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Market size, institutions, and the value of rights provided by patents

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Abstract

Despite the centrality of incentives for innovation in models of economic growth, there is little systematic evidence that the value of technologies varies with market size and institutional arrangements. This paper presents micro-evidence indicating that the value of patent rights for a given technology show substantial variation across countries. A large part of this variation can be attributed to market size and institutional arrangements. We estimate the value of patent rights by exploiting the validation behavior of holders of European Patents granted in 2004. We control for unobserved patent and country characteristics. The mean value of patent rights across countries ranges from 17 thousand euro in Germany to 400 euro in Ireland. The mean value over 16 countries is 9 thousand euro per country. Protection of intellectual property rights and market size seem to explain most of the German advantage. The estimated total value of granted European Patents is 2.6 billion euro in 2004, of which a third are German patent rights.

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1 Introduction

Market size and institutions feature prominently in theories that seek to explain economic growth through incentives provided by intellectual property rights (Romer, 1990; Aghion and Howitt, 1992; Jones, 1995). This paper aims to identify how the implicit research subsidy provided by patents depends on a country's market size and on its institutional characteristics, which shape its human and social capital, and its enforcement of intellectual property rights. Knowing how innovators assess these institutional characteristics is of interest because it can guide policy makers in shaping incentives for innovation.

The impact of market size and institutions on the value of patent rights is difficult to isolate because patents are strongly heterogeneous in terms of the commercial potential of the underlying invention (see for example Silverberg and Verspagen (2007)). We exploit a particular characteristic of European Patents to identify how the value of a single patent varies with country and industry characteristics. Once a European Patent has been granted, the holder of the patent has the choice to validate the patent in member states of the European Patent Convention (EPC). The patent-holder might choose not to validate his patent in a country if the cost of validation (validation fees, translation costs, and future renewal fees) are larger than the expected benefits of having a patent right in that country. We use these validation decisions to simultaneously infer the value of the patent right in particular countries and the factors that influence this value. We present a theoretical model of validation behavior that forms the basis of the empirical analysis.

The evidence shows that potential demand influences the validation decision, and by inference, the value of the patent. We find that the value of patent rights is positively related to the potential demand for the underlying invention, i.e., the larger the market the more valuable the patent is. Potential demand is approximated by two variables. The first variable is market size measured in value added of the sectors in which the patent can be used. The second variable is the average education level in the sectors of use.

Sectors that employ a higher educated workforce are more likely to demand advanced and recent technologies.

Besides potential demand, also the need for protection against infringement determines the value of patent rights. We use the level of general trust as an indicator of the inclination to imitate. For example, in high-trust sectors and countries (former) employees, suppliers or customers might be less inclined to steal business secrets. The (perceived) degree of protection in a country is positively related to the value of patent rights.

Validation costs for individual patents are approximated using the number of pages with claims for all European Patents granted in 2004. Validation costs are central to our analysis for two reasons. First, without validation costs, we would not be able to compute a monetary value for patent rights. We use validation costs in a similar way as Pakes and Schankerman (1984) and Schankerman (1998) use renewal fees to derive the value of patents. Second, validation costs of European Patents are very high compared to national patent systems and vary substantially between countries, primarily due to differences in translation requirements (Harhoff et al., 2009).

We find that the variation in the mean value of patent rights is substantial, ranging from 17 thousand euro in Germany to 400 euro in Ireland. Taking Germany as a benchmark country, we find that the most important factors contributing to this variation are the unobserved institutional differences and market size. The estimated total value of European Patents granted in 2004 is 2.6 billion euro. If all countries would have the same characteristics as Germany, then the aggregate value would rise to 15 billion euro.

We confirm earlier results that the distribution of patent rights is highly skewed. This property has been discussed in detail by other authors, e.g. Pakes and Schankerman (1984), Pakes (1986), Griliches (1990), and Silverberg and Verspagen (2007).

Our empirical specification is derived from a theoretical model of validation behavior. We model the validation decision as the outcome of a three-stage game. In the first stage the incumbent firm decides on validation, in the second stage competing firms decide on entering the market, and in the third stage the incumbent decides whether to litigate or not if its patent is infringed by the entrant(s). The model is related to other models of patent litigation by Bessen and Meurer (2006) and Galasso and Schankerman (2010).

Three strands of literature are closely related to our work. First there is the literature on patent value estimation using patent renewal data as initiated by Pakes and Schankerman (1984), who developed a model where the returns to protection evolve deterministically over time of a patent. Payment of renewal fees implies that the patent value is larger than the fee required to keep it in force, which in turn reveals the implicit value of the patent. Versions of this model have been applied by Schankerman and Pakes (1986), Sullivan (1994), and Schankerman (1998). A stochastic version of this model has been formulated by Pakes (1986) and has been applied by Lanjouw (1998), and Lanjouw et al. (1998). However, as remarked by Bessen (2008), many other factors influencing patent value are not explored in this context.

The second line of research is concerned with the impact of intellectual property rights and R&D on the valuation of firms by stock markets. **?** have shown that the market value of Australian firms–and by implication their ability to attract funding–is positively related to their patenting activity. **?** find that the market valuation of R&D is lower in more competitive sectors. In addition, their results suggest that not all patents are equally valuable: European Patents are positively related to the market value of firms, while UK patents seem to have no effect.

A third strand of literature related to our work uses proxy variables of patent value. These studies look, for example, at survey measures of subjective value of patents (Silverberg and Verspagen, 2007; Harhoff et al., 1999), the filing of opposition to and / or litigation of patents (Harhoff et al., 2003; Lanjouw and Schankerman, 2004), number of filed countries (Lanjouw and Schankerman, 2004), firm market value (Hall et al., 2005) and citations (Trajtenberg, 1990; Hall et al., 2005). Each of these indicators individually is not likely to lead to the best possible approximation of patent value. Studies combining various patent characteristics and renewal data, such as Bessen (2008), claim that patent citations explain little variance in value suggesting that citations are of limited use as a measure of patent quality.

This paper contributes to these strands of literature by estimating the value of granted European Patents using the validation behavior of its owners. Once a European Patent has been granted, the owner has to decide in which Member States of the European Patent Convention[1] (EPC) she wants to validate the patent. Besides payment of validation and renewal fees for each of the selected countries, the owner also has to incur substantial costs for meeting translation requirements. These costs summed up are called validation costs and differ across countries and patents. The expected value of validation in a particular country also varies across countries and patents. By assuming that a patent owner will only validate a patent in countries for which the expected benefits outweigh the validation costs, we can identify the value of patent rights that are validated in some countries but not in others. In this way, we explicitly estimate the value of the patent itself (as a right) and not the value of the underlying invention–even though the underlying value is important for the value of the patent.

Our sample includes the validation decisions for all European Patents granted in 2004 and for 16 major EPC countries[2]. Validation decisions are modeled as a binary choice and are estimated by penalized partial likelihood (McGilchrist and Aisbett, 1991; Duchateau and Janssen, 2008). We take the net present value of validation as a latent variable. If a patent is validated in a particular country, then we assume that the validation value for that particular patent-country combination exceeds the cost of validation. The cost of validation are treated as given and the benefits of validation are estimated by including indicators for market size, education, trust, and distance as regressors.

We can control for (unobserved) patent characteristics as we observe 16 validation decisions per patent, one for each country in our sample. Patent fixed effects are taken into account by conditioning on the number of countries a patent is validated in. This

[1] See Appendix for the current members of the European Patent Convention

[2] Austria, Belgium, Denmark, Finland, France,Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom

resembles the logit fixed effects estimator of Chamberlain (1980). Country characteristics are modeled as random effects, such that we can include regressors that only vary at the country level. Random effects are implemented by introducing a penalty function in the partial likelihood estimator McGilchrist and Aisbett (1991). There are two reasons to control for unobserved patent and country characteristics. First, controlling for patent effects will avoid that residuals will be clustered by patent because of patent heterogeneity, and adding country effects will avoid clustering by country caused by a.o. country-specific regressors. Avoiding clustering prevents that estimates of coefficients and standard errors are biased. Second, the patent effects can be used to infer the distribution of the value of patents. Similarly, the country effects can be used to compare a country's attractiveness for IPR conditional on market size, education, and trust.

Data on validation of European Patents are taken from the European Patent Office's (EPOs) INPADOC Legal Status database, other data on patents come from the EPOs PATSTAT data. A patent-country specific indicator of market size is constructed by using the OECD Technology Concordance (OTC) to link IPC codes with 4-digit industry data from OECDs STAN database. Education and trust data stem from the European Social Survey and are linked to patents using the OTC at the 2-digit industry level. Translation costs are approximated taking into account the number of pages with claims on each patent. Renewal and validation fees are extracted from the Official journal and the National Law relating to the EPC.

The paper is organized as follows. The next section presents a model of the validation decision. Section 3 introduces the empirical strategy and the data are described in Section 4. Section 5 presents the baseline estimation results and robustness analysis. The estimation results are used to infer the value of patent rights in Section 6. The last section summarizes the main results.

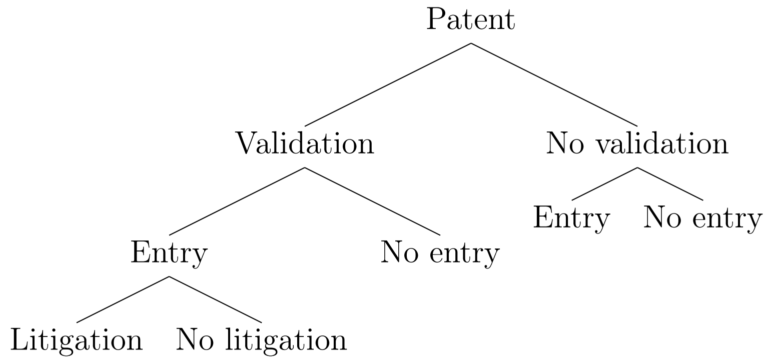


Figure 1: Validation game

2 A model of validation choice

A firm has invented a new product and has patented part of it, while keeping another part of the invention secret. After the patent has been granted, the firm has to decide in which countries it will validate the patent. A firm will validate in a particular country if the benefits of legal protection offered by validation in that country outweigh the validation fee and (additional) translation costs. The benefits of legal protection depend on the expected increase in operating profits if exclusivity is maintained and on the strength of legal protection if the patent is infringed. (Operating profits are assumed to be zero if a firm does not want to be active in a particular country regardless of the costs of legal protection.) We assume that the firm makes the decision to validate in a particular country independently from validation decisions for other countries and independently from validation decisions by other firms.[3]

We model the validation decision as the outcome of a three-stage game. In the first stage the incumbent firm decides on validation, in the second stage competing firms decide on entering the market, and in the third stage the incumbent decides whether to litigate or not if its patent is infringed by the entrant(s). The three stages are illustrated in Figure 1.

[3]Firms may consider the (validation) behavior of competitors when making validation choices. For example, a firm may validate in a competitor's market without the intend to actually produce or sell in this market. Another example is that firms may collude and agree not to validate in eachother's markets.

2.1 Single entrant

Without entry by a competitor, the incumbent makes a monopoly operating profit π_m; with entry, the entrant and the incumbent form a (Cournot) duopoly in which both firms have the same operating profit π_d. Entry requires the entrant to invest e in imitating the incumbent's product. Validation costs for the incumbent are f. Let ϕ be the probability that litigation is successful and the incumbent retains the exclusive right to sell its product and let the costs of litigation be l. The legal costs are borne by the party that lost the case. We describe the decisions in each stage in reverse order:

Stage 3. The incumbent will respond to infringement by litigating if the expected value of litigation is positive, $\phi\pi_m + (1-\phi)(\pi_d - l) \geq \pi_d$.

Stage 2. The competitor enters the market if:

1. the incumbent refrained from validating the patent and the entrant's profits are at least as large as the costs of imitation $\pi_d \geq e$, or
2. the incumbent validates the patent and expected value of entry followed by litigation exceeds imitation costs, $(1-\phi)\pi_d - \phi l \geq e$.

Stage 1. The incumbent chooses validation if:

1. litigation is credible, validation deters entry, and monopoly profits minus validation costs exceeds duopoly profits, $\pi_m - f \geq \pi_d$, or
2. litigation is credible, validation does not deter entry, and the expected profits of litigation minus validation costs exceed duopoly profits, $\phi\pi_m - (1-\phi)(\pi_d - l) - f \geq \pi_d$

The three choices (validation, entry, litigation) imply five different outcomes that are consistent with profit-maximizing behavior. Table 1 lists the combination of decisions for each of the potential outcomes (Cases 1 to 5). The last column shows whether litigation is credible

Table 1: Potential outcomes validation game

Case	Validation	Entry	Litigation	Litigation credible?
1. Entry is barred	no	no	no	irrelevant
2. Entry is deterred	yes	no	no	yes
3. Entry despite validation	yes	yes	yes	yes
4. Non-credible litigation	no	yes	no	no
5. High validation costs	no	yes	no	irrelevant

Validation will never be chosen if entry costs are prohibitive ($e > \pi_d$) or if validation costs are too high ($f > \pi_m - \pi_d$). When entry costs are high there is no threat of entry, such that the incumbent has no incentive to validate. This is Case 1. The incumbent will also choose not to validate if the maximum reduction in its profits due to entry is smaller than the costs of validation (Case 5). These cases are corner outcomes and do not involve strategic interaction. Combing both conditions, there will be an interior solution if $e \leq \pi_d \leq \pi_m - f$.

Validation will deter entry (Case 2) if an interior solution exists and two conditions hold:

1. Entry leads to losses if litigation is certain: $(1 - \phi)\,\pi_d - \phi l < e$,

2. Litigation must be credible: $\pi_d \leq \phi\pi_m + (1 - \phi)\,(\pi_d - l)$.

Validation will only deter entry if duopoly profits are small compared to litigation costs and compared to monopoly profits:

$$\pi_d < \min\left\{\frac{e + \phi l}{1 - \phi},\ \pi_m - \left(\frac{1}{\phi} - 1\right) l\right\} \tag{1}$$

When only the second condition holds, then entry will occur followed by litigation (Case 3). If the second condition does not hold (litigation is not credible), then validation is useless and we end up in Case 4.

Validation only has a positive value in Cases 2 and 3. In Case 2 the value of validation is $\pi_m - \pi_d - f$; in Case 3 the expected value of validation is $\phi\pi_m + (1 - \phi)\,(\pi_d - l) - f - \pi_d$.

Combining the conditions for Case 2 and Case 3, we know that a positive validation value will only occur if validation costs are not prohibitive and litigation is credible.

$$\pi_m - \pi_d > \max\left\{f,\ \left(\frac{1}{\phi} - 1\right) l + \frac{f}{\phi}\right\} = \left(\frac{1}{\phi} - 1\right) l + \frac{f}{\phi} \tag{2}$$

In both Case 2 and 3, the value of validation hinges on the absolute difference between monopoly profits and duopoly profits.

2.2 Multiple entrants

We can generalize the game to allow for multiple entrants. Allowing for multiple entrants implies that a single patent needs to be defended more than once. This requires additional assumptions on how entry affects the probability of successful litigation. We will discuss two extreme assumptions: 1) probability of success is independent of earlier trials and 2) trial outcomes are identical to the outcome of the first trial.

If the probability of success is independent of the outcomes of earlier trials, then the conditions under which litigation is credible become more strict. Suppose there are k potential entrants and entry is sequential. Let π_n be the operating profits when n firms are active in the market (such that $\pi_m = \pi_1$ and $\pi_d = \pi_2$). The conditions for Cases 1 and 2 remain essentially unaltered, while the condition for Case 5 changes into $f > \pi_m - \pi_n$. When entry costs permit the entry of just one firm, the incumbent has to win k cases in order to secure its monopoly. The expected value of litigation for the incumbent depends on the number of *potential* entrants:

$$\phi^k \pi_m + \left(1 - \phi^k\right)(\pi_d - l) \tag{3}$$

A larger number of potential entrants imposes stricter conditions on the credibility of litigation. This effect will be stronger if the market supports more than two firms.

Suppose now that trial outcomes are identical to the outcome of the first trial. If the incumbent wins, then no firm will enter the market, while if the incumbent loses then all firms enter the market provided that operating profits remain large enough to cover entry costs ($\pi_n \geq e$). The expected value of litigation depends on the number of *active* firms in the market:

$$\phi\pi_m + (1-\phi)(\pi_n - l) \tag{4}$$

2.3 Empirical operationalization

Assuming that the first trial completely determines the outcomes of later trails and assuming $k \geq n$, the game gives us some simple solutions that can be operationalized empirically in a straightforward manner. As $k \geq n$, entry costs will be binding and $\pi_n \approx e$. The expected value of validation now equals $\pi_m - e - f$ in Case 2 and $\phi\pi_m + (1-\phi)(e-l) - f$ in Case 3. The incumbent's validation decision is positively related to monopoly profits and legal certainty, and is negatively related to validation and litigation costs and entry barriers:

$$\pi_m - e > \max\left\{f,\ \left(\frac{1}{\phi}-1\right)l + \frac{f}{\phi}\right\} \tag{5}$$

As the majority of granted patents are never defended in court (Case 3 is rather rare), we can assume that $\pi_m - e > f$ for most patents. We will use this condition as the backbone of the empirical analysis.

3 Empirical strategy

Validation cost f can be approximated using data on the language of the patent and the number of pages with claims (see section 4), but we can not observe the expected value of validation $\pi_m - e$ directly. Instead, we treat $\frac{\pi_m - e}{f} \equiv v^*$ as a latent variable. If patent i is validated in country j, then we assume that the expected value of validation outweighs the validation costs:

$$v_{ij} = 1 \quad \text{if} \quad v^*_{ij} > 1$$
$$v_{ij} = 0 \quad \text{if} \quad v^*_{ij} \leq 1 \tag{6}$$

We let v^*_{ij} depend on validation costs, a set of variables related to profits and entry barriers, denoted by $\mathbf{x}$. We hypothesize that the expected benefits from validation are positively correlated with market size and education in the sector of use of the validated country. A larger market size in the sector of use implies greater potential demand for the products that make use of the patent. Education in the sector of use is a second indicator of the demand potential as a better educated workforce is likely to use more advanced and more recent technology.

We expect that the benefits of validation will be lower in countries and sectors with a high degree of trust. If people – notably former employees – are less tempted to steal business information, then there will be a smaller incentive for firms to seek formal protection of their intellectual property. Lastly, the incentive for validation is higher in countries and sectors where the (perceived) enforcement of intellectual property rights is stronger.

It is well-known that the value of patent rights varies wildly, but there is less agreement on the shape of the distribution of these values. As high-value patents are likely to be validated in more countries than low-value patents, we allow for patent fixed effects α_i. Unobserved differences across countries are captured by the country effects γ_j. As our indicators of IPR enforcement vary only at the country level, we treat the country effects as random effects in most regressions. Hence,

$$v^*_{ij} = \exp\left(\alpha_i + \mathbf{x}_{ij}\beta + \gamma_j\right) / f_{ij} \tag{7}$$

The vector of coefficients β and the patent and country effects are estimated with a binary choice model.

$$\Pr\left(\ln v_{ij}^{*} > 0|\mathbf{x}_{ij}\right) = F\left(\alpha_i + \mathbf{x}_{ij}\beta + \gamma_j - \ln f_{ij}\right) \tag{8}$$

Here, F is the cumulative distribution function of the residuals.

We treat the patent and country effects in different ways as the number of patents is very large and the number of countries is very small. The patent effects are taken into account by using a partial likelihood estimator. We assume that the residuals have a logistic distribution, such that integration of the partial likelihood function is straightforward. The advantage of this method is that no particular distribution is assumed for the patent effects: finding the distribution of the value of patent rights is interesting in its own right.

Patents with a large α_i are likely to be validated in more countries than patents with a small α_i. The fixed effects can be controlled for by conditioning the probability of validation of patent i in country j on the number of countries the patent is validated in ($\sum_j v_{ij}$).

$$\Pr\left(\ln v_{ij}^{*} > 0|\mathbf{x}_{ij}, \sum_h v_{ih}\right) = \prod_j \frac{\Pr\left(\ln v_{ij}^{*} > 0|\mathbf{x}_{ij}\right)}{\sum_h \Pr\left(\ln v_{ih}^{*} > 0|\mathbf{x}_{ih}\right)} \tag{9}$$

Using these conditional probabilities of validation, the partial likelihood function becomes:

$$\mathcal{L}\left(\beta, \alpha|\gamma, \mathbf{x}\right) = \prod_{ij} \frac{\Pr\left(\ln v_{ij}^{*} > 0|\mathbf{x}_{ij}\right)}{\sum_h \Pr\left(\ln v_{ih}^{*} > 0|\mathbf{x}_{ih}\right)} \tag{10}$$

The partial likelihood no longer depends on the α_i and can be written as:

$$\mathcal{L}\left(\beta, \alpha|\gamma, \mathbf{x}\right) = \mathcal{L}\left(\beta|\gamma, \mathbf{x}\right) = \prod_{ij} \frac{\exp\left(\mathbf{x}_{ij}\beta + \gamma_j - \ln f_{ij}\right)}{\sum_h \exp\left(\mathbf{x}_{ih}\beta + \gamma_h - \ln f_{ih}\right)} \tag{11}$$

Maximization of this likelihood function is straightforward for given country effects.

The country effects are treated as random effects and are estimated by maximizing a penalized partial likelihood. Country effects are taken into account by conditioning on the number of patents that are validated in country j in similar way as the patent effects were controlled for by conditioning on the number of countries a patents is validated in. The main difference is that we impose that the country effects have a Gaussian distribution with mean zero and variance δ. This restriction takes the form of a penalty function.

The penalized partial log likelihood function $l_{ppl} \equiv \ln \mathcal{L}_{ppl}$ consists of two parts: a partial log likelihood l_{part} and a penalty function l_{pen}:

$$l_{ppl}\left(\beta,\, \gamma,\, \delta|\mathbf{x}\right) = l_{part}\left(\beta,\, \gamma|\mathbf{x}\right) - l_{pen}\left(\gamma,\, \delta\right) \tag{12}$$

The partial likelihood is the likelihood conditional on the patent *and* country effects.

$$l_{part}\left(\beta,\, \gamma|\mathbf{x}\right) = \sum_{ij}\left(\eta_{ij} - \ln\left(\sum_{h}\exp\eta_{ih}\right)\right) \tag{13}$$

$$\eta_{ij} \equiv \mathbf{x}_{ij}\beta + \gamma_j - \ln f_{ij} - \ln\sum_{h}\left(\mathbf{x}_{ih}\beta + \gamma_h - \ln f_{ih}\right)$$

The penalty function imposes a normal distribution on the country effects.

$$l_{pen}\left(\gamma,\, \delta\right) = \frac{1}{2}\sum_{j}\left(\frac{\gamma_j^2}{\delta} + \ln\left(2\pi\delta\right)\right) \tag{14}$$

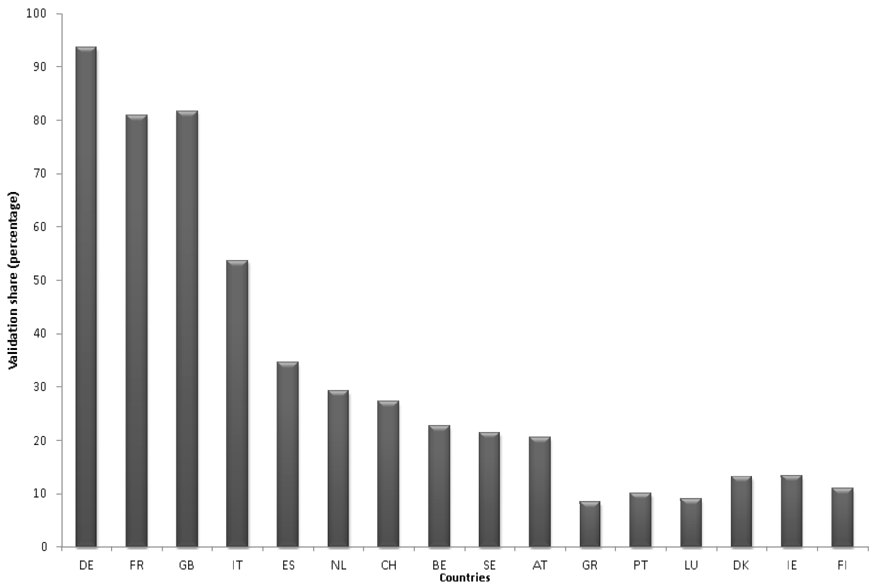
Maximization of the penalized partial log likelihood consists of an inner and an outer loop. In the inner loop, the β and γ are estimated for a given value of δ. In the outer loop, δ is estimated by restricted maximum likelihood given the estimates of γ. Details of the estimation procedures are described in Duchateau and Janssen (2008, Ch. 5).

4 Data

The empirical analysis relies on disaggregated data on the legal status database and the PATSTAT produced by the EPO. From the EPO Legal Status database we extract patent lapses and the countries in which the owner wants its European Patent to be validated. The PATSTAT database provides information on grants, IPC classifications, etc. The sample contains 56,980 patents granted by the EPO in 2004 and validated in at least one of the sixteen major EPC Member States.[4] The independent variables are described hereafter.

Validation Validation is a binary variable which is one if a patent has been validated in a country. To construct this variable the following assumptions are made[5]: (i) when renewal fees have been paid for a particular patent or if it lapses, then it is assumed that this patent initially had been validated in that country; (ii) if a patent lapses in a particular country within 365 days after grant, then this patent is considered as lapsed ab initio in that country. In other words, these patents are considered to have never been validated in that country.

Figure 2: Validation shares in EPC contracting states of European Patents granted in 2004



[4]The 16 countries of validation are Austria (AT), Belgium (BE), Switzerland (CH), Denmark (DK), Finland (FI), France (FR), Germany (DE), Greece (GR), Ireland (IE), Italy (IT), Luxembourg (LU), Netherlands (NL), Portugal (PT), Spain (ES) and Sweden (SE). Other EPC countries that have joined the EPC before 2004 are left out of the sample since they are still in the start-up phase.

[5]These assumptions are similar to those made in Harhoff et al. (2009) to analyze the patent validation flows between applicant and validation countries.

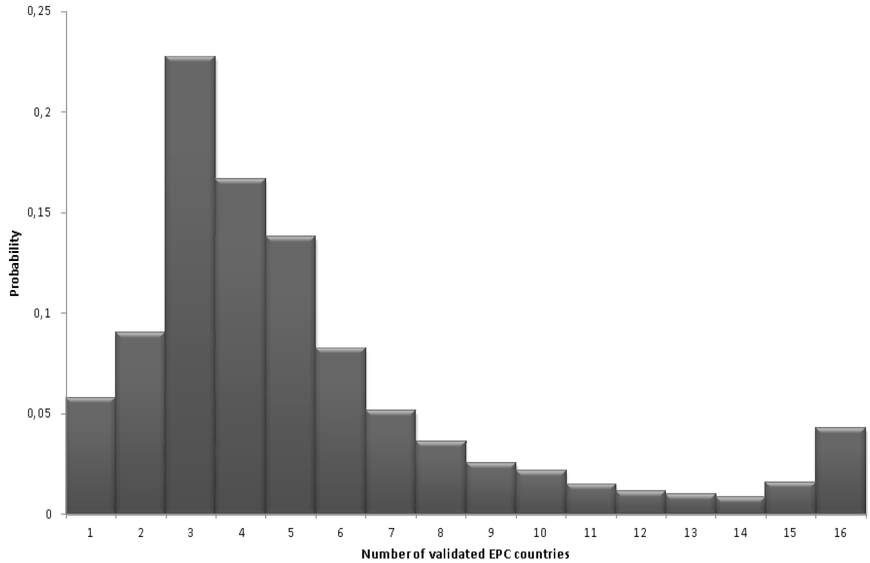
Figure 2 shows the validation shares of granted European Patents in 2004. In 2004, about 93 percent of all granted European Patents has been validated in Germany, 81 percent has been validated in France and 82 percent in the United Kingdom. Other contracting states of the EPC have lower validation shares. Different trends related to country size and EPC membership duration can be observed over time. At first, the larger countries Germany, France and United Kingdom have had high validation shares from the start of the EPC onwards. Other founding member states like the Netherlands, Belgium and Sweden show declining proportions of European Patents being validated at a steady pace. Late adopters of the EPC like Spain, Greece, Portugal and Denmark converge towards a more or less constant validation share. Straathof and van Veldhuizen (2010) argue that low validation rates reduce technological competition within the EU and make individual countries less attractive for foreign innovators.[6]

The value of an European Patent and the number of member states in which it has been validated are highly correlated. Figure 3 depicts the distribution of the number of validated countries of European Patents validated in 2004. The distribution is skewed to the right and there is more probability mass at 15 and 16 validated countries. The patents characterized in this part of the distribution are patents of high value which would have been validated in more than 16 countries if possible. Due to the high correlation between the number of validated countries and patent value it is expected that the distribution of patent value follows approximately the same distribution. On average a patent has been validated in 5.3 countries.

Market size Market size of a patent in country j is approximated by the weighted average of country specific production value of 4-digit industries that are associated with the IPC codes assigned to the patent. By denoting y_{ij} as the market size of patent i in

[6] These arguments and the reduction of cost of patenting, are the most important reasons for implementing an EU Patent, see Danguy and van Pottelsberghe de la Potterie (2010) and Straathof and van Veldhuizen (2010).

Figure 3: Distribution of number of validated countries of European Patents granted in 2004



country j, we have

$$y_{ij} = \sum_{\substack{m \in \{IPC\}_i \\ n \in ISIC}} w_{im} \bar{w}_{mn} \bar{y}_{nj} \tag{15}$$

where w_{im} is the weight of IPC code m for patent i[7], $\bar{w}_{mn}$ is the relative frequency with which IPC code m is assigned to ISIC industry n according to the OECD Technology Concordance (Johnson, 2002) and $\bar{y}_{nj}$ is the market size of 4 digit ISIC industry n in country j .

Enforcement of intellectual property rights In the literature a few indicators are available that have gauged the overall strength of the patent system on the country level. Widely used is the Ginarte Park (GP) index (Ginarte and Park, 1997; Park, 2008), which is the unweighted sum of five separate scores for coverage of inventions that are patentable, membership of international treaties, duration of protection, enforcement mechanisms and restrictions. Accordingly, the GP index measures IPR enforcement *de jure*, while we are interested in the *de facto* enforcement of such rights. The GP index shows almost no variation in our data sample and is therefore not very useful.

[7] w_{im} equals one over the number of IPC codes assigned to patent i

Another IPR enforcement indicator is available through the World Economic Forum's Executive Opinion Survey. This indicator resembles the protection of intellectual property including anti-counterfeiting measures per country over the period 2009-2010. It is important to note that this indicator has not been cleaned for generalized trust. The uncorrected indicator shows a reasonable amount of variation over the countries in our data sample. The third indicator we use is the IPR indicator constructed by the Property Rights Alliance (PRA). It is partially based on the GP index, as well as on the World Economic Forum's 2007-2008 Global Competitiveness Index and the US Trade Representative's 2008 Watch List Report.

Education and trust Focusing on IPR there are two relevant measures that shape the business climate on the country-industry level, namely trust and education. It is widely recognized in the social science literature that both measures are highly correlated. That is, general trust levels are higher among higher educated people. From the European Social Survey we have extracted the generalized trust in other citizens variable *ppltrst*[8] and the highest education level variable *edulvl*. The last variable has been transformed into years of education according to international standards. Both variables are measured per country at the two-digit industry level and are weighted in the same way as market size.

Validation and renewal costs The translation costs of a patent are approximated by using the number of pages of the granted patent and translation fees per page. The number of pages per patent are obtained through EPO's Open Patent Services (OPS)[9]. Page counts are reported for both descriptions and claims and refer to the B1 publications of the EPO which have a standard layout. Figures are not included in the page counts for descriptions and claims. For descriptions we assume 875 words per page, while for

[8]The ESS question belonging to this variable: Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people? Please tell me on a score of 0 to 10, where 0 means you can't be too careful and 10 means that most people can be trusted.

[9]`http://www.epo.org/searching/free/ops.html`

claims we assume 630 words per page. These assumptions are based on word counts for a sample of patents. We have divided the number of pages reported by OPS by three as the claims are always listed in English, German, and French. Descriptions are always in a single language (English, German, or French).

Translation fees per page are taken from a survey among attorneys and translation service providers conducted by **?**. We have used the average translation costs reported by attorneys for a page of 325 words with descriptions and for a page of 325 words with claims.[10] Table 2 shows the costs of translating a standard page with descriptions and claims by original language and destination country. According to the Roland Berger survey, translation costs are the same if the original language is German or French in stead of English.

There are two reasons for separating claims from descriptions: 1) translation of descriptions is not always required by the validating country, and 2) translation services and attorneys charge different fee for pages with claims and description pages. If a single translation is required for validation in multiple countries (e.g. a translation form English into German is required for validation in Germany and Austria), then translation costs are allocated to the largest country (e.g. if the patent is validated in Germany, the marginal translation costs when validating in Austria are assumed to be zero). Without this assumption we would substantially overestimate the total cost of validation for smaller countries.

Most countries charge a fee for validating a patent. Besides a fixed fee, some countries charge a fee per page as well if the number of pages of a patent exceeds a threshold. Validation fees are reported in Table 3.

In addition to the immediate costs of validation, we also take into account the expected costs of keeping the patent active in the country of validation. We assume that the expected net present value of renewal fees are equal to the average fees paid in 2004

[10]Translation service providers tend to charge lower translation fees than attorneys. We have used the translation costs provided by attorneys as they perform a legal check of the translation, something a patent holder has to do himself is he used a translation service provider. Translation fees charged by translation service providers underestimate the overall costs of translation.

Table 2: Translation costs and translation filing costs (EUR)

Country	**Translation costs / page**				**Filing costs**
	Descriptions			*Claims*	
	English	German	French		
AT	78	0	78	0	472
BE	78	78	0	0	608
CH	89	0	0	0	591
DE	78	0	78	0	472
DK	107	107	107	107	680
ES	67	67	67	68	695
FI	116	116	116	115	680
FR	78	78	0	0	541
GR	82	82	82	81	629
IE	0	65	65	0	521
IT	72	72	72	73	629
LU	78	0	0	0	608
NL	88	88	88	87	608
PT	78	78	78	77	695
SE	107	107	107	107	680
UK	0	65	65	0	521

Notes: Translation costs are based on the survey among patent attorneys by Roland Berger (2004), which was conducted in 2004 and refers to patents granted in 2002 and 2003. "Country" refers to the country of validation. A page is 325 words. Whether a description needs to be translated depends on the original language and on the validation country. Claims are already available in English, German, and French, such that translation costs for claims only depend on the validation country. Filing costs are per validation country, regardless of the number of pages that are translated.

Table 3: Validation fees (EUR)

Country	Fixed validation fee	Validation fee / page	Page threshold
AT	116.00	25.00	5
BE	0.00		
CH	0.00		
DE	150.00		
DK	148.00	10.78	35
ES	245.24	9.85	22
FI	85.00	10.00	4
FR	35.00		
GR	299.00		
IE	35.00		
IT	10.33		
LU	0.00		
NL	25.00		
PT	91.28		
SE	121.00	17.05	8
UK	0.00		

Notes: Data refer to fees charged in 2003. Some countries charge a validation fee per page if the number of pages of the patent exceeds a threshold. The validation fee does not apply to pages below the threshold, shown in the last column.

for the corresponding country and industry. A limitation of this assumption is that we ignore that patents within a country-industry cell differ in value and thus also differ in their expected lifespan.

5 Estimation results

5.1 Baseline results

We estimate the propensity to validate using four indicators that potentially affect the value of a patent: market size, an dummy variable for validation in the home country, the education level in the sectors in which the patent is used, trust in other people, and an indicator for the level of protection of intellectual property rights (IPR). The baseline specification is build up in five steps, which are reported in Table 4. The baseline specification is repeated for different countries of origin of the (first) applicant (Table 5), and for industries (Table 6).

The results shown in column (1) of Table 4 are obtained using a standard logit estimator. The log of market size in the validating country and the home country dummy are included as regressor and the coefficient on the log validation costs is constrained to -1. Both market size and home country validation are positively related to the propensity to validate a patent.

The model of column (2) takes care of omitted variable bias caused by unobserved patent characteristic using a conditional logit estimator. Adding patent fixed effects leads to a modest increase in the estimated coefficient on market size. Less valuable patents tend to be validated in large markets only. For a given patent, the correlation between validation and market size is therefore expected to be smaller than without fixed effects– rather than larger. The reason why this does not appear in the results reported is that the home bias effect is overestimated in the first regression.

Patents that are validated in a small number of countries are more likely to be held by small firms and are therefore more likely to be validated in the home country. After controlling for patent fixed effects, the coefficient on home country validation decreases and now has a negative sign. A negative sign can be explained be the common observation that firms first apply for a national patent and then proceed with applying for a European Patent–making home country validation sometimes redundant.

A second source of omitted variable bias is due to unobserved country characteristics. In column (3), random country effects are added by employing the penalized maximum likelihood estimator introduced in Section 3. (Results for fixed country effects are reported later on, in Table 8.) This leads to a large drop in the coefficient on market size: from 1.0 to 0.3. There can be two reasons for this adjustment. First, country characteristics that are favorable to validation can be correlated with market size, e.g. large countries may protect intellectual property rights better. Second, including country effects corrects for clustering of standard errors, which would lead to biased coefficient estimates in non-linear models.

In column (4) three regressors are added related to a country's institutions: education and trust in the sector of use, as well as the country-level index for protection of intellectual property rights (IPR). The coefficient on education is positive and significant, which suggests that protection of patents is more valuable in when more people can use a technology. The coefficient on trust is negative and significant, which is consistent with the thesis that formal property rights and informal institutions can be substitutes. The IPR index is not significant. This is not very surprising as this variable only varies at the country level. The last column excludes the IPR index from the regression as it was insignificant. The results are unchanged.

As a measure of goodness-of-fit we use the proportion of correctly predicted (non-)validations, the "hitrate". The hitrate is computed as follows. From the parameter estimations it is rather straightforward to recover α_i. The details of the procedure are described in Section 6. Once the patent fixed effects are known, the value of validating patent i in country j can be computed. Lastly, we assume that validation happens when this value is larger than or equal to the costs of validation. We include both patent and country effects when making predictions. The goodness of fit for the last three models is more than 80 percent, which suggests that the models have a reasonable goodness-of-fit.

5.2 Results by origin of applicant

Next, we compare coefficient estimates across the nationality of the applicant, where we distinguish between EU and non-EU countries, tax havens, the United States, and Japan. Tax havens are included as a separate category since many large firms have their headquarters located in tax havens. The results are reported in Table 5. Applicants from EU countries tend to be more sensitive to market size in comparison with the estimates for the full sample. They seem to be less responsive to home bias, education, and trust. For non-EU countries the reverse applies. Remarkably, the coefficient on market size is small and only slightly significant.

The results for tax havens are comparable to those of EU countries where standard

Table 4: Estimates of the patent validation model

	(1)	(2)	(3)	(4)	(5)
ln(Market size)	0.91***	1.0***	0.25***	0.28***	0.28***
	(0.00)	(0.00)	(0.03)	(0.03)	(0.03)
Home country	1.5***	-0.19***	-0.53***	-0.54***	-0.54***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Education				2.2***	2.2***
				(0.23)	(0.23)
Trust				-3.7***	-3.7***
				(0.19)	(0.19)
IPR protection				3.9	
				(3.1)	
Patent effects	none	fixed	fixed	fixed	fixed
Country effects	none	none	random	random	random
Hit rate	33%	33%	81%	78%	80%

Notes: Sample is based on random draw of 50% of all European Patents granted in 2004; number of observations is 453,680; number of patents is 28,355; all specifications include the log of the validation costs with a coefficient constrained to -1; stars indicate statistical significance levels: *10%, **5% and ***1%; hitrate is the proportion of correctly predicted outcomes.

errors are not too large–except for home country validation. The United States and Japan differ from each other in two respects. Education matters for US applicants, while market size does not. For Japan precisely the opposite pattern is observed. This difference might be explained by the high proportion of (consumer) electronics patents from Japan, and the high proportion of pharmaceuticals from the United States (see also Section 6).

5.3 Results by industry

Table 6 shows the estimation results by industry, following the Fraunhofer industry classification. Different factors are important for different industries. The results for Pharmaceuticals are not very reliable as a substantial proportion of patents are validated in all countries and are not included in the regression for this reason. Market size is of particular importance for electrical and mechanical engineering, while education matters most for Chemistry and Electrical Engineering. Trust is important for Electrical engineering.

Table 5: Estimates by origin of patent holder

	EU	non-EU	Tax havens	United States	Japan
ln(Market size)	0.4***	0.077*	0.23***	-0.16***	0.73***
	(0.04)	(0.04)	(0.09)	(0.06)	(0.1)
Home country	-0.46***	0.87***	0.34***		
	(0.01)	(0.04)	(0.11)		
Education	1.8***	2.9***	0.76	2.3***	0.11
	(0.31)	(0.34)	(0.84)	(0.45)	(0.82)
Trust	-2.5***	-6.0***	-2.7***	-6.0***	-5.2***
	(0.26)	(0.28)	(0.71)	(0.37)	(0.74)
Observations	224,608	229,072	19,376	109,792	82,656
Patents	14,038	14,317	1,211	6,862	5,166

Notes: Samples are based on random draw of 50% of all European Patents granted in 2004; the log of the validation costs is included with a coefficient constrained to -1; tax havens are: Netherlands Antilles, Barbados, Switzerland, Liechtenstein, Luxembourg, and the British Virgin Islands; stars indicate statistical significance levels: *10%, **5% and ***1%.

Table 6: Estimation results by industry

	Chemistry	Pharmaceuticals	Electrical engineering	Instruments	Mechanical engineering	Other fields
ln(Market size)	0.52***	0.35***	1.0***	-0.27*	1.1***	0.48***
	(0.06)	(0.07)	(0.12)	(0.16)	(0.07)	(0.09)
Home country	-0.65***	-0.4***	-0.68***	-0.65***	-0.49***	-0.3***
	(0.02)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)
Education	2.8***	1.2	3.0***	0.16	1.6**	2.2*
	(0.53)	(0.89)	(0.92)	(1.6)	(0.69)	(1.15)
Trust	-1.1**	-4.4***	-3.6***	-1.6	-0.76	-0.039
	(0.45)	(0.47)	(0.68)	(1.16)	(0.58)	(0.95)
Observations	104,176	50,000	91,216	37,344	137,840	33,104
Patents	6,511	3,125	5,701	2,334	8,615	2,069

Notes: Samples are based on random draw of 50% of all European Patents granted in 2004; the log of the validation costs is included with a coefficient constrained to -1; stars indicate statistical significance levels: *10%, **5% and ***1%.

5.4 Robustness analysis

Robustness of the estimation results is illustrated along two dimensions. We show that the main results hold in a qualitative sense for different sub samples and for various econometric methods.

5.4.1 Sample variation

Table 7 shows estimation results for three sub samples of the data. For the sample of large firms[11] the estimations are in line with the baseline estimations. Restricting the sample to patents that are not validated in neither Germany, France nor the United Kingdom the estimations are mostly in line with the baseline results although the size of the coefficients is larger. These patents are more likely to be validated in the home country compared to the baseline. Education is not statistically significant for patents validated in more than five countries.

Table 7: Sample variation estimates of the patent validation model

	Baseline	Large firms	Not validated in DE, FR or GB	Validated in more than 5 countries
ln(Market size)	0.28***	1.0***	0.48***	0.11***
	(0.03)	(0.11)	(0.04)	(0.04)
Home country	-0.54***	-1.1***	0.33***	-0.42***
	(0.01)	(0.05)	(0.02)	(0.02)
Education	2.2***	-1.9*	-3.1***	0.39
	(0.23)	(0.97)	(0.3)	(0.28)
Trust	-3.7***	-4.8***	-0.56**	-1.5***
	(0.19)	(0.82)	(0.23)	(0.23)
Observations	453,680	42,848	368,615	145,120
Patents	28,355	2,678	23,038	9,070

Notes: Samples are based on random draw of 50% of all European Patents granted in 2004; "large firms" are firms with more than 5000 applications for European Patents; the log of the validation costs is included with a coefficient constrained to -1; stars indicate statistical significance levels: *10%, **5% and ***1%.

[11] Firms with more than 5000 applications for European Patents, cumulatively.

5.4.2 Econometric methods

Table 8 shows estimation results for the baseline specification using four different estimators: logit, conditional logit, mixed effect logit and conditional logit with country dummies. All coefficients have the expected sign. The logit coefficient estimates are larger than the baseline estimates, possibly because of omitted variable bias. Using patent fixed effects and country dummies instead of mixed effects hardly changes the coefficients and the standard errors. From this we can conclude that mixed effects logit yields reliable results.

Table 8: Robustness to omitted variable bias and clustering of residuals

	(1)	(2)	(3)	(4)
ln(Market size)	0.28***	1.0***	0.90***	0.27***
	(0.03)	(0.00)	(0.00)	(0.03)
Home country	-0.54***	1.3***	-0.57***	-0.53***
	(0.01)	(0.00)	(0.01)	(0.01)
Education	2.2***	4.8***	-5.0***	2.3***
	(0.23)	(0.00)	(0.14)	(0.23)
Trust	-3.7***	-12***	-6.9***	-3.8***
	(0.19)	(0.00)	(0.05)	(0.19)
Patent effects	fixed	none	fixed	fixed
Country effects	random	none	none	fixed

Notes: Sample is based on random draw of 50% of all European Patents granted in 2004; number of observations is 453,680; number of patents is 28,355; the log of the validation costs is included with a coefficient constrained to -1; stars indicate statistical significance levels: *10%, **5% and ***1%.

6 Value of patent rights

Let V_i be the private value of patent i and C_i the set of countries in which the patent is validated. The value of patent i then can be recovered using the estimated coefficients and (16).

$$V_i = \sum_{j \in C_i} (\Delta\pi_{ij}) = \sum_{j \in C_i} \exp(\alpha_i + \mathbf{x}_{ij}\beta + \gamma_j) \tag{16}$$

The only unknown parameter in this expression is α_i, the patent fixed effect.

We can recover the patent fixed effects in two steps. First, we compute a series of residuals α_{ij} for all countries in which the patent is validated:

$$\exp(\alpha_{ij}) = \frac{f_{ij}}{\exp(\mathbf{x}_{ij}\beta + \gamma_j)}. \tag{17}$$

If α_i would be equal to one, these residuals are cost-value ratio's . The residual will be small in countries where the value of validation is large compared to validation costs, whereas the residual will be small in countries

Second, we make use of our earlier assumption that a patent is only validated if the value of patent rights in a country exceeds the costs of validation. This assumption will only hold if $\alpha_i \geq \ln f_{ij} - \mathbf{x}_{ij}\beta + \gamma_j \ \forall j \in C_j$. This implies that we need to select the largest residue per patent:$\alpha_i = \max_j \{\alpha_{ij}\}$. If a smaller residual would be selected then we could observe a validation in a country for which our estimated value of validation is smaller than the validation costs. This would be inconsistent with our assumption that validation only takes place when the value of patent rights exceed the costs of validation.

Likewise, an alternative approach would be to proxy the patent fixed effect by $\min(\alpha)$ for each α for which $v_{ij} = 0$. One could also take the average of both approaches, which in fact averages the upper and lower bound of the patent fixed effect. There are, however, reasons why the second approach is not preferred. Strategic behavior of firms avoiding competitors in countries in which they are not active is not captured by our empirical framework, whilst the benefits of validating in these countries outweighs the costs. In the same line of reasoning, firms that are not active in particular countries might not consider to validate in these countries at all. Again, this is not captured by the current model specification. The residuals belonging to validated countries are monotonically decreasing in value, whilst the computed residuals belonging to non-validated countries do not. This confirms the strategic behavior described above. For this reason we use the first approach to compute the patent fixed effect.

Table 9: Value of patent rights by country

Country	Total value (mln EUR)	Mean value (EUR)	Sd value (EUR)
All countries	2,680	8,834	19,788
AT	65	5,592	8,843
BE	59	4,508	6,672
CH	46	2,958	4,741
DE	904	16,921	33,296
DK	47	6,203	9,961
ES	165	8,335	14,451
FI	29	4,653	7,334
FR	576	12,431	23,253
UK	176	3,767	7,415
GR	17	3,616	5,499
IE	3	380	597
IT	260	8,452	15,313
LU	4	863	1,107
NL	202	12,090	20,601
PT	21	3,596	5,620
SE	106	8,601	14,460

Notes: Based on the coefficient estimates reported in column (5) of Table 4; validation costs are not subtracted from patent values.

6.1 Value of patent rights by country

The procedure outlined above allows us to predict the private value for each (potential) patent rights (each patent-country combination). Table 9 shows summary statistics of the value of patent rights by country. The total value of all patents granted in 2004 is EUR 2,7 billion, a third of which is attributable to Germany. France takes the second place, but has only half of the German value.

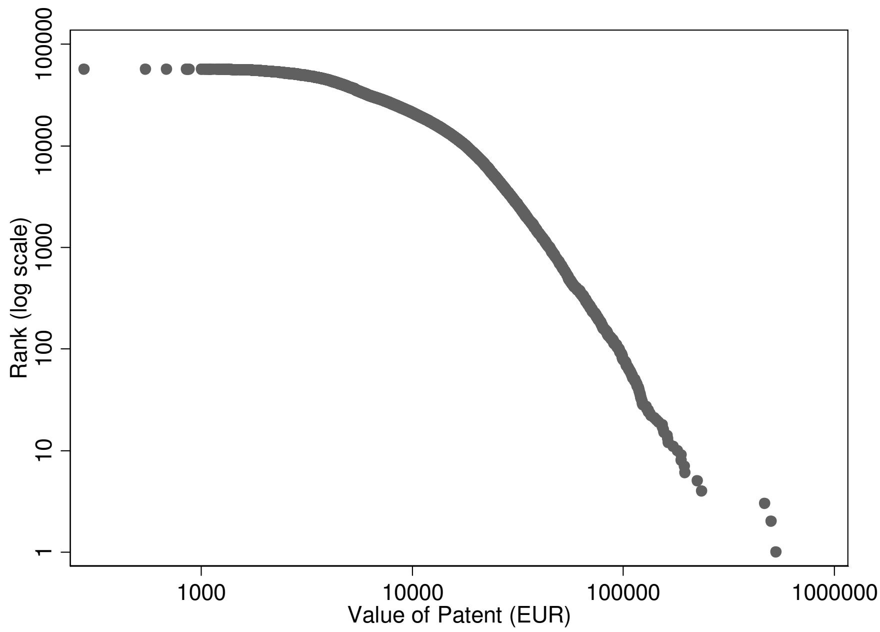
The mean value of German patent rights (EUR 16,921) is also substantially larger than the mean over all countries (EUR 8,834). Smaller countries tend to have less valuable patent rights than lager countries. This despite the fact that only more valuable patents are validated in smaller countries. Ireland has the smallest mean value of the countries in our sample, only four hundred euros.

6.2 Distribution of patent value

The distribution of the value of European Patent rights is presented in figure 4. The right tail of the distribution resembles a straight line, which indicates a Pareto distribution. This type of distribution has been found before by Pakes and Schankerman (1984), Pakes (1986), Griliches (1990), and Silverberg and Verspagen (2007).

Our method for recovering the unobserved part of the value of patents can only work if a "marginal" country can be identified. For this reason, we will underestimate the value of patents that are validated in all countries. Despite this methodological limitation, no obvious underestimation of the right tail is visible in the figure.

Figure 4: Distribution of the value of European Patents granted in 2004



6.3 Determinants of patent value

Table 10 reports the counterfactual aggregate patent values that would occur if all countries would have the same score as Germany on a particular variable, keeping the levels of the other variables fixed. Due to the non-linearity of (16) the contribution of the individual variables to the aggregate value does not add up.

The column "Actual validations" shows the aggregate value of patents given the actual validation decisions by the patent holders. The column "New validations" shows the value of the patent rights for validations that did not occur in reality, but that would take place when patent holders adjust their validation decisions. The column "Lost validations" contains the aggregate value of patent right that would be lost in the counterfactual situation.

"Validation costs" are of a somewhat different nature than the other variables as validation costs do not change the value of a patent right–only the validation decision. The change in validation costs to German levels does not change the value of actual validations. Only differences in validation decisions affect the total change in patent value for counterfactual validation costs.

The effect of new validations is of approximately the same size as the gain in value actual patent rights. The relatively small losses due to lost validations confirms that the characteristics of Germany are favorable for the value of patent rights compared to most other countries. Overall, the largest impact is due to unobserves country effects, followed by market size. If all variables are set to German levels then the aggregate patent value would increase fivefold, from EUR 2.7 billion to EUR 14.8 billion.

Table 10: Aggregate patent value when variables are set to German levels (mln EUR)

	Validations			Total effect	Gain
	Existing	New	Lost		(% of current)
All variables	7,640	7,230	-47	14,823	451.2
Country effects	5,120	3,320	-20	8,420	213.1
Market size	3,240	1,400	-51	4,589	70.7
Trust	2,840	1,160	-87	3,913	45.5
Education	2,900	939	-67	3,772	40.3
Validation costs	2,689	743	-216	3,216	19.6
Home country	2,540	678	-107	3,111	15.7

Notes: Based on the coefficient estimates reported in column (6) of Table 4; validation costs are not subtracted from patent values.

7 Conclusion

The value of patent rights varies across both inventions and countries, which makes it difficult to identify the contributions of factors like market size and the level of enforcement of intellectual property rights. We exploit the validation behavior of European Patent owners to estimate how the value of a single patent varies with country and industry characteristics. Assuming that patent-holders only validate their patents in countries where value of patent rights are at least as large as the cost of validation (validation fees, translation costs, and future renewal fees) we can simultaneously infer the value of the patent right in particular countries and the factors that influence this value.

The mean value of patent rights varies substantially across countries, from 17 thousand euro in Germany to four hundred euro in Ireland. Enforcement of intellectual property rights and market size explain most of the German advantage. The mean value is nine thousand euro per country. The estimated total value of patents granted in 2004 is 2.6 billion euro, of which a third is due to German patent rights. The empirical evidence confirms earlier results that the value of patent rights is highly skewed, with most of the value concentrated in the tail of the distribution.

The evidence suggests that potential demand for the invention that is patented influences the validation decision, and by inference, the value of the patent. Potential demand has been approximated by market size measured in value added and the average education level in the sectors of use. Trust appears to be functioning as a substitute for formal intellectual property rights. Unobserved differences between countries are a substantial part of the variation in patent right values across countries. Together with tentative results on the impact of IPR indexes, this suggests that differences in patent laws and legal institutions have a profound influence on the value of patent rights.

A EPC Member States

Table 11: EPC Member States as of June 2011

Code	Country	Date of entry	Sample	Code	Country	Date of entry	Sample
BE	Belgium	7 October 1977	Yes	TR	Turkey	1 November 2000	No
DE	Germany	7 October 1977	Yes	BG	Bulgaria	1 July 2002	No
FR	France	7 October 1977	Yes	CZ	Czech Republic	1 July 2002	No
LU	Luxembourg	7 October 1977	Yes	EE	Estonia	1 July 2002	No
NL	Netherlands	7 October 1977	Yes	SK	Slovakia	1 July 2002	No
CH	Switzerland	7 October 1977	Yes	SI	Slovenia	1 December 2002	No
GB	United Kingdom	7 October 1977	Yes	HU	Hungary	1 January 2003	No
SE	Sweden	1 May 1978	Yes	RO	Romania	1 March 2003	No
IT	Italy	1 December 1978	Yes	PL	Poland	1 March 2004	No
AT	Austria	1 May 1979	Yes	IS	Iceland	1 November 2004	No
LI	Liechtenstein	1 April 1980	No	LT	Lithuania	1 December 2004	No
GR	Greece	1 October 1986	Yes	LV	Latvia	1 July 2005	No
ES	Spain	1 October 1986	Yes	MT	Malta	1 March 2007	No
DK	Denmark	1 January 1990	Yes	HR	Croatia	1 January 2008	No
MC	Monaco	1 December 1991	No	NO	Norway	1 January 2008	No
PT	Portugal	1 January 1992	Yes	MK	Fmr Yugoslav Republic of Macedonia	1 January 2009	No
IE	Ireland	1 August 1992	Yes	SM	San Marino	1 July 2009	No
FI	Finland	1 March 1996	Yes	AL	Albania	1 May 2010	No
CY	Cyprus	1 April 1998	No	RS	Serbia	1 October 2010	No

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