Patent Value: Issues, Measurement & Determinants

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Background papers

- **The Value of European Patents**, *European Management Review (July, 2008)*
- **Determinants of the Private Value of Patents** (*draft*)
- Both with
  - *Dietmar Harhoff*, LMU
  - *Bart Verspagen*, University of Maastricht

Plan of presentation

- Patent Value, measurement and issues
- Determinants
- Role of patent institutions (granting process)

Value of a Patent

- Hard to measure without a well defined market (e.g., compare to real estate)
- Clearly patents are an asset
- Value of patents = Value of invention + Patent premium
- Linked to other assets
  - Can be more valuable to you than to others
  - It is less valuable if the value of some complementary asset diminishes
- Value to you different from value at which you can liquidate it
- Studying patent value important for understanding markets for technology

Commonly Used Valuation Terms

Boehringer Ingelheim

NPV—the current value of predictable future cash flows. NPV = $x/(1xK)^n$. The net cash flow (x) is discounted annually at the discount rate (k) and is paid in n years.

rNPV—the current value of risky future cash flows. rNPV = $xr/(1 + k)^n$. Net present value is risk adjusted (r; typically clinical trial pass-or-fail probabilities).

Real options—a valuation method based on financial options pricing in which options to increase or decrease investment are accounted.

Cash-on-cash valuation—a comparison of the cash invested in a company with the cash received upon liquidity. This is commonly used in private equity.

Internal rate of return (IRR)—The ‘interest rate‘ an investment earns.

Comparable analysis—A potential investment‘s value at liquidity (exit value) is estimated by comparison to similar exit values. This is typically paired with IRR or cash-on-cash valuation.

Monte Carlo simulation—Different outcomes are assigned probabilities and random numbers are used to generate a histogram of outcomes.

Source: Nature Biotechnology

Literature

- Cites, background references, claims, states
- Change in market value of firms due to increase in patents (or citations) – Hall et al., 2005; Bessen, 2008, 2009

Patents as an Asset

- Our measure of patent value (PatVal-EU):

  What is your best guess of the minimum price at which the owner of the patent would sell the patent right to an independent party on the day in which the patent was granted?

- Follows Harhoff and Scherer

- We offer a menu of 10 value intervals: < 30K; 30-100; …; to > 300M

- Can also be interpreted as market value of a company whose only asset is the patent

The PatVal-EU Survey

- EPO patents with priority date 1993-1997
- Denmark, France, Germany, Hungary, Italy, Netherlands, Spain, UK
- Questionnaire sent to first inventor (if not available: any other inventor)
- Questions on inventor biography, employer, invention process, invention characteristics
- 27,000 questionnaires mailed, nearly 10,000 responses (17.9% UK, 40.2% DE, 13.8% IT, 1.7% ES, 12.9% FR, 13.3% NL)
- For details see PatVal-EU Final Report (2005) (www.alfonsogambardella.it; Giuri et al. *Research Policy* 2007, October)

Value of European Patents (EMR)

- Assess distribution of patent values
- Validates PatVal-EU measure of value
- Correlate it with commonly used indicators
- Shows that cites, claims, references, states, technology, country and IPC3 dummies only explain 11% of variance
- “Measure of our ignorance”

Figure 1: Distribution of VALUE

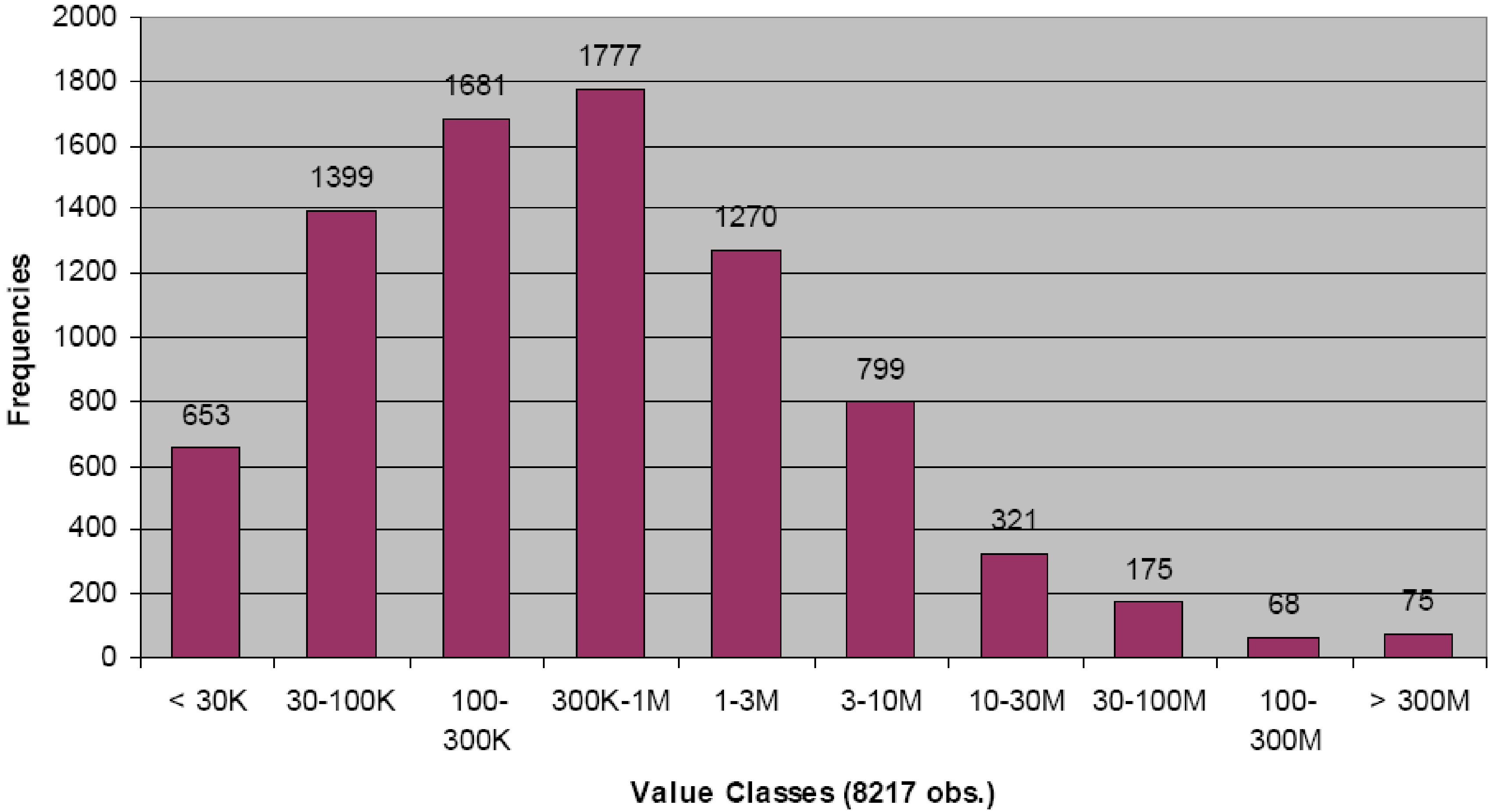


Figure shows that the PatVal-EU patent VALUE distribution is skewed. Since the difference in the logs of the boundaries of the intervals is roughly constant, the distribution in the figure is an approximation of a log-normal. Even the log-normal distribution looks skewed.

Table 8: Estimated moments of the patent value distribution, assuming log-normality (values in 000 2003 Euros, corrected by German dummy)

Moment	*Theoretical expression for the log-normal distribution* (+) (^)	*Estimated moment* (§)(^)
Mean	$exp(\mu + \sigma^2/2)$	Average of $exp(\mu_i + \sigma^2/2)$
PatVal-EU sample (N = 8217)	3138.6	3550.8
All patents (N = 49941) (*)	3015.6	3422.6
Median	$exp(\mu)$	Median of $exp(\mu_i)$
PatVal-EU sample (N = 8217)	397.4	382.7
All patents (N = 49941) (*)	381.8	365.3
Mode	$exp(\mu - \sigma^2)$	Average of $exp(\mu_i - \sigma^2)$
PatVal-EU sample (N = 8217)	6.4	7.2
All patents (N = 49941) (*)	6.1	6.9

(+) The parameter μ is the average of the fitted values of the first equation in Table 7, viz. E(*log*(VALUEM), using the German constant for all the observations. For the PatVal-EU sample the average is computed across the 8,217 PatVal-EU observations, and it is $\mu = 5.985$. For the full set of patents is predicted from the available regressors for all the 1993-1997 EPO patents, and it is $\mu = 5.945$.

(^) The estimated $\sigma = 2.033$ is the standard error of the first regression in Table 7.

(§) The parameter μ_i denotes the fitted values of *log*(VALUEM) for the generic *i*th observation.

(*) All EPO patents with priority year 1993-1997 granted by 2003.

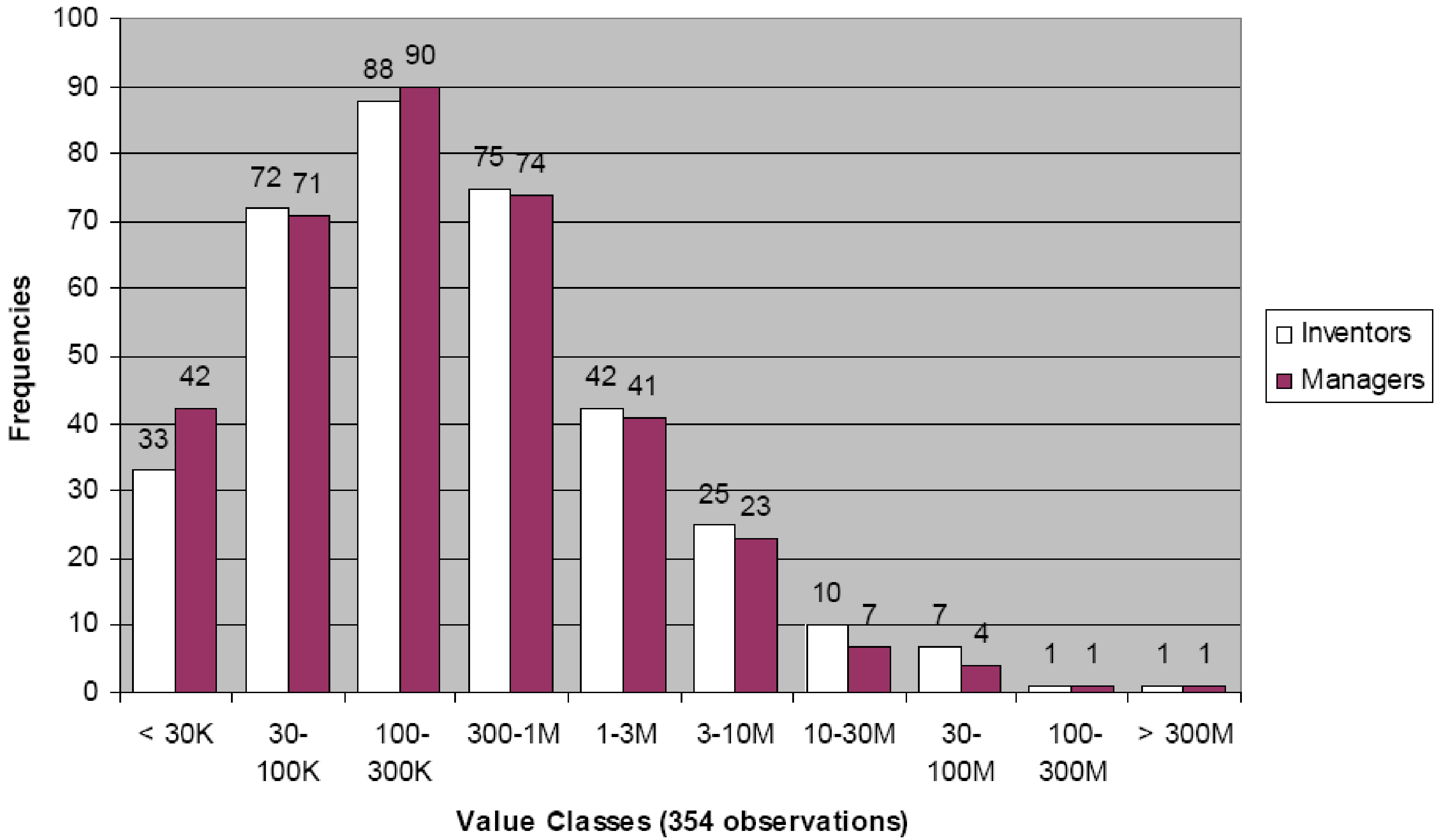
Problems/Validation

- We ask the inventor
- Is it correlated with commonly used indirect indicators (cites, refs, etc.)?

We ask the inventor

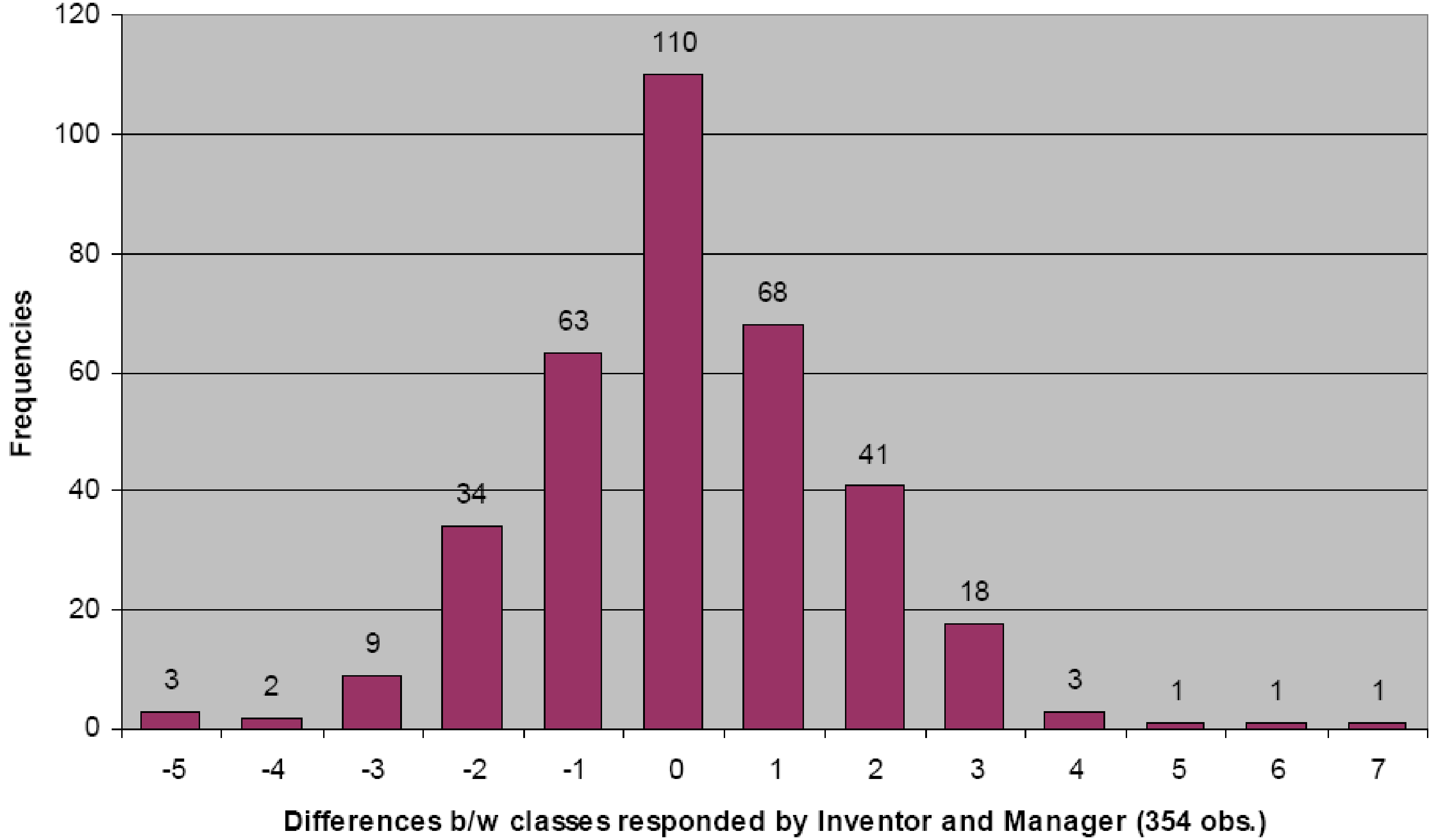
- But
  - It is hard to find the right manager for each patent in a large scale survey (Who? Where? Still there?)
  - The inventor is the easiest person to identify who is associated to the invention, and knows about the patent
- We compare responses of 354 French managers and inventors, and find small differences
- Formal test shows that difference is slightly significant for larger firms

Figure 2: Distribution of VALUE, responses by 354 French inventors and managers



VALUE responses by 354 French inventors and managers who were responsible for the patent and provided independent responses about its value of the same patent. Figure shows that the two distributions are similar.

Figure 3: Differences in VALUE, responses by 354 French Inventors and Managers



VALUE responses by 354 French inventors and managers who were responsible for the patent and provided independent responses about its value. Figure shows that almost 90% of the responses fall within two VALUE classes

Correlation with other indicators

- Show that it is correlated with cites, backward references, states, claims
- Moreover, right tail cites correlated with right tail patent values

Table 1: Description of variables employed in the analysis

Variable	Description
VALUE	Index equal to 1-10 for the following PatVal-EU classes of patent values: ≤€30K; 30-100K; 100-300K; 300K-1M; 1-3M; 3-10M; 10-30M; 30-100M; 100-300M; ≥300M
VALUEM	Mid point of VALUE (15K; 65K; 200K; 650K; 2M; 6.5M; 20M; 65M; 200M; 650M [(§)])
CITES	# of forward citations to the patent within 5 years after the publication of the patent (usually 18 months after the priority date), including citations to equivalent patents
REFS	# of backward references in the patent
CLAIMS	# of claims of the patent at the moment of grant
STATES	# of designated European countries in which the patent is applied for
CITES0-5	6 dummies for CITES = 0; 1; 2; 3-5; 6-8; or ≥ 9, corresponding to the following percentiles of the CITES distribution of all the EPO patents with priority date 1993-1997 granted by 2003 and with first inventor in our eight countries (49941 patents): 1-45; 46-70; 71-83; 84-96; 96-98; ≥ 99.
VALUE≥5, VALUE≥6, VALUE≥7	3 dummies equal to 1 if VALUE ≥ 5, 6 or 7, corresponding to 17.5%, 7.8%, or 3.9% of the 8217 PatVal-EU patents for which data on VALUE are available.
Country dummies	8 dummies for address of the first inventor in Denmark, France, Germany, Hungary, Italy, Netherlands, Spain, UK
Application year dummies	6 dummies for application years 1993-1998 [(+)].
Technology dummies	30 technological area dummies obtained by converting the IPC classes of the patent using the ISI-INPI-OST concordance list [(*)].
IPC 3-digit dummies	117 dummies for the main IPC 3-digit class of the patent

Table 10: Testing the impact of the tail of CITES on the tail of VALUEM

	Dependent Variable log(VALUEM) OLS	*Dependent Variable VALUE≥5 Probit (marginal effects)*	*Dependent Variable VALUE≥6 Probit (marginal effects)*	*Dependent Variable VALUE≥7 Probit (marginal effects)*
CONST	5.835***	--	--	--
	(0.000)			
CITES1	0.152**	0.017	0.006	-0.000
	(0.011)	(0.101)	(0.342)	(0.989)
CITES2	0.204***	0.016	0.005	0.002
	(0.005)	(0.213)	(0.560)	(0.670)
CITES3	0.602***	0.076***	0.041***	0.013***
	(0.000)	(0.000)	(0.000)	(0.007)
CITES4	0.732***	0.103***	0.053***	0.019*
	(0.000)	(0.001)	(0.002)	(0.065)
CITES5	1.142***	0.194***	0.064***	0.055***
	(0.000)	(0.000)	(0.006)	(0.001)
LOG(1+REFS)	0.136**	0.018	0.009	0.004
	(0.031)	(0.106)	(0.136)	(0.201)
LOG(CLAIMS)	0.168***	0.019***	0.005	-0.001
	(0.000)	(0.006)	(0.274)	(0.675)
LOG(STATES)	0.395***	0.048***	0.022***	0.015***
	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.114	--	--	--
N. Observations	8217	8143	8007	7344

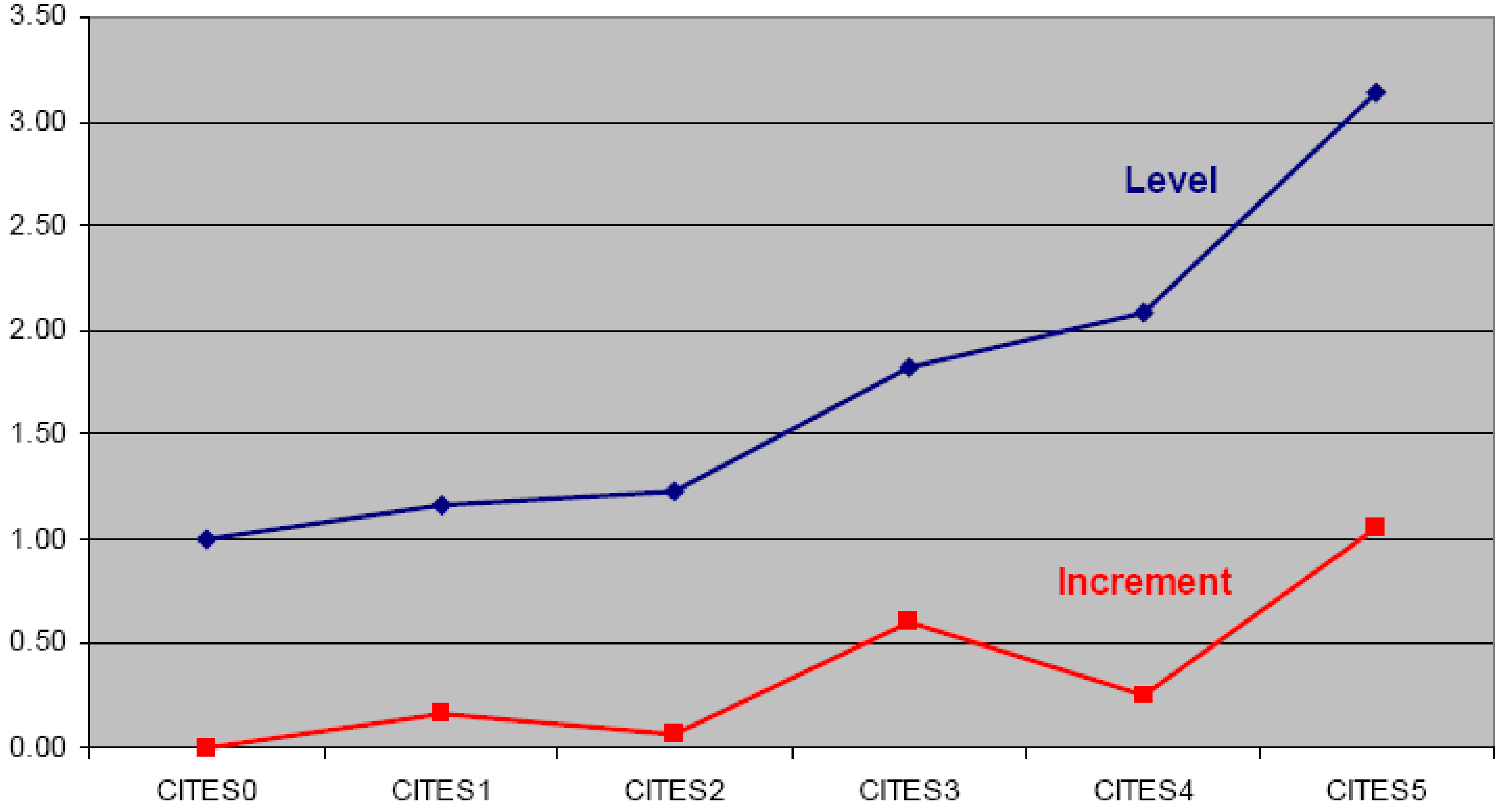
P-values based on robust standard errors in parentheses. * p < 10%; ** p < 5%; *** p< 1%. All regressions include country, application year, industry and IPC 3-digit dummies, sampling weights, and clustering by patent applicants. In the probits some IPC 3-digit dummies perfectly predict the dependent variable, and the corresponding observations are dropped. However, the results shown here are robust to several alternative estimations. Table shows that the right tail of the citation distribution predicts increasingly higher patent values (first column) and that it highly correlated with the probability that the patent falls in the top VALUE classes.

Table 11: Estimated probabilities of patents being in the top value classes conditional upon citation class

CITES classes (%tiles)	*Prob(VALUE≥5 | CITES)* (top 17.5% patent values)	*Prob(VALUE≥6 | CITES)* (top 7.8% patent values)	*Prob(VALUE≥7 | CITES)* (top 3.9% patent values)
CITES0 (1-45)	15.4%	6.9	3.6
CITES1 (46-70)	17.1	7.5	3.6
CITES2 (71-83)	17.0	7.4	3.8
CITES3 (84-96)	23.0	11.0	4.9
CITES4 (96-98)	25.7	12.2	5.5
CITES5 (≥ 99)	34.8	13.3	9.1

Prob(VALUE≥X | CITES0) = $P^* - \sum_{i=1}^{5} b_i w_i$, where X = 5-7; P* = 17.5%, 7.8% or 3.9%; b_i is the estimated marginal effect of the CITES classes i = 1-5 in the column of Table 10 corresponding to X=5-7; w_i is the share of the CITES class in the 49941 EPO patent distribution (respectively 25.1%, 12.8%, 12.3%, 2.6%, 1.3% for CITES1-5). The probabilities conditional upon CITES1-5 are then computed by adding the corresponding estimated marginal effect. Table confirms that patents in the right tail of the citation distribution are also more likely to be in the top value classes. Yet, quite a few patents with high citations have low value and vice versa. For instance, of the patents in CITES5, 34.8%, 13.3% and 9.1% fall in the top 17.5%, 7.8% and 3.9% patents ranked by VALUE, which is a much higher probability than the random patent. Yet, this also means that for the vast majority of CITES5 patents (65.2%) VALUE < 5.

Figure 4: Estimated impacts of the citation dummies (CITES0-5) on patent value (first column of Table 10), impact of CITES0 normalized to 1



Impact of CITES1-5 computed as the exponential of the corresponding estimated parameter in the first column of Table 10. Increment is the change vis-à-vis the previous class of CITES. Figure shows that patent values grow exponentially as we move to higher citation classes. Also, increment increases.

Determinants of patent value

- We know
  - Value of PatVal-EU patent (**V**)
  - # of technically related patents (portfolio) (**N**)
  - Man-months invested in patent and in portfolio (**M**, **MF**)
  - Age, Education, Past Cites of inventor (**A**, **E**, **Z**)
  - Other characteristics of the organization, the patent, along with proxies of the patent premium
- We then look at determinants of **V** and **N**, and thus of **V*N** (value of portfolio)

What we expect to find (theory)

- View of the innovation process
  - Easier to control N than V
  - Stronger effect of resources other variables on N than V

What do we find?

- ***V = V(N, M, Z, A, E, X), N = N(M, MF, Z, A, E, X)***
- M → V 4% (hence NV 4%)
- Same M spread on N patents → NV 24%
- Z → no effect on V, *negative* on N (exhaustion effect)
- A & E → no effect on V, *positive* on N (PhD)
- Z → negative effect on M & MF but stronger on M (costs)
- A & E → positive effect on M & MF (experience or edu, work more on inventions)

What do we find?

- Value of patent portfolio increased more by spreading on technically related patents than focussing on raising the value of one patent (suggests value of exploration in inventive activity)
- Past inventor successes reduce N (and NV)
- But these inventors produce N with fewer M, MF – thus could raise NV in a given interval of time (or produce lower values at much lower costs)
- Otbe, a PhD produces more value than a college inventor as if she had the experience of a 60 compared to a 30 year inventor (strong effect of education)
- PhDs with no past successes most likely to produce high value portfolios in the near future … but PhDs with past successes could produce lower values at much lower costs (exploration vs exploitation)
- Implications for patent offices? … accomodate granting of variants by inventors (though careful about strategic patenting)

Does Patent Granting Make a Difference?

- Gili Greenberg (two papers)
- Studies 600 Israeli start-ups, and looks at how VC evaluation changes when patents are applied for and then when granted
- Theory suggests that there should be no difference if there are unbiased expectations about grant
- Grant could change things from application but the key is whether such changes are systematically unpredicted by VC because of asymmetric information

Does Patent Granting Make a Difference?

- Greenberg finds that grants raises evaluation of start-ups on top of pending only for firms less than 6 years old
- Suggests that grants provide good info about young firms that VCs were unable to see
- She finds the same effect on acquisitions
- Suggests that granting process by patent offices can be value creating as it helps good young firms … faster assessment of patent applications of younger firms?

Conclusions

- It is important to study the value of patents
  - Sure it’s hard and unclear what patent value is, but is it a reason for not trying to understand it?
  - One good reason is that a clearer assessment of patent values facilitates technology markets
  - Need to study values of technically related patents (portfolios)
- Easier to control breadth than depth of invention value
  - Suggests that Patent Offices may want to accommodate technically relevant variants of basic patents, though careful about strategic intents
- Granting can be a value creating process for younger firms because it provides an independent assessment of their value
  - Faster granting processes for very young firms?

Thank you for your attention!

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