hold for this wider set of firms.

Lastly, a concern is whether our results would change when information on R&D expenditures is incorporated into the analysis. To address this, we re-estimate the extended model for a small subset of firms for which R&D data is available. Specifically, we add the log of R&D expenditures to the vector of matching arguments, and compare the results with a benchmark model based on the original covariate vector. Interestingly, the estimates obtained from these two specifications differ little – especially when taking the relatively high standard errors into account; the latter are partly due to the small number of matched pairs formed (about 1,000 over the period 2004-2011). We therefore assume that differences in R&D expenditures are largely captured by the other observed covariates. However, for the small subset of firms reporting R&D, pooled activity gaps are found to sometimes exceed 10% (NAT-PAT-ACT, EUR-PAT-ACT),

while several count gaps are well above one filing per year. In the subsequent section, we will explore the sources of such heterogeneity in more detail.

5.3. Exploring Heterogeneity

We have seen that – within our sample of matched firms – the typical German firm, compared to its UK "twin" (i) has, with the important exceptions of EU-wide trademarks and registered designs, a higher propensity to use registrable IPRs, and (ii) tends to file greater numbers of all types of IPRs – that is, German firms typically have larger IPR portfolios. However, there is also an indication that these aggregate level conclusions may be masking some important heterogeneity. In this section, we tackle this by relating the magnitude of IPR gaps to firm characteristics, focusing on company size and principle sector of activity. To this end, we evaluate the results of the baseline model separately for different groups of matched pairs. As in the robustness analysis, activity and count gaps are pooled over time to facilitate comparability.

Specifically, we split the sample of matched pairs into Eurostat sectors, dividing manufacturing industries by R&D intensity (HT: high-tech; MHT: medium high-tech; MLT: medium low-tech; LT: low-tech), and services according to the share of tertiary educated personnel (KIS: knowledge-intensive services; LKIS: less knowledge-intensive services). Other industries (comprising primary activities, the utilities and construction) are gathered into a residual category. Moreover, we distinguish two types of firms: SMEs (<250 employees) and large firms (≥250 employees). Note that for both countries our sample of SMEs is atypical, because we include only firms with revenues of >€10m. Therefore our sample of SMEs biased to high performing SMEs. The matched pairs are allocated according to the number of employees of the German firm in a particular year.

The differential activity and count gaps are presented in Figure 1 and Figure 2, respectively, and it is immediately clear that substantial heterogeneity exists across sectors and size categories. The largest absolute gaps all favor the German firms, and are found (i) primarily with respect to large firms rather than SMEs, (ii) particularly with respect to patenting (and national and international trademarking), and (iii) mainly in the high-tech and medium high-tech sectors of the economy. By contrast, the smallest absolute gaps exist for services, and especially knowledge intensive services. Note that these sectors are those that are least likely to use IPRs in Germany and the UK (e.g., Greenhalgh and Rogers, 2006; Thomä and Bizer, 2013). Both count and

activity gaps are smaller for SMEs than for large firms, which indicates that the SMEs in our sample are more similar than the large firms, but these findings must be treated with caution as the SMEs in our sample are atypical of those from both countries.

Insert Figure 1 and Figure 2 about here
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6. Discussion

Do similar firms in different contexts behave in similar or different ways? A substantial literature has developed on "varieties of capitalism" (Hall and Soskice, 2001) or "capitalist diversity" (Crouch, 2005), which argues that firms will behave differently in different context because their behavior is shaped by institutions (including the financial system, the labor market, legal frameworks, etc.). As is shown by the game of rugby, even relatively small differences in the rules of the game can lead to quite different patterns of behavior. In relation to firms, multinationals even engage in "institutional arbitrage" (e.g., Ghemawat, 2007) by locating activities in different jurisdictions; in effect, they are able to simultaneously play the game according to the various sets of rules available.

Although this literature appreciates that innovation is the ultimate source of economic growth, and makes broad (or bold) assertions about the types of innovation most attuned to the different "varieties of capitalism," this literature is perhaps surprisingly quiet on the details of the legal systems and instruments intended to support innovation.

This paper has sought to address this by empirically examining the use (and extent of use) of various types of registered IPRs by firms in Germany and the UK. Importantly, we have matched the firms, so that we are comparing like with like. Although this comes at a cost of generalization – our matched firms are not necessarily typical of firms in Germany or the UK –, the choice of comparison countries is not arbitrary. On the one side, both Germany and the UK are members of the European Union, which is seeking to develop a single market. A single market can only really exist if the pertinent institutions are homogeneous. The European Commission is of course aware of this, and has been working to harmonize institutions, including those related to IPRs. To date, most progress has been made with respect to trademarks and designs.

On the other, Germany and the UK remain significantly different. In the "varieties of capitalism" literature Germany is characterized as a prime example of a "coordinated market economy," whereas the UK (alongside the U.S.) exemplifies a "liberal market economy." Being two different types of economy, Germany and the UK not only host but also favor different types of firms and firm behaviors. The two countries also differ in their legal frameworks. The UK is a common law country, so – as well as by statutes – law of precedent applies and is developed by judges through the decisions of courts. The German legal system is based on civil law, which is much more extensively codified, and less open to interpretation by the judiciary. In the UK common law – such as the law against "passing off" – can be used instead of seeking damages for the infringement of IPRs.

The structure and functioning of the legal system also matters. Any right is ultimately only valuable if the owner is able to assert that right. The German legal system appears to be (or to have been) much more favorable to the owners of (registered) IPRs than the UK legal system. This is for at least three reasons. First, the German system allows the right owner to choose the forum for the fight, and naturally there is some tendency to choose the courts most favorable to right owners. The UK only has a few specialist courts for IP matters.

Secondly, and particularly for patents, the dual system which hears infringement cases separately from invalidity proceedings favors right owners over defendants. Infringement cases proceed on the assumption that the right is valid. In the UK defendants accused of infringement are more likely than not to counter-claim that the patent is invalid, and the courts do not assume validity. Indeed, analysis by Cremers et al. (2013) shows that, after out-of-court settlements, the most likely outcome for a UK patentee in an infringement case is that the patent is revoked. By contrast, and again excluding settlements, the most likely outcome for a German patentee in an infringement case is that infringement is found.

Third, although the UK system can award punitive damages (which the German system cannot), the cost of litigation in the UK is typically much higher. This raises the bar significantly in terms of the quality of value of intellectual properties that are likely to be defended. It also greatly favors those with deep pockets. If a right owner knows that he/she cannot afford to protect his/her rights, then there is less incentive to obtain the right in the first place.

Interestingly, the UK (or more specifically England and Wales) has recently been reformed, with the Patents County Court becoming the Intellectual Property Enterprise Court in October

2013. These changes are intended to make justice more accessible – the cost of cases is capped, as are maximum damages; but it will also make justice less thorough, increasing the chances that invalid rights are upheld. These changes were made after our period of study, and it will be interesting to observe whether they influence behavior. During the period of our study, the incentives to register IPRs were greater in Germany than the UK, especially for properties of low to moderate values. It was therefore to be expected that German firms would register more; the interesting question is how much more.

Because Germany and the UK host different populations of firms, the demographics of which are at least partially attuned to the variant of capitalism that operates in each country, we opted for a matched pairs approach. This ensured that each German firm in our dataset was "twinned" to the nearest UK firm on a set of observed characteristics, including age, size, labor productivity, and industry sector. Partly because they are difficult to observe, we did not match firms on other characteristics, such as sources of finance, or labor force characteristics that the varieties of capitalism literature considers salient.

We find that, after matching, German firms tend to make, as expected, greater use of registered forms of IP protection: this is true of patents, trademarks and design rights – but that in general the absolute size of the differences is small. German firms are especially more likely to register patents and designs, and to register more of these, with the largest absolute difference being for national patents, the instrument for which the difference in the legal systems is probably most favorable to owners in Germany relative to those in the UK. Because German firms are, in general, both more likely to register intellectual property, and to register larger numbers of each type, they tend to have larger IPR portfolios than comparable UK firms.

A more detailed analysis found that the differences in IPR filing propensities and the numbers of rights filed are, perhaps unsurprisingly, greatest in the high- and medium high-tech sectors. Differences, especially in the number of registrations, tend to be much smaller in low-tech manufacturing sectors and services. Also notable is that the differences between German and UK firms are much more pronounced among large firms. Unfortunately, we do not and cannot know to what extent the observed differences between German and UK firms are due to differences in their productivity of creating "pieces" of registrable intellectual property, and to what extent German firms tend to register more IP because they have greater incentives to do so. We suspect that, among this matched sample of firms (which are not wholly representative of the firms in

each country), the latter explanation is more important. One possible way to examine this in future research would be to match our matched sample to the German and UK innovation surveys, and compare their reported innovation activities, including the share of sales arising from innovative products. However, such comparisons may be problematic, as innovation survey data is subjective, and it is possible that different understandings of innovation may prevail in both countries.

Very interesting findings that arise from our study are that the differences between German and UK firms in the use of EU-wide Community Trade Marks and Registered Community Designs are in general small, and even statistically insignificant. While the use of these instruments is presumably biased towards firms that are, or wish to be, active in several European countries as opposed to confining themselves to their domestic markets, the finding that German and UK firms are behaving in similar ways with regard to these "single market" instruments (and in more similar ways than with yet to be harmonized patents) indicates that the European Commission has succeeded in introducing instruments which are not favorable to businesses that originate from quite different institutional contexts. Another interpretation is that it shows that when institutions are harmonized, firms' observed behavior (after controlling for other observed characteristics) will converge.

Ultimately, the European Commission has a major challenge in creating a single set of rules which are a necessary underpinning for a single market. This is particularly challenging because, like the advocates of rugby union and rugby league, each tribe tends to celebrate the apparently positive aspects of their game, and the set of rules that underpin this, while placing less value on the features valued by the other side. With regard to IPRs, the UK system is less likely to be granting rights (and therefore creating properties) which are invalid, but access to justice has been expensive, and the system favors the rich. The German system, by contrast, is more likely to grant rights for low value properties, and to uphold rights which, if subject to scrutiny, would be found invalid. Justice is more accessible, but less thorough, and tends to favor right owners. Although not as open to strategic abuse as the U.S. system (largely because punitive damages are not permitted), it is more open to abuse than the UK system (to date). The delay in introducing a European patent is understandable in light of the difficulty in finding common ground. What is clear is that the use of IPRs as indicators of innovation performance is extremely hazardous.

7. Conclusions

This paper examines the extent to which firms in two different, but possibly converging contexts (Germany and the UK) behave similarly or differently with regard to their use of registrable intellectual property rights (IPRs). We find that overall, and after matching firms, German firms still make greater use of IPRs, but that the absolute differences are modest. However, especially in high-tech and medium high-tech sectors, German firms are likely to have considerably larger IPR portfolios. We suspect that (after controlling for observed firm characteristics) these differences have more to do with incentives to register IPRs than the fecundity of firms in Germany and the UK to produce "pieces" of intellectual property. In future work we will aim to further explain these differences, possibly by linking the data to innovation survey data, which would enable us to see whether observed differences in the use and extent of use of registered intellectual properties is linked to innovation performance, and especially the share of sales attributed to innovations. If that exercise were to find that UK firms also have an innovation performance deficit, then it begs the question how they are managing to keep up in terms of productivity while being less innovative.

Notable among our findings is that German and UK firms are making similar use, and extent of use, of "harmonized" European instruments, including the Community Trade Mark and Registered Community Design. Institutional harmonization appears to encourage behavioral convergence.

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Figures and Tables

Figure 1: Activity gaps by company size and industry sector (pooled over years)

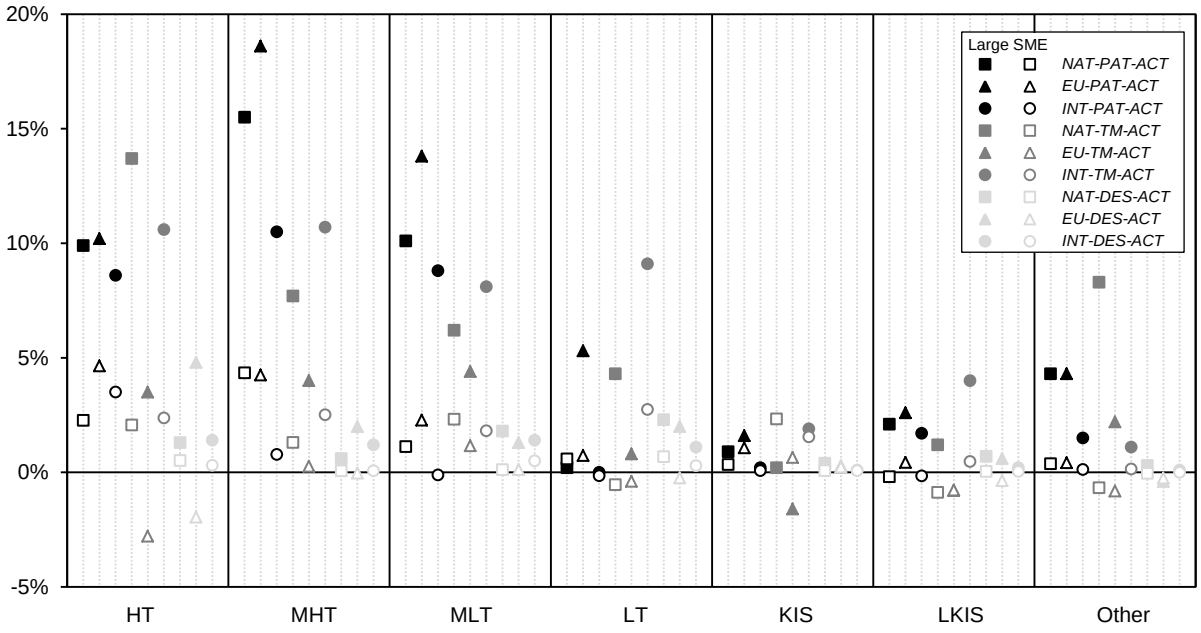

Figure 2: Count gaps by company size and industry sector (pooled over years)

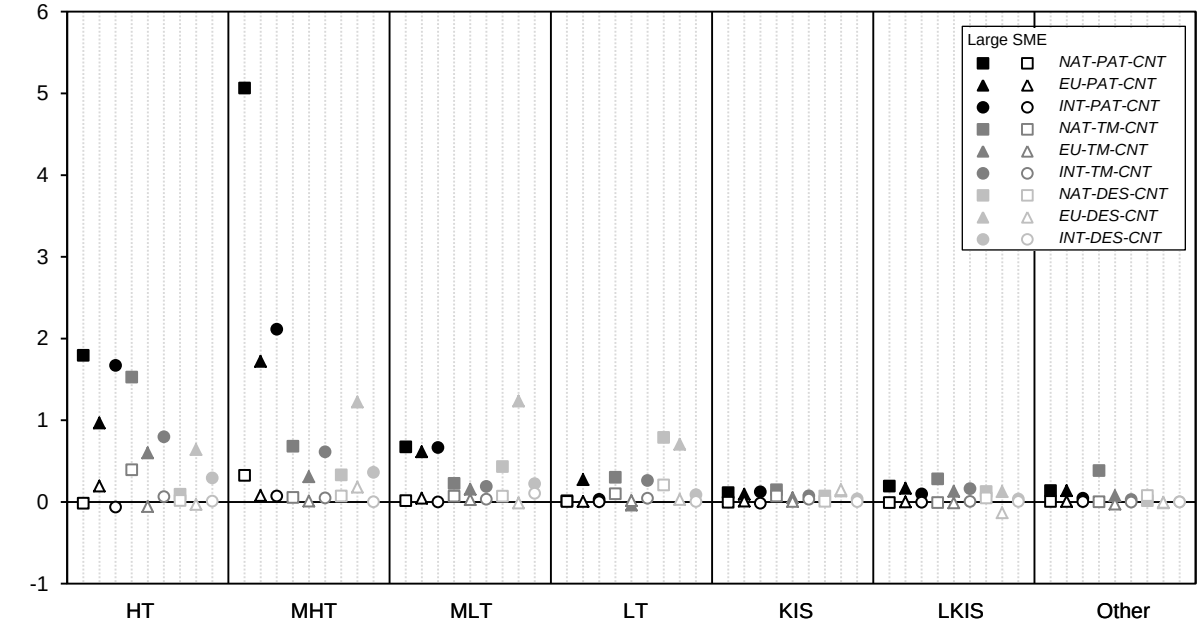

Table 1

Matching protocol

Step 1	Estimate a probit model to obtain the propensity scores.
Step 2	Restrict the sample to common support
Step 3	Estimate the counterfactual outcomes within subgroups of industries: a) Choose one observation from the subgroup of German firms and delete it from that pool. b) Calculate the Mahalanobis distance between this firm and all UK firms in the same industry to identify the most similar control observation. Do not remove the selected controls from the pool of potential controls. c) Repeat a) and b) for all observations in the subgroup of German firms. d) Using the matched sample, calculate the difference in proportions of binary outcomes and, respectively, the difference in means of continuous outcomes between the two groups.
Step 4	e) Compute overall activity and count gaps by aggregating industry-specific gaps weighted by the number of matched pairs formed in each industry.

Table 2

Descriptive statistics of the baseline sample, time-averaged (2006-2011)

Description	Variable	DE N=9,696		UK N=14,547		Diff. of means	Relative diff. of means
		Mean	s.d.	Mean	s.d.		
Filing probability (per year):							
National patents	NAT-PAT-ACT	0.054	0.179	0.020	0.097	0.034***	2.65
European patents	EUR-PAT-ACT	0.048	0.170	0.008	0.058	0.041***	6.40
International patents	INT-PAT-ACT	0.047	0.171	0.021	0.107	0.026***	2.26
National trademarks	NAT-TM-ACT	0.093	0.209	0.070	0.171	0.024***	1.34
European trademarks	EUR-TM-ACT	0.059	0.170	0.050	0.147	0.010***	1.19
International trademarks	INT-TM-ACT	0.046	0.150	0.014	0.074	0.031***	3.20
National designs	NAT-DES-ACT	0.008	0.061	0.003	0.035	0.005***	2.52
European designs	EUR-DES-ACT	0.020	0.107	0.012	0.074	0.008***	1.68
International designs	INT-DES-ACT	0.003	0.040	0.000	0.004	0.003***	34.00
Number of filings (per year):							
National patents	NAT-PAT-CNT	0.974	24.891	0.066	0.988	0.908***	14.86
European patents	EUR-PAT-CNT	0.380	6.723	0.037	1.555	0.343***	10.25
International patents	INT-PAT-CNT	0.707	18.295	0.099	1.480	0.608***	7.17
National trademarks	NAT-TM-CNT	0.438	3.478	0.209	1.245	0.229***	2.10
European trademarks	EUR-TM-CNT	0.212	1.757	0.122	0.612	0.091***	1.74
International trademarks	INT-TM-CNT	0.166	1.707	0.029	0.243	0.137***	5.79
National designs	NAT-DES-CNT	0.157	2.451	0.020	0.406	0.137***	8.04
European designs	EUR-DES-CNT	0.404	5.339	0.084	1.563	0.320***	4.83
International designs	INT-DES-CNT	0.086	2.562	0.000	0.018	0.086***	286.00
Revenues (1000 EUR)[a]	LREV	11.042	1.343	10.642	1.323	0.400***	1.04
Employees (1000s)[a]	LEMPL	5.318	1.509	5.086	1.495	0.232***	1.05
Company age (yrs+1)[a]	LAGE	3.232	0.910	3.025	0.815	0.207***	1.07
Group dummy[b]	GROUP	0.878	0.328	0.943	0.231	-0.066***	0.93
Industry dummies[b,c]							

***(**,*) indicates a significance levels of 0.1% (1%, 5%) based on two-tailed t-tests on difference of means

[a] Means and standard deviations of the log are shown for these variables.

[b] No time-series data was available for group and industry dummies. Values as reported in ORBIS (October 2013).

[c] Industry dummies (NACE, 2-digit level) are not presented. With few exceptions, the means of these 61 variables differ significantly across groups, too.

Table 3

Common support analysis

	2006	2007	2008	2009	2010	2011
Matched pairs	9,487	9,504	9,524	9,543	9,546	9,519
DE firms off support	2.2%	2.0%	1.8%	1.6%	1.5%	1.8%

Table 4

Standardized bias [%] of covariates before (i) and after (ii) matching

Variable	2006		2007		2008		2009		2010		2011	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
LREV	19.5	3.0	23.1	3.7	37.5	5.8	32.7	5.2	31.7	4.4	31.2	4.3
LEMPL	13.6	1.2	13.6	1.2	13.9	1.9	16.4	2.2	16.8	1.6	17.1	1.3
LAGE	23.2	1.8	23.6	2.4	23.9	3.5	24.1	4.0	24.4	3.9	24.6	4.2
GROUP	-23.2	-0.1	-23.2	-0.1	-23.2	0.0	-23.2	-0.5	-23.2	-0.5	-23.2	-0.1

Note: The distribution of firms across industries is identical after matching.

Table 5

Matching results: activity gaps

Variable	2006	2007	2008	2009	2010	2011
NAT-PAT-ACT	0.026***	0.025***	0.024***	0.025***	0.028***	0.023***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
EUR-PAT-ACT	0.035***	0.036***	0.040***	0.036***	0.031***	0.033***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
INT-PAT-ACT	0.015***	0.018***	0.021***	0.018***	0.012***	0.012***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
NAT-TM-ACT	0.031***	0.023***	0.025***	0.024***	0.002	0.001
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
EUR-TM-ACT	-0.004	-0.002	0.005	0.002	0.004	0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
INT-TM-ACT	0.028***	0.034***	0.035***	0.025***	0.026***	0.028***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
NAT-DES-ACT	0.004***	0.004***	0.005***	0.005***	0.002	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
EUR-DES-ACT	0.003	0.001	0.007***	0.005**	0.000	0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
INT-DES-ACT	0.002***	0.002***	0.003***	0.003***	0.004***	0.004***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)

Note: Standard errors in parentheses. ***(**,*) indicates a significance levels of 0.1% (1%, 5%) based on McNemar's test.

Table 6

Matching results: count gaps

Variable	2006	2007	2008	2009	2010	2011
NAT-PAT-CNT	0.455***	0.400***	0.460**	0.463*	0.493**	0.465*
	(0.119)	(0.115)	(0.162)	(0.186)	(0.180)	(0.191)
EUR-PAT-CNT	0.236***	0.228***	0.229***	0.199***	0.194***	0.202***
	(0.030)	(0.029)	(0.031)	(0.028)	(0.026)	(0.026)
INT-PAT-CNT	0.277***	0.266***	0.216***	0.204***	0.205***	0.226***
	(0.065)	(0.067)	(0.051)	(0.048)	(0.053)	(0.054)
NAT-TM-CNT	0.257***	0.272***	0.231***	0.161***	0.104***	0.046
	(0.044)	(0.052)	(0.043)	(0.033)	(0.028)	(0.026)
EUR-TM-CNT	0.020	0.039	0.057*	0.082***	0.093***	0.069***
	(0.021)	(0.021)	(0.026)	(0.019)	(0.014)	(0.018)
INT-TM-CNT	0.117***	0.126***	0.133***	0.098***	0.106***	0.100***
	(0.020)	(0.019)	(0.021)	(0.016)	(0.015)	(0.012)
NAT-DES-CNT	0.152***	0.130**	0.170**	0.115***	0.121**	0.071**
	(0.037)	(0.042)	(0.054)	(0.029)	(0.044)	(0.026)
EUR-DES-CNT	0.156*	0.150*	0.256***	0.245***	0.205**	0.144*
	(0.062)	(0.062)	(0.069)	(0.062)	(0.065)	(0.059)
INT-DES-CNT	0.043**	0.053*	0.074*	0.041***	0.060**	0.082**
	(0.016)	(0.024)	(0.036)	(0.011)	(0.019)	(0.029)

Note: Standard errors in parentheses. ***(**,*) indicates a significance level of 0.1% (1%, 5%) based on paired t-tests.