Market size, education, trust, and the value of IPRs: Evidence from the validation of European Patents*

Bas Straathof †[1,2] and Sander van Veldhuizen‡[1]

[1]CPB Netherlands Bureau for Economic Policy Analysis, The Hague, The Netherlands

[2]University of Groningen, Department of Economics & Business, Groningen, The Netherlands

August 31, 2011

Abstract

The value of a patent rights not only varies across inventions, but also across countries and sectors. This paper uses the validation behavior of holders of granted European Patents to estimate the value of patents and to identify its determinants. The potential market for the invention and the average education level in the sector of use are positively associated with the value of patent rights, whereas a high level of trust and weak enforcement of intellectual property rights reduce the value of these rights.

*We thank Elwyn Davies for really excellent research assistence.

†Bas Straathof: `s.m.straathof@cpb.nl`, Tel: +3170 338 3382. Address: CPB Netherlands Bureau for Economic Policy Analysis, P.O. Box 80510, 2508 GM The Hague, The Netherlands

‡Sander van Veldhuizen: `s.van.veldhuizen@cpb.nl`, Tel: +3170 338 3495. Address: CPB Netherlands Bureau for Economic Policy Analysis, P.O. Box 80510, 2508 GM The Hague, The Netherlands

We control for unobserved patent and country effects. We confirm that the distribution of the value of patent rights is highly skewed. We find that the aggregate value of European Patents granted in 2004 is EUR 2.9 billion. Introduction of the EU Patent would increase this value by 15 percent through a reduction in validation costs. A theoretical model of validation behavior provides the basis of the empirical analysis.

1 Introduction

The oldest and most widespread public policy that aims to encourage innovation is to reward inventors with a monopoly on the use of their inventions.[1] Although the value of patents has been studied extensively, few empirical researchers have focussed on the determinants of the value of patent rights. Knowing why a patent is worth what it is worth is of interest because it can guide policy makers in shaping incentives for innovation.

The impact of factors like market size on the value of patent rights is difficult to isolate because patents are heterogeneous in terms of the commercial potential of the underlying invention. 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.

We present evidence showing that potential demand influences the validation decision,

[1] The Statute of Monopolies passed by the English parliament in 1624 granted monopolies to skilled individuals for new techniques. The United States granted its first patent in 1790.

and by inference, the value of the patent. We find that the value of a patent 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 Harhoff et al. (2009) and are the central in reforms of the European patent system, like the London Protocol van Pottelsberghe and Mejer (2008) and the EU Patent Danguy and Van Pottelsberghe de la Potterie (2009); Van Pottelsberghe de la Potterie and Mejer (2009); Van Pottelsberghe de la Potterie (2010).

We confirm earlier results that the distribution of patent rights is highly skewed. This property has been discussed by numerous authors, e.g. Pakes and Schankerman (1984), Pakes (1986), Griliches (1990), and Silverberg and Verspagen (2007). Finally, by adjusting validation costs and the costs associated with the numerous translation requirements, we can simulate the value added of introducting an EU Patent. Our simulations show an increase of 15 percent of the value of the European Patent stock granted in 2004.

A theoretical model of validation behavior provides the basis of the empirical analysis. 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 patent litigation by Bessen and Meurer (2006) and Galasso and Schankerman (2010).

There are two strands of literature 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 patentvalue 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.

A second 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 charactersitics and renewal data, such as Bessen (2008), claim that patent citations explain little variance in value suggesting a limited use as a measure of patent quality.

This paper contributes to both 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[2] (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 benefits of validation in a particular country also vary along 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.

Our sample includes the validation decisions for all European Patents granted in 2004 and for 16 major EPC countries[3]. Validation decisions are modelled as a binary choice and are estimated by penalised 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 is positive. The cost of validation are treated as given and the benefits of validation are estimating by including indicators for market size, education, trust, distance, common borders, shared language as regressors.

We can control for (unobserved) patent charactistics as we observe 16 validation decisions per patent, one for each country in our sample. We control for patent effects by conditioning on the number of countries a patent is validated in. This resembles the logit fixed effects estimator of Chamberlain (1980). Country characteristics are modelled as random effects, such

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

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

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 why we control for unobserved patent and country characteristics. First, this will avoid that residuals will be clustered by patent because of patent heterogeneity and this 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 second part of the results originate from simulations of the proposed introduction of an EU Patent, which would end the possibility of separate validation of European Patents for members of the European Union. In the simulations the adoption of a single EU Patent would imply no additional translation cost at the time of validation, a single validation fee, and single renewal fees within the EU. We infer that introduction of the EU Patent would raise the value of newly granted patents by at least 15 percent on average. These gains stem from two sources. First, the costs of validation decrease substantially, raising the net value of patent rights. Second, patents will be validated in more countries, such that benefits of patent rights come into existence that would have been forgone under the old validation regime.

This paper is organized as follows. The next section presents a model of the validation decision at the grant of an European Patent. Section 3 describes the accompanying empirical strategy. The data are described in Section 4. Section 5 presents the mixed effects logit estimates and a robutsness check. The distrubutions of the private value of patents are discussed in Section 6, followed by the simulations. Concluding remarks highlight the key findings and directions for future research.

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.

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.

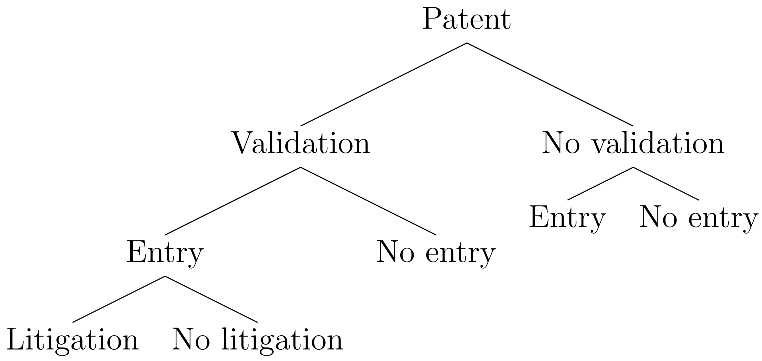


Figure 1: Validation game

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. Let ϕ be the probability that litigation is succesful and the incumbent retains the exclusive right to sell its product and let the costs of litigation be l. The legal costs are bourne 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:

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

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 of the table shows whether litigation is credible

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.

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

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 succesful 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 straightfoward 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 bariers:

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

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 benefits from 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 benefits from validation outweigh the validation costs:

$$\begin{aligned} v_{ij} &= 1 \quad \text{if} \quad v_{ij}^* > 1 \\ v_{ij} &= 0 \quad \text{if} \quad v_{ij}^* \leq 1 \end{aligned} \tag{6}$$

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 coeffients 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 cummulative 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 straigthforward for given country effects.

The country effects are treated as random effects and are estimated by maximizing a penalised 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 penalised partial loglikelihood function $l_{ppl}\equiv\ln\mathcal{L}_{ppl}$ consists of two parts: a partial loglikelihood 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.

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

Maximization of the penalised partial loglikelihood 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 disaggregrated 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.

[4]The 16 countries of validation are Austria (AT), Belgium (BE), Switserland (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 analyse the patent validation flows between applicant and validation countries.

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

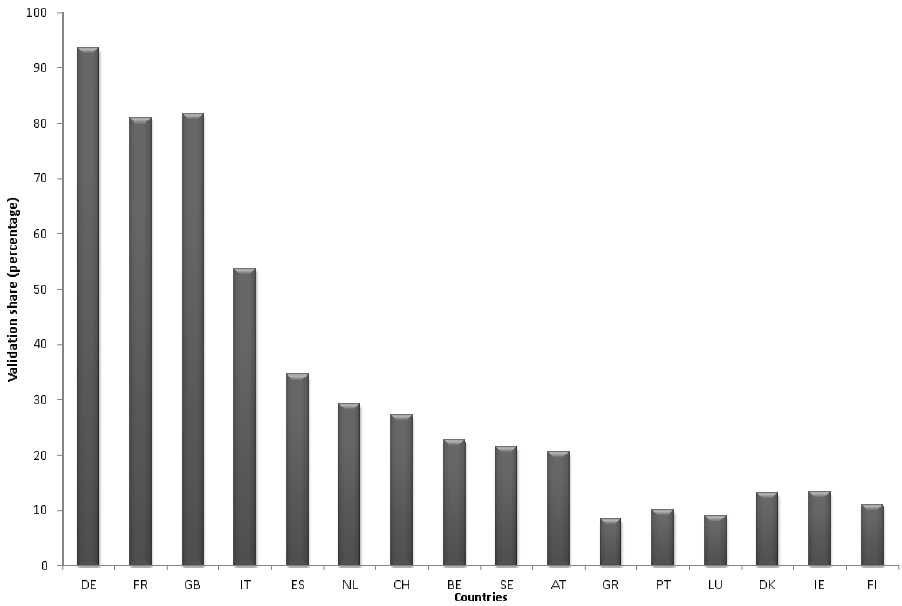
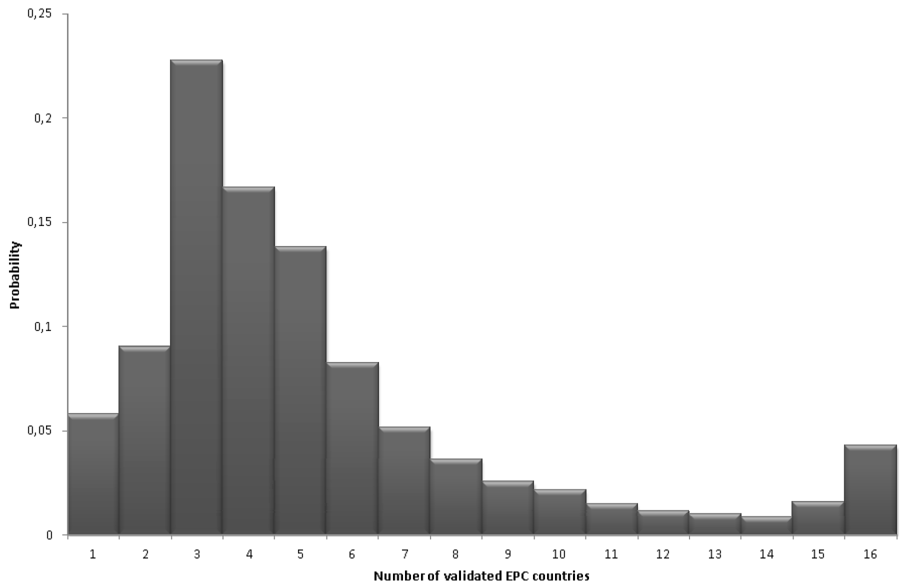


Figure 2 shows the validation shares of granted European Patents in 2004. In 2004, about 93 percent of all granted European Patents has been validated in Germany, 81 percent has been validated in France and 82 percent in the United Kingdom. Other contracting states of the EPC have lower validation shares. Different trends related to countrysize 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]

[6]These arguments and the reduction of cost of patenting, are the most important reasons for implementing

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 probabilty mass at 15 and 16 validated countries. The patents characterised 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.

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



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 country j, we

an EU Patent, see Danguy and van Pottelsberghe de la Potterie (2010) and Straathof and Van Veldhuizen (2010).

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 seperate 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.

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.

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

Business climate indicators Focussing 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 fees The patentee has to pay a validation fee in a contracting state to validate a granted European Patent in that contracting state.[9] Validation fees differ considerably across EPC countries. For example, Belgium, Switserland, United Kingdom and Luxembourg do not charge validation fees at all, whilst the remaining countries in our sample do charge validation fees. Austria, Denmark, Finland, Spain and Sweden charge on top of a fixed fee also a page-based fee when a patent exceeds a certain number of pages.[10] The 2003 validation fees taken from EPO (2003) are illustrated in Figure 4.

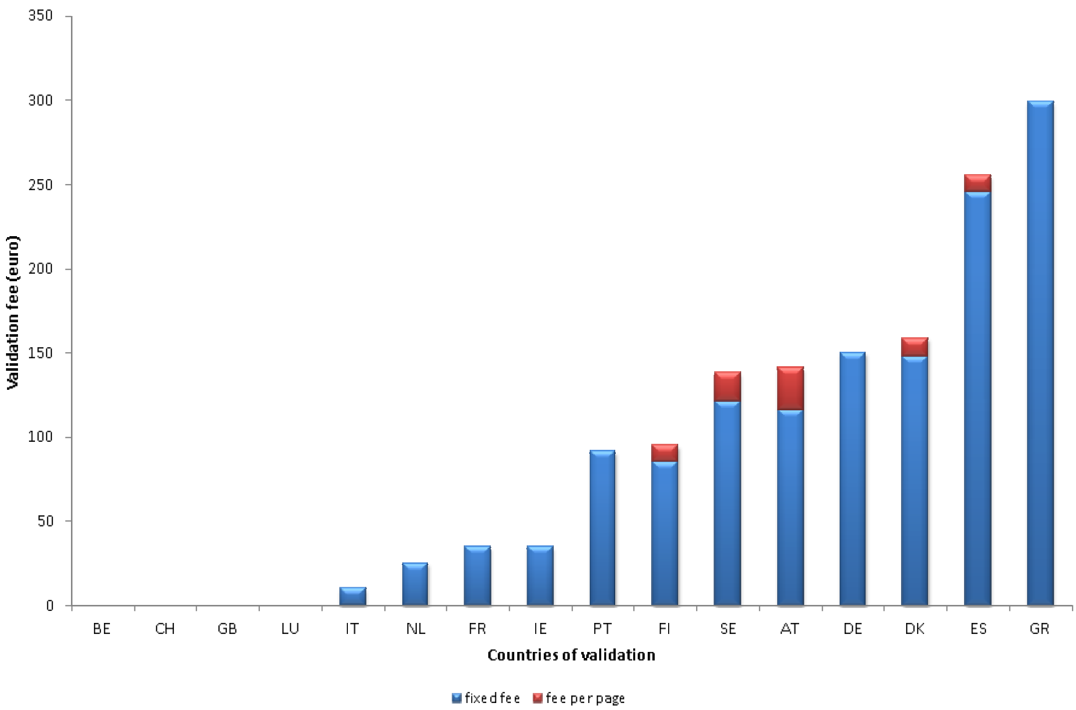
Renewal fees Figure 5 displays the renewal fees, grouped in subtotals over 5 years, for the EPC countries in the sample. The Netherlands, Austria and Germany overall charge the highest renewal fees, in particular in the last 5 years of the lifetime of a patent. Data on the renewals fees have been extracted from EPO (2003).

[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]In case a European Patent is granted in one of the official languages of the country in which the patent should be validated (in other words the proceedings language is one of the offical languages of the country of validation), then no validation action is required and no validation fees have to be paid. Data on the proceedings language was used to correct validation fees for these cases.

[10]Page-based fee in Austria in excess of 5 pages, in Denmark in excess of 35 pages, in Finland in excess of 4 pages, in Spain in excess of 22 pages and in Sweden in excess of 8 pages.

Figure 4: Validation fee per country in 2003.



Translation costs Translation costs are primarily determined by the number of words that have to be translated and the number of languages in which they have to be translated. The best proxy available is the number of pages of descriptions and the number of pages of the claims, which have been taken from the Open Patent Services available from the EPO.[11]

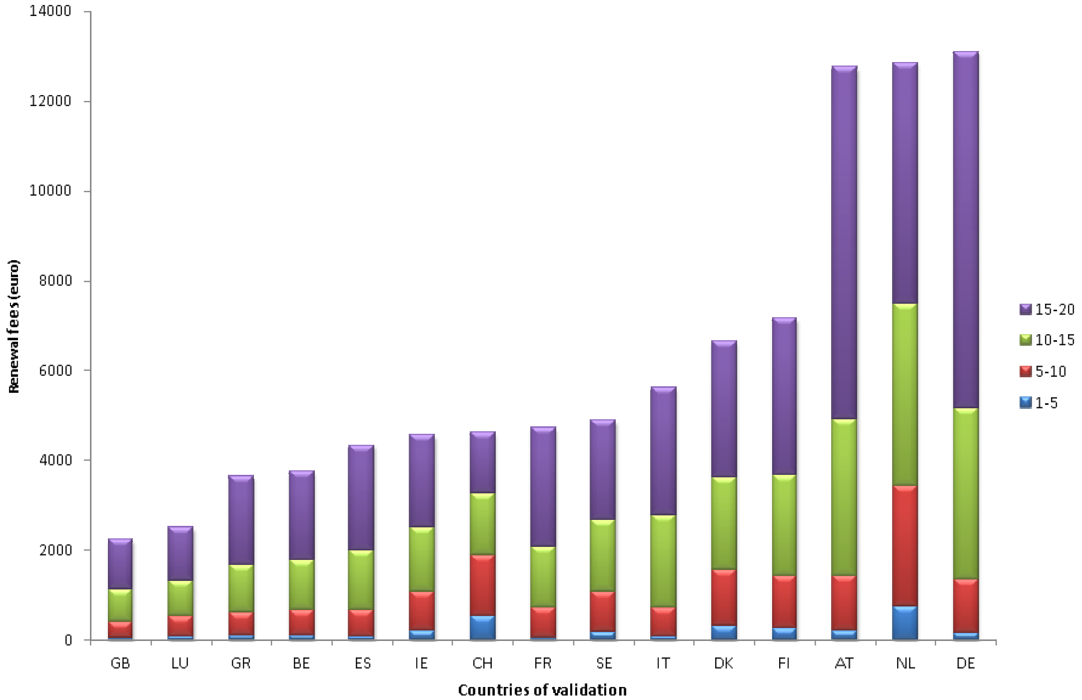
Translations of the patent are needed in two stages of the application proces, namely at the grant and validation procedures. In the application and granting stage, the patent descriptions are published in the proceedings language, whereas the claims have to be available in English, French and German.[12][13] In the second stage of validating the granted patent

[11]See `http://www.epo.org/patents/patent-information/free/open-patent-services.html`

[12]From May 2008 onwards the London Agreement has been entered into force aiming at reducing the translation costs of European Patents, see for example van Pottelsberghe and Mejer (2008). Our analysis is restricted to the period before May 2008, and henceforth, the translation requirements correspond to those before the London Agreement had set in.

[13]The official languages of the European Patent Office are English, French and German. A European Patent application should be filed in on of the official languages or, if filed in any other language, translated into one of the official languages. In general, the language in which the European Patent application has

Figure 5: Renewal fees by country in 2003.



in one or more contracting states, the descriptions and claims have to be translated in the official language of the particular contracting state. In case a contracting state has multiple official languages submitting a translation in one of these languages is sufficient. For our data sample the translation requirements are listed in Table 2.

Following the European Commission Communication (2007) we assume translation costs of 76 euro per page descriptions and 85 euro per page claims. Further it is also assumed that the translation costs for translations from any language A to any other language B is equal for all European languages A and B, with $A \neq B$. To give an impression of the translation costs we use an example taken from European Commission Communication (2007). Assume that a patent has 16 pages of descriptions, 4 pages of claims and is validated in 13 most frequently validated contracting states. [14] To meet the national translation requirements,

been filed will be used as the language of the proceedings.

[14]This patent is validated in Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy,

the descriptions and claims have to be translated into the remaining two of the three EPO languages and into Danish, Dutch, Finnish, Italian, Spanish and Swedish. Hence, the total translation costs are 12,448 euro.

Table 2: Translation requirements for the description and claims in the contracting states

Country	**Official language(s)**	**Country**	**Official language(s)**
Austria	German	Ireland	English
Belgium	Dutch, French, German	Italy	Italian
Denmark	Danish	Luxembourg	French, German
Finland	Finnish	Netherlands	Dutch
France	French	Portugal	Portuguese
Germany	German	Spain	Spanish
Great Britain	English	Sweden	Swedish
Greece	Greek	Switserland	German, French, Italian

5 Estimation results

Table 3 presents the empirical results for various versions of the baseline model. We first compare different specifications and then compare parameter the estimates in the preferred specification across countries of application and technology fields. The latter regressions are presented in table 4.

Regression (1) of table 3 is a standard logit model showing a positive parameter for market size. However, knowledge as captured by patents differ greatly in market potential, and the invention potential influences the validaton decision. Hence, there is a selection bias towards large countries, that have more low-valued patents. Regression (2) is a conditional logit model that filters out patent-applicant-specific effects. In addition, regressions (3)-(7) are mixed effect logit models which compute cluster-robust standard errors to correct for possible different error variances over countries. Note that the parameter values for

Netherlands, Spain, Sweden, Switserland and United Kingdom.

market size, education, trust and IPR protection are nearly constant when building up the specification. Market size, education and IPR protection postively influence the probability of validation, whilst general trust reduces the probability of validation. The bilateral distance indicators respond as expected, that is, distance infers a negative relationship whereas shared language and common border emlpoy a positive relationship.

As a measure of goodness-of-fit we use the hitrate of correctly predicted validations, wihch has been computed as follows. From the parameter estimations it is rather straightforward to recover α_i. In section 6 this has been explained in detail. Once the patent fixed effects are known the net present value of validating patent i in country j can be computed. We assume that actual validation happens when this value is nonnegative.

Table 3: Estimates of the patent validation model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln(market size)	0.9679***	0.9257***	0.2817***	0.3217***	0.3023***	0.3101***	0.2995***
	(0.0025)	(0.0020)	(0.0191)	(0.0193)	(0.0194)	(0.0190)	(0.0191)
education				1.734***	2.287***	2.2927***	2.2328***
				(0.1584)	(0.1601)	(0.1599)	(0.1605)
trust					-4.003***	-4.0090***	-3.9356***
					(0.13)	(0.1297)	(0.1299)
IPR protection						5.4748***	5.3328***
						(1.3713)	(1.4584)
ln(distance)							-0.0149***
							(0.0044)
Shared language							0.1162***
							(0.0071)
Common border							0.0301***
							(0.0067)
econometric	standard	conditional	mixed effect	mixed effect	mixed effect	mixed effect	mixed effect
method	logit	logit	logit	logit	logit	logit	logit
hit rate	33.4%	33.4%	61.6 %	66.6%	70.1 %	74.8%	74.3%
No. observations	911,680						
No. patents	56,980						

Next we compare parameter estimates across the nationality of the applicant, where we distinct EU- and non-EU countries, tax havens, the United States of America and Japan. Large firms have their intellectual property registered at their headquarters address. Since a large amount of large firms have their headquarters located in taxhavens, this group has been seperated. For the EU countries the estimated coefficients are as expected. For non-EU countries the incentive captured by market size seems to be less important, whereas education and IPR protection show stronger positive effects and trust stronger negative effects compared to the EU sample. Moreover, the effect of distance cannot be distinguished from zero. For both market size as distance the effects can be explained by the following arguments. First, granted patents from applicants outside the EU are of relatively high value and quality since the costs for nonEU applicants are higher than for EU applicants. Hence, the marginal effect of market size is less important and the same argument holds for distance. Secondly, because physical distance between the patentee and the country in which her patent is validated is larger, she will be more demanding regarding the protection of the intellectual property.

When electrical engineering is included, market size is not significant for the USA and education is not significant for Japan. Estimations with all industries except electrical engineering yield coefficients that are to be expected. The estimations point out that characteristics of the electrical engineering industries of the USA and Japan are quite different. For US patentees education in the country of validation is far more important than marktsize. For Japanese patentees it is the other way around. This can be explained by the different natures of both electrical engineering industries. Japanese engineering is more focussed on development of products for large markets such as consumer electronics. Hence, this implies a relative large coefficient for market size in the estimations. Electrical engineering in the US is on the technology frontier, of which the most clear example is the research performed in Silicon Valley. For validation is in this case education more important than market size.

Table 4: Country estimates of the patent validation model

	All industries					All industries except electrical engineering	
	EU countries	non EU countries	Taxhavens	Japan	USA	Japan	USA
ln(market size)	0.4104***	0.08022***	0.3534***	0.6252***	-0.03126	0.8749***	0.2617***
	(0.0237)	(0.031)	(0.059)	(0.0632)	(0.0386)	(0.0556)	(0.0383)
education	1.683***	3.98***	3.497***	0.2909	3.769***	3.695***	4.791***
	(0.2072)	(0.2564)	(0.5868)	(0.5715)	(0.3189)	(0.711)	(0.3565)
trust	-2.356***	-7.41***	-3.428***	-5.565***	-6.845***	-4.341***	-5.794***
	(0.1678)	(0.2077)	(0.4928)	(0.4941)	(0.2563)	(0.5974)	(0.2886)
IPR protection	3.257***	7.851***	3.109*	8.164***	7.696***	4.394***	5.41***
	(1.2026)	(2.1766)	(1.5995)	(2.3526)	(2.5208)	(1.4582)	(1.4689)
ln(distance)	-0.163***	0.02114	-0.2643***	-1.873	0.9115	-1.677	0.5562
	(0.0048)	(0.0389)	(0.0281)	(2.0562)	(2.0984)	(1.2771)	(1.2108)
Shared language	-0.02089*	-0.1537***	0.1965***		0.1245		-0.1089
	(0.0109)	(0.0143)	(0.0531)		(0.5921)		(0.3414)
Common border	0.06732***	-0.1605**	-0.2769***				
	(0.0074)	(0.0816)	(0.0698)				
No. observations	486,544	425,136	40,944	164,720	219,360	101,104	154,288
No. patents	30,409	26,571	2,559	10,295	13,710	6,319	9,643

5.1 Robustness checks

Robustness of the estimation results is illustrated along four dimensions. We show that the main results hold under sample variation and under various ecocometric methods. Estimations with alternative regressors for education and IPR protection also confirm the main results, as does an industry decomposition.

5.1.1 Sample variation

Table 5 shiws estimation with variatons on the data sample. We see that for the sample of large firms the estimations are in line with the baseline estimations. Restricting the sample to patents that are not validated in neither Germany, France or the United Kingdom the estimations are still quite in line with the baseline results.

Table 5: Sample variation estimates of the patent validation model

	Large firms	Not validated in DE, FR or GB	Validated in more than 5 countries
ln(markt size)	0.3357***	0.2774***	0.284***
	(0.0357)	(0.0196)	(0.0235)
education	3.259***	2.129***	2.005***
	(0.2826)	(0.1629)	(0.1976)
trust	-6.419***	-3.893***	-2.094***
	(0.2238)	(0.1311)	(0.1547)
IPR protection	6.855***	5.246***	2.843**
	(1.6313)	(1.492)	(1.1781)
ln(distance)	0.09763***	-0.00985**	-0.05744***
	(0.0085)	(0.0044)	(0.0052)
Shared language	-0.001525	0.09536***	0.01382
	(0.0125)	(0.0072)	(0.0092)
Common border	0.07027***	0.04381***	0.07532***
	(0.0121)	(0.0069)	(0.0089)

5.2 Econometric methods

Table 6 show estimations using logit, conditional logit, mixed effect logit and conditional logit with country dummies. Using patent fixed effects and country dummies instead of mixed effects hardly changes the coefficients and the standard errors.From this we conclude that mixed effects logit employs reliable results. One could wonder whether using advanced econometrics as mixed logit pays off compared to conditional logit with country dummies. The use of mixed logit allows us to use indicators that vary on the country level, such as for example IPR indicators. Often, such indicators are only available on the country level.

Table 6: Various econometric methods applied to the patent validation model

	Logit	Logit patent fixed effects	Mixed effects logit	Patent and country fixed effects logit
ln(markt size)	0.9017***	0.8320***	0.2921***	0.2874***
	(0.0688)	(0.0026)	(0.0194)	(0.0196)
education	1.1185***	4.9587***	2.227***	2.2136***
	(0.0478)	(0.0742)	(0.1606)	(0.1607)
trust	-5.4142***	-1.3827***	-3.9300***	-3.9380***
	(0.0460)	(0.0419)	(0.1301)	(0.1302)
ln(distance)	-0.2980***	-0.1031***	-0.01500***	-0.0149***
	(0.0024)	(0.0040)	(0.0044)	(0.0044)
Shared language	0.6887***	-0.0690***	0.1165***	0.1166***
	(0.0088)	(0.0062)	(0.0071)	(0.0071)
Common border	-0.5269***	0.1711***	0.0299***	0.0298***
	(0.0095)	(0.0062)	(0.0067)	(0.0067)
No. observations	911,680			
No. patents	56,980			

5.3 Alternative regressors

Table 7 present estimations of the patent validation model with alternative regressors for education and IPR protection. From the ESS different measures for education are available. Next to our constructed education years variable, in Table 7 denoted as *education years* *(standardized)*, suitable alternative regressors are the original education years variable, denoted by *education years (ESS)*, education level denoted as *education level (ESS)* and R&D expenditures. Alternative regressors for IPR portection are the Ginarte-Park index (Ginarte and Park, 1997; Park, 2008) and the IPP index (Forum, 2008).

Comparison of the baseline estimations (regressions (1) and (5) in Table 7) with the estimations using alternative regressors for education and IP enforcement yields the following results. Substitution of alternative regressors for education does not influence the size and sign of the other regressors, see estimations (2) - (4) in Table 7. Inclusion of country level IP enforcement indicators does not influence the coefficients of the other regressors. The IPR indicator yields a positive significant effect on the probability of validation. Alternative regressors of IP enforcement yield a postive, but imprecisely estimated, coefficient on the probability of validation. We conclude that the baseline results keep one's feet under the robustness analysis of alternative regressors.

Table 7: Alternative regressors

	(1)	(2)	(3)	(4)	(5)	(6)
ln(market size)	0.2921***	0.3668***	0.2765 ***	0.2553***	0.2995***	0.2953***
	(0.0194)	(0.0197)	(0.01939)	(0.02153)	(0.0191)	(0.0194)
education years (standardized)	2.2271***			1.4440***	2.2328***	2.2295***
	(0.1606)			(0.1651)	(0.1605)	(0.1606)
education years (ESS)		2.3802***				
		(0.1092)				
education level (ESS)			0.9378***			
			(0.0853)			
ln(R&D expenditures)				0.0449***		
				(0.0200)		
trust	-3.9299***	-4.1161	-3.8634***	-4.6234***	-3.9356***	-3.9348***
	(0.1301)	(0.1305)	(0.1299)	(0.1356)	(0.1299)	(0.1300)
IPR protection					5.3328 ***	
					(1.4584)	
park index						6.6647
						(3.8597)
IPP						1.7585
						(1.1884)
ln(distance)	-0.0149***	-0.0140***	-0.0157***	-0.0168***	-0.0149***	-0.0149***
	(0.0044)	(0.0044)	(0.0044)	(0.0044)	(0.0044)	(0.0044)
Shared language	0.1165***	0.1208***	0.1168***	0.1238***	0.1162***	0.1164***
	(0.0071)	(0.0071)	(0.0071)	(0.0072)	(0.0071)	(0.0071)
Common border	0.0299***	0.0248***	0.0291***	0.03222***	0.0301***	0.0300***
	(0.0067)	(0.0067)	(0.0067)	(0.0068)	(0.0067)	(0.0067)
No. observations	911,680					
No. patents	56,980					

5.4 Industry decomposition

Patenting behavior varies across industries. For example, there are differences in traditions to patent, differences in proportions of low valued patens and lastly, per industry the channels through which the patent incentives run differ across industries. Table 8 contains the estimations on industry level. We follow the Fraunhofer industry classification, which distinguishes six industries on the highest level of aggregation.

The industry level estimates split the technology groups in three categories. The first category comprises chemistry and pharmaceuticals for which the estimations reveal that market value, education, generall trust and IPR protection are significant and have the signs corresponding with the baseline model. The second group consists of electrical engineering, mechanical engineering and other fields. This group can be identified by a positive coefficient for market size, but one or more other channels are not significant. Compared with the baseline is market size relatively more important in electrical engineering, general trust is relatively less important and IPR protection is relatively more important. The level of education is, however, not significant. In mechanical engineering only market size is important. The third category is instruments, for which trust and IPR protection are the only significant channels.

Table 8: Industry decomposition estimates of the patent validation model

	Chemistry	Electrical engineering	Instruments	Mechanical engineering	Other fields	Pharmaceuticals
ln(market size)	0.5547***	0.7451***	-0.1351	1.033***	0.4233***	0.3423***
	(0.0376)	(0.0696)	(0.111)	(0.0438)	(0.0559)	(0.043)
education	3.15***	0.1156	-0.6332	0.2989	2.221***	5.129***
	(0.361)	(0.6669)	(1.1114)	(0.4757)	(0.7951)	(0.6004)
trust	-2.628***	-2.474***	-4.771***	-0.2772	0.4278	-4.219***
	(0.2876)	(0.4955)	(0.7578)	(0.3986)	(0.634)	(0.3323)
IPR protection	3.131***	7.002***	10.19***	2.397	1.512	3.201***
	(1.0421)	(1.4195)	(3.8836)	(1.6887)	(1.4712)	(1.2102)
ln(distance)	-0.003532	0.07839***	0.07868***	-0.02817***	-0.1743***	-0.03107***
	(0.0084)	(0.0135)	(0.0194)	(0.0079)	(0.0134)	(0.0109)
Shared language	0.08377***	0.2392***	0.1992***	0.1487***	0.3058***	0.08284***
	(0.0136)	(0.0195)	(0.027)	(0.014)	(0.0257)	(0.0174)
Common border	0.02121	0.09745***	0.01053	0.02631**	0.09121***	-0.04089**
	(0.0133)	(0.0182)	(0.0271)	(0.012)	(0.0215)	(0.0196)
No. observations	208,768	175,600	75,520	281,456	67,808	102,528
No. patents	13,048	10,975	4,720	17,591	4,238	6,408

6 Implications

In this section the parameter estimates are used to simulate the ex post distribution of patent value. The analysis then focusses on te contributions of various technologies and nationalities of the patentee. Finally, the value added of introducing an EU Patent is derived.

6.1 Estimates of the private value of European Patent rights

In this section we derive the distribution of the private value of European patent rights of applications which have been validated in 2004 at the EPO. The private value of a single patent is given by

$$V_i = \sum_j (\Delta\pi_{ij} - f_{ij}) = \sum_j (y_{ij}\alpha_i f(L_j)g(O_j) - f_{ij}), \tag{16}$$

in which the patent-specific effects α_i are unknown. Below we discuss our strategy to recover the patent fixed effects α_i.

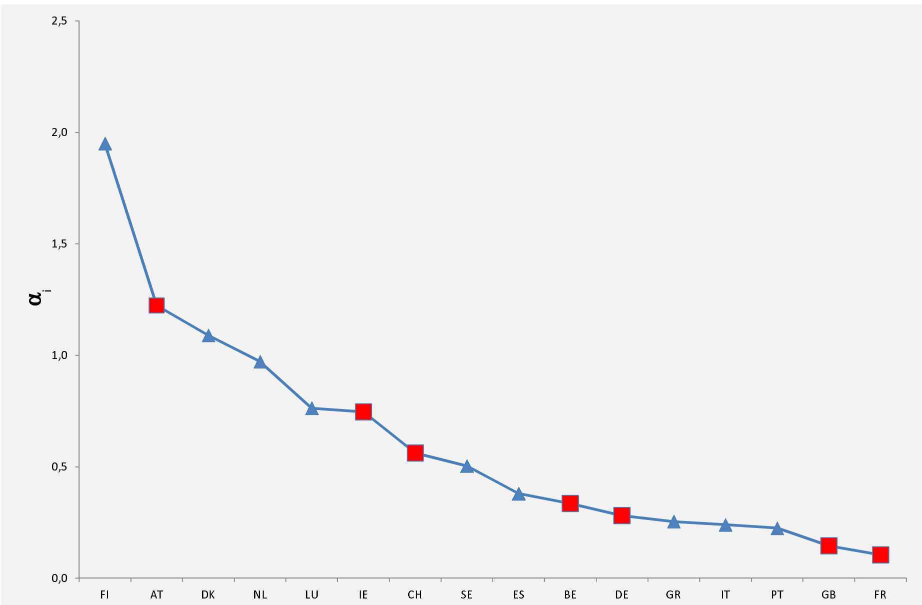
6.1.1 The proxy of patent fixed effects

Per patent we construct a series of φ's:

$$\alpha_i = \frac{C_{ij}}{y_{ij}f(L_j)g(O_j)}. \tag{17}$$

An illustration of such a series is given in figure 6. The patent fixed effect resulting from a country in the marge of validation is where we are interested in. Various approaches can be taken from here, since the marginal country generally does not exist. The preferred approach is to take $\max(\alpha_i)$ for every α for which holds that $v_{ij} = 1$. 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 lowerbound 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 beneifts 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 computed series φ's belonging to validated countries are monotonically decreasing in value, whilst the computed series φ's belonging to nonvalidated countries do not. This confirms the strategic behavior described above. For this reason we use the first approach to compute the patent fixed effect.

Figure 6: Illustration of a series $\{\alpha_{ij}\}_j$ for a patent from the data sample. The patent has been validated in the countries marked by a red square.



6.1.2 Distribution of the value of European Patents

The distribution of the value of European Patent rights is presented in figure 7. Approximately 95% of the patents follow a power law, which has been plotted as well. The 5% of patents that are below the fitted power law represent patents that are validated in 15 and 16 countries. The current methodology underestimates their value, because these patents are not part of the estimation of the parameters. We assume that the estimated value of these patents should follow the same fitted power law.

Table 9 presents the value distribution by industry, where the top 5% has been fitted by a power law.[15] Most European Patents are of moderate value: the median value is 14k euro for the whole sample, only 6k euro in electrical engineering, 15k euro in instruments, 23k euro in chemistry, 11k euro in mechanical engineering and 116k euro in pharmaceuticals. The value rises sharply with the quantile, especially in pharmaceuticals. For all industries holds that there are some very valuable patents in the tail that represent a large fraction of the total value in each industry. For example, the 1 % most valuable patents in pharmaceuticals represent 11% of the total patent value in pharmaceuticals. For mechanical engineering this is 5%, while for the whole sample the top 1% patents represent about 9% of the total value.[16] Nonetheless, the means differ greatly along industries. Over all industries the mean patent value is about 51k euro. Electrical engineering, instruments and mechanical engineering have mean patent values of 18k, 27k and 15k euro, respectively. The mean patent value in chemistry is higher, namely 78k euro. Pharmaceuticals has, as to be expected, a much higher mean patent value: about 400k euro.

Table 9 confirms that patent value distributions are highly skewed, see for example Schankerman (1998). Our estimations of pharmaceutical patents differ largely from the ones by Schankerman (1998), whose value estimations of pharmaceutical patent are rather low. The estimations of Schankerman are largely influenced by regulation in the pharmaceutical sector in France in the 1980s, which leads to underestimations of the patent value. Our estimations, however, reveal that patents from the pharmaceutical industry are more valuable than patents in other industries. Given the substantial development and test phase costs,

[15]The value distributions by industry wihtout power law fits can be found in appendix B.

[16]The top 1% in electrical engineering represent about 7% of the total value; the top 1% of instruments about 8%; the top 1% in chemistry about 10%.

and the large markets for pharmaceutical products, it is more than likely that intellectual property in this industry is highly valuable.

Figure 7: Distribution of the value of European Patents granted in 2004 (blue dots). Power law fit (magenta solid line).

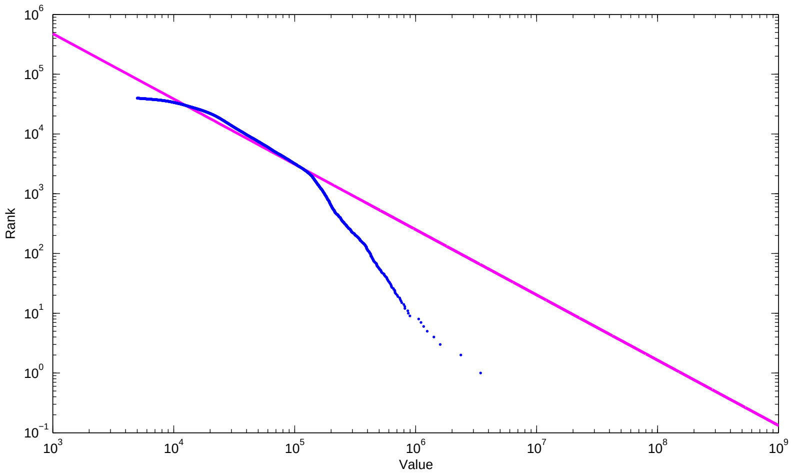


Table 9: Distribution of the value of European Patent rights after power law fit, by technology field.

Quantile	Whole sample	electrical engineering	instruments	chemistry	mechanical engineering	pharmaceu-ticals	other industries
.25	3,350	2,325	3,215	9,000	2,165	36,465	4,640
.50	13,750	5,825	15,100	22,735	10,500	115,730	11,700
.75	29,325	24,550	27,660	45,900	18,870	235,625	22,330
.90	62,500	38,950	59,125	92,400	35,000	544,625	38,850
.95	108,420	56,565	85,800	146,675	48,275	1,008,615	49,925
.99	472,730	129,975	202,975	794,925	73,620	4,382,340	66,860
mean	50,815	18,320	26,650	77,940	14,500	401,325	16,075

6.1.3 Relative contribution of determinants of patent value

The individual contribution of the determinants of the value of an European Patent are listed in table 10. The shares are scaled such that they add up to 100 percent. As it turns out, market size is the largest contributor to patent value: it accounts for about 67 percent of the value. The second major contributor is the enforcement of intellectual property rights with a share of 37%. Education accounts for 14 percent of the value, whilst generalized trust accounts for a reduction in value by 17 percent. The other determinants of patent value, namely distance, shared language and common border hardly contribute to the average value of European Patents.

Table 10: Contribution of explanatory variables towards the value of the patent stock

Explanatory variable	Share	Explanatory variable	Share
Market size	67%	Distance	-1.1%
IPR enforcement	37%	Shared language	0.1%
Education	14%	Common border	0.1%
General trust	-17%		

6.2 The value added of an EU Patent

European Patents are in reality nothing more than a bundle of national patents, with each country applying its own set of patent laws. Obtaining an European Patent in the current situation is very costly and there are possible legal difficulties for companies that want to protect their inventions across all European countries. Mainly for these two reasons the European Community has been working on a European Union Patent, or EU Patent[17], since the 1970s. The current status of this ongoing debate is a proposition by twelve member states to use the enhanced cooperation procedure to set up a unitary patent applicable in all participating European Union Member States. Twenty-five Member States have written

[17] The EU Patent is formerly known as the Community Patent, or European Community Patent, or EC Patent. Often, it is abbreviated as COMPAT.

to the European Commission requesting to participate. Spain and Italy remain outside the enhanced cooperation process of forming an enhanced coorperation EU Patent primarily on the basis of ongoing concerns over translation issues.[18]

Using the estimates of the private value of European Patent rights we find that the aggregate value of granted European Patents in 2004 is 2.9 billion euros. The average value of an European Patent granted in 2004 is approximately 51 thousand euros. Table 11 presents the aggregate value of gratned European Patents in 2004 under the reduction of validation and translation costs in the form of an EU Patent and an enhanced coorperation EU Patent. In these simulations it is assumed that the validation costs reduce to zero and the patent only has to be translated in the three official languages of the EPO, namely English, French and German. Since the renewal fees of the national patent offices are the major part of the revenues, we assume that the renewal fees for an EU Patent as a whole have to replace the renewal fees of the national patent offices. Under these assumptions we find that the introduction of an EU Patent would increase the aggregate value of European Patents granted in 2004 by 15%. The average value of an European Patent increases by 15% as well to 59 thousand euro. Excluding Italy and Spain from the EU Patent and maintaining the present situation for these countries would increase the aggregate value of European Patents granted in 2004 by 11% to 3.23 billion euros. The average patent value under enhanced coorperation increases by 11 % to 57 thousand euro.

For both the EU Patent as the enhanced cooperation EU Patent the gains in average

[18]On 15 February, the European Parliament gave its approval for member states to make use of the enhanced cooperation procedure for setting up a common patent system. The agreement among 25 member states concerns the creation of the European patent which in legal jargon is known as a "unitary patent title" as well as the use of English, French and German as the three main working languages. Before the agreement on enhanced co-operation had even been reached, on 8 March, the European Court of Justice ruled that the creation of a Community Patent Court would not be compatible with the provisions of EU law, thereby casting a shadow of doubt over plans to establish a Europe-wide patent system. On March 11 2011, ministers from 25 member states decided to go ahead with plans to introduce a common system for registering patents that would save European businesses millions of euros each year. Italy and Spain excluded themselves, because they refused to accept the proposed rules regarding the choice of official working languages.

and aggregate value stem from three sources. First, the cost associated with validation at the national level are cancelled. In 2004 the aggregate validation costs are over 90 million euro, leading to an average increase in patent value by 1,600 euro. The second source of value increase is cancellation of additional patent translations, except for the three offical EPO languages. On the aggregate level this leads a growth of aggregate patent value by 575 million euro. However, part of this aggregated patent value depreciates by 250 million euro due to patents that make a loss when validated in all EU-countries. This is the case for 16,620 European Patents granted in 2004. The remaining 40,360 European Patents generate additional benefits of patent rights when validated in all EU-countries. This third source generates an additional aggregate value of approximately 25 million euro. Summed up, The introduction of an EU Patent generates 575+90+25-250 = 440 million euro of additional benefits.

In the same way the introduction of an enhanced cooperation EU Patent lead to an increased aggregate value due to 70 million euro savings on validation costs, 470 million euro savings on patent translations, a 230 million euro depreciation due to patents making a loss when validated in the enhanced cooperation and an additional benefit of 20 million euro due to patent rights validated in the enhanced cooperation.

Table 11: Value estimates of European Patent, the EU Patent and the enhanced cooperation community patent.

European Patent	
Stock value (mln euro)	2,900
Mean patent value (euro)	50,895
EU Patent	
Stock value (mln euro)	3,340
Value increment	15%
Mean patent value (euro)	58,617
enhanced coorperation EU Patent	
Stock value (mln euro)	3,230
Value increment	+11%
Mean patent value (euro)	56,687

7 Conclusion

The value of patent rights varies across inventions, countries and industries, which makes it very difficult to study its determinants. Identifying the contribution of factors like market size and the level of enforcement of intellectual property rights can guide policymakers in shaping and enhancing incentives for innovation.

We exploit the validation behavior of European Patent owners to identify how the value of a single patent varies with country and industry characteristics.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. These validation decisions are then used to simultaneously infer the value of the patent right in particular countries and the factors that influence this value.

The empirical evidence confirms earlier results that the value of patent rights is sharply skewed, with most of the value concentrated in the tail of the distribution. It also shows that there are differences between industries in terms of the characteristics of the distribution. Over all industries the mean patent value is about 51k euro. The mean patent values in electrical engineering, instruments and mechanical engineering are much lower, 18k, 27k and 15k respectively. Patent values in chemistry and pharamceuticals rise much sharper with the quantile than in other industries, resulting in higher mean values, 78k and 400k ,respectively.

We have presented evidence showing that potential demand for the underlying invention 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. The relative contribution of potential demand as measured by market size to the value of patent rights is 67%. For education this is 14%. Besides demand, also the need for protection against infringement is a determinant of the value of patent rights. We use the level of general trust as an indicator of the inclination to imitate. Our empirical results show that general trust accounts for a -17% contribution to the value of a patent right. Lastly, we have shown that the level of enforcement of IPR rights in a country positively affects the validation decision and the value of the patent as well. It accounts for 37% to the value of patent rights.

The aggregate value of European Patents granted in 2004 is about EUR 2.90 billion. By adjusting validation costs and the costs associated with the numerous translation requirements, we can simulate the value added of introducting an EU Patent. Our simulations show an increase of 15 percent of the value of the in 2004 granted European Patent stock to EUR 3.34 billion.

A EPC Member States

Table 12: EPC Member States as of June 2011

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

B Value of European Patent rights

Table 13: Distribution of the value of European Patent rights, by technology field.

Quantile	Whole sample	electrical engineering	instruments	chemistry	mechanical engineering	pharmaceu-ticals	other industries
.25	3,350	2,325	3,215	9,000	2,165	36,465	4,640
.50	13,750	5,825	15,100	22,735	10,500	115,730	11,700
.75	29,325	24,550	27,660	45,900	18,870	164,660	22,330
.90	62,500	38,950	59,125	92,400	35,000	215,617	38,850
.95	109,325	56,565	85,800	135,980	48,275	288,940	49,925
.99	205,875	126,500	155,275	256,200	73,620	520,100	66,860
mean	27,240	16,940	23,395	38,975	14,490	120,380	16,075

References

Bessen, J., 2008, The value of US patents by owner and patent characteristics, *Research Policy*, vol. 37, pp. 932–945.

Bessen, J.E. and M.J. Meurer, 2006, Patent litigation with endogeneous disputes, *American Economic Review*, vol. 96, no. 2, pp. 77–81.

Chamberlain, G., 1980, Analysis of covariance with qualitative data, *Review of Economic Studies*, vol. 47, pp. 225–238.

Danguy, J. and B. van Pottelsberghe de la Potterie, 2010, On the consequences of an EU patent for inventors and patent offices, Tech. rep., VoxEU.org, http://www.voxeu.org/index.php?q=node/5294.

Danguy, J. and B. Van Pottelsberghe de la Potterie, 2009, Cost-benfit analysis of the community patent, Breugel Working Paper 2009/08.

Duchateau, L. and P. Janssen, 2008, *The Frailty Model*, Springer, New York.

EPO, 2003, National law relating to the EPC, Tech. rep., Munchen.

European Commission Communication, 2007, Enhancing the patent system in Europe, Com (2007) 165.

Forum, W.E., 2008, Global competitiveness index, Tech. rep.

Galasso, A. and M. Schankerman, 2010, Patent thickets, courts, and the market for innovation, *the RAND Journal of Economics*, vol. 41, no. 3, pp. 472–503.

Ginarte, J.C. and W.G. Park, 1997, Determinants of patent rights: a cross-national study, *Research Policy*, vol. 26, pp. 283–301.

Griliches, Z., 1990, Patent statistics as economic indicators: a survey, *Journal of Economic Literature*, vol. 28, pp. 1661–1707.

Hall, B.H., A. Jaffe and M. Trajtenberg, 2005, Market value and patent citations, *RAND Journal of Economics*, vol. 36, no. 1, pp. 16–38.

Harhoff, D., N. Francis, F.M. Scherer and K. Vopel, 1999, Citation frequency and the value of patented inventions, *Review of Economics and Statistics*, vol. 81, pp. 511–515.

Harhoff, D., K. Hoisl, B. Reichl and B. van Pottelsberghe de la Potterie, 2009, Patent validation at the country level - The role of fees and translation costs, *Research Policy*, vol. 38, pp. 1423–1437.

Harhoff, D., F.M. Scherer and K. Vopel, 2003, Citations, family size, opposition and the value of patent rights - Evidence from Germany, *Research Policy*, vol. 32, pp. 1343–1363.

Johnson, D.K., 2002, The OECD Technology Concordance (OTC): Patents by industry of manufactore and sectors of use, OECD Science, Technology and Industry Working Papers, 2002/5.

Lanjouw, J.O., 1998, Patent protection in the shadow of infringement: simulation estimations of patent value, *Review of Economic Studies*, vol. 65, pp. 671–710.

Lanjouw, J.O. and M. Schankerman, 2004, Patent quality and research productivity: Measuring innovation with multiple indicators, *Economic Journal*, vol. 114, no. 495, pp. 441–465.

Lanjouw, J., A. Pakes and J. Putnam, 1998, How to count patents and value intellectual property: The uses of patent renewal and application data, *Journal of Industrial Economics*, vol. 46, no. 4, pp. 405–32.

McGilchrist, C.A. and C.W. Aisbett, 1991, Regression with frailty in survival analysis, *Biometrics*, pp. 461–466.

Pakes, A., 1986, Patents as options: some estimates of the value of holding European Patent stocks, *Econometrica*, vol. 54, pp. 755–784.

Pakes, A. and M. Schankerman, 1984, The rate of obsolence of patents, research gestation lags, and the private rate of return to research resources, in Z. Griliches, ed., *R&D, Patents, and Productivity*, pp. 73–88, University of Chicago Press.

Park, W.G., 2008, International patent protection: 1960-2005, *Research Policy*, vol. 37, pp. 761–766.

Schankerman, M., 1998, How valuable is patent protection? Estimates by technology field, *RAND Journal of Economics*, vol. 29, no. 1, pp. 77–107.

Schankerman, M. and A. Pakes, 1986, Estimates of the value of patent rights in European countries during the post-1950 period, *The Economic Journal*, vol. 96, pp. 1052–1076.

Silverberg, G. and B. Verspagen, 2007, The size distribution of innovations revisited: an application of extreme value statistics to citation and value measures of patent significance, *Journal of Econometrics*, vol. 139, no. 2, pp. 318–339.

Straathof, B. and S. van Veldhuizen, 2010, Another reason for the eu patent: Declining validation rates, Tech. rep., VoxEU.org, http://www.voxeu.org/index.php?q=node/5909.

Sullivan, R., 1994, Estimates of the value of patent rights in Great Britain and Ireland, *Econommica*, vol. 61, pp. 37–58.

Trajtenberg, M., 1990, A penny for your quotes: Patent citations and the value of inventions, *RAND Journal of Economics*, vol. 21, pp. 172–187.

van Pottelsberghe, B. and M. Mejer, 2008, The London agreement and the cost of patenting in Europe, Discussion Paper 7033, CEPR.

Van Pottelsberghe de la Potterie, B., 2010, Europe should stop taxing innovation, Breugel Policy Brief 2010/02.

Van Pottelsberghe de la Potterie, B. and M. Mejer, 2009, Economic incongruities in the european patent system, Breugel Working Paper 2009/01.