Appendix 1 - Theoretical Model

Introduction

Our empirical analysis focuses on the probability that a patent application is opposed. We adopt the perspective of the potential opponents choosing whether or not to oppose. The solution to their decision problem yields characteristics of the patents that these firms are likely to oppose and of the technologies that the opposed patents belong to.

We model two effects that reduce a firm's incentives to oppose a patent application. The patent thicket effect derives from the behaviour of the applicant in a patent thicket. The public good effect derives from the presence of other potential opponents and may be effective in or outside a patent thicket.

1. The patent thicket effect is based on two aspects of patent thickets: patent owners hold large portfolios of patents covering related or similar technologies and patents are losely drafted leading to many potential conflicts between the patent owers. We identify two possible explanations for the patent thicket effect:

    - retaliation - the opponent may fear retaliatory oppositions or other forms of retaliation initiated by the patent applicant;
    - ineffectiveness of opposition - if the applicant makes multiple simultaneous applications, each one of which could reduce the opponent's profits, then opposing all of these applications may not be cost effective.

2. The public good effect - the opponent may perceive less need to oppose a patent that affects several other firms. If so, the aggregate effect on all opponents may be strong enough to reduce the overall probability of opposition.

We begin by analyzing the patent thicket effect, focusing on one applicant and one opponent. Once we have developed the logic of the opposition decision for this case, we add further potential opponents to the model to analyze the public good effect.

Literature Review

The literature on patent litigation, and by extension opposition, has largely focused on factors that determine when firms might settle disputes over a patent application cooperatively (Lanjouw and Lerner, 1998, Siegelman and Waldfogel, 1999, Harhoff and Reitzig, 2004). Our analysis focuses on a preceding decision which is made by a potential opponent, namely the decision whether or not to initiate opposition at all. We focus on variables that might lead the patent owner to conclude that opposition will be more expensive than simply living with the patent.

In undertaking this analysis we abstract from the costs of the opposition procedure for the applicant. This means we do not have to consider the possibility that firms settle their disputes, which keeps our analysis simple. The reason is that the applicant has no incentive to settle as

they will still have some positive expectation that opposition might fail. In the resulting model potential opponents therefore choose between living with the patent or opposition and any resulting behavior on the part of the applicant.

Notation

Assume that a potential opponent's profits are initially π. With exogenously varying probability $1 \geq \sigma \geq 0$ the applicant firm's patent is significant enough to pose a threat to the potential opponent's future profits and the costs which it can create for the opponent are Γ. The probability that the applicant's patent will not survive opposition is given by $1 \geq \nu \geq 0$. The applicant's profits if the patent is granted are $\tilde{\pi} < \Gamma$, explaining why there is no cooperative solution.

The potential opponent's decision to oppose the applicant's patent depends on the degree of overlap between the two firms' patent portfolios. If overlap is high, then it is likely that the applicant firm will be able to retaliate, creating further costs Ψ for the focal firm. The probability that this happens and lowers own profits is $1 \geq \rho \geq 0$.

1.1 The Patent Thicket Effect

In a patent thicket opposition may prove to be costly, because it gives rise to retaliation by the opposed firm, or opposition may prove to be futile. We develop both cases below. First, consider retaliation.

Retaliation

The opponent will oppose the applicant's patent if this is more profitable than not opposing:

$$\sigma\Big[\nu\Big((1-\rho)\pi+\rho(\pi-\Psi)\Big)+(1-\nu)\Big((1-\rho)(\pi-\Gamma)+\rho(\pi-\Psi-\Gamma)\Big)\Big] + (1-\sigma)\,(\pi-\rho\Psi) > \sigma\,(\pi-\Gamma)+(1-\sigma)\,\pi \Leftrightarrow \sigma\nu\Gamma > \rho\Psi \quad . \quad (1)$$

The opponent will choose to oppose the patent application whenever the expected value of the costs that opposition would remove $(\sigma\nu\Gamma)$ exceed the expected cost of retaliation $(\rho\Psi)$.

This simple trade-off explains why we expect opposition to be less likely between firms at the centre of a patent thicket: the probability of retaliation (ρ) is higher for such firms, because the applicant is more likely to hold a large portfolio of patents that allow such retaliation.

This explains Hypotheses 1 - 3. Insiders in the patent thicket have highly linked portfolios, making retaliation very easy, while outsiders have fewer links with a given insider's portfolio, which lowers ρ in any bilateral relationship between an insider and an outsider.

The model indicates that there could be a counteracting effect. Technology areas affected by a thicket are characterized by a high volume of patent applications. The quality of patents

issued in areas with higher demands on the patent office's resources will not be higher than the quality of patents in other technology areas and most likely is significantly lower. Therefore ν is likely higher in a patent thicket increasing the expected profits from opposition.

In our empirical analysis we employ a number of variables that proxy the quality of patent examination. This allows us to identify the effects of retaliation on opposition using the triples measure.

Ineffective Opposition

Even if the opponent does not fear retaliation by the applicant, it may be that opposition is seen to be futile because the applicant has made multiple similar applications.

To capture this effect we introduce two further parameters:

C - the fixed cost of opposition for the opponent and

τ - the number of simultaneous applications that could affect the opponent's profits, where ($\tau \geq 1$).

To isolate the effects of multiple simultaneous applications we assume that the probability of retaliation is zero ($\rho = 0$). Then the tradeoff between opposing all τ patents submitted by the applicant and not opposing any is:

$$\begin{aligned}[(1-\sigma)+\nu\sigma]^{\tau}\pi + (1-[(1-\sigma)+\nu\sigma]^{\tau})(\pi-\Gamma) - \tau C > \\ (1-\sigma)^{\tau}\pi + (1-(1-\sigma)^{\tau})(\pi-\Gamma) \\ \Leftrightarrow \Gamma\Big([(1-\sigma)+\nu\sigma]^{\tau} - (1-\sigma)^{\tau}\Big) > \tau C \quad (2)\end{aligned}$$

Here $[(1-\sigma)+\nu\sigma]^{\tau}$ is the probability that none of the τ patent applications will reduce the opposing firm's profits. In setting up this expression, we assume that the outcome of opposition cases is independent and that the opposing firm does not know which of the τ patents are problematic, so that it must oppose all of them. Equation (2) shows that as the number of simultaneous patent applications by the applicant (τ) increases the cost of opposing all of these applications rises linearly, while the expected benefit of opposition falls in τ.

Therefore, as applicants submit increasing numbers of simultaneous patent applications relevant to a specific technology, opposition becomes proportionately less cost effective.

This mechanism can also support Hypotheses 1-3. Insiders in the thicket are identified as being linked by more critical references. This implies that simultaneous applications by an insider are likely to be more threatening for another insider than the same number of simultaneous applications by an outsider. Therefore insiders will evaluate opposition against insider patent applications as being futile sooner than against outsider patent applications.

The triples measure will capture this effect, but a better measure would consist of the number of simultaneous patent applications covering similar technology submitted by the applicant. To construct this measure requires information on similarity of technology covered

by patent applications which would have to be derived using text mining techniques. Such measures are only just being tested and we do not yet have the necessary information to use such a measure.

1.2 Public Good Effect

In this section we extend the logic of the patent thicket effect to a setting with $\eta-1$ further firms all of whom are equally affected by the focal patent application. The η potential opponents are playing a coordination game amongst themselves. We solve for the mixed strategy equilibrium of this game in which each firm opposes the applicant's patent with probability ω. The public good effect can be derived for settings in which retaliation or ineffective opposition are at work.

The Public Good Effect and Retaliation

The main difference between opposing and not opposing the patent is that firms which do not oppose the patent are not in danger of retaliation from the patent's owner. Payoffs from opposing the patent application are:

$$\Big(\big(\pi-\rho\Psi\big)-\sigma(1-\nu)\Gamma\Big) \tag{3}$$

Payoffs from not opposing the patent application are:

$$\Big(1-(1-\omega_{i\not j})^{\eta-1}\Big)\Bigg(\pi-\sigma(1-\nu)\Gamma\Bigg)+(1-\omega_{i\not j})^{\eta-1}\Big(\pi-\sigma\Gamma\Big) \tag{4}$$

Initially we investigate whether not opposing can be a dominant strategy for all firms. Comparing the payoffs obtainable from opposing to those obtainable from not opposing, it is obvious that $(\pi-\sigma(1-\nu)\Gamma) > ([\pi-\rho\Psi]-\sigma(1-\nu)\Gamma)$ and it can be shown that $(\pi-\sigma\Gamma) > ((\pi-\rho\Psi)-\sigma(1-\nu)\Gamma) \Leftrightarrow \rho\Psi > \sigma\nu\Gamma$. This implies that if an individual firm does not find it optimal to oppose, adding any number of further firms as additional potential opponents will not alter this firm's decision. However, if opposition is optimal for each firm alone, then choosing to oppose with positive probability ($1>\omega>0$) is optimal in the presence of multiple potential opponents. Expected payoffs are:

$$\begin{aligned}\omega_i&\Big(\big(\pi-\rho\Psi\big)-\sigma(1-\nu)\Gamma\Big)\\&+(1-\omega_i)\Bigg[\Big(1-(1-\omega_{i\not j})^{\eta-1}\Big)\Bigg(\pi-\sigma(1-\nu)\Gamma\Bigg)+(1-\omega_{i\not j})^{\eta-1}\Big(\pi-\sigma\Gamma\Big)\Bigg]\end{aligned} \tag{5}$$

As all firms are symmetrical this leads to the following expression for the probability with which firms oppose the patent application, whenever opposition is optimal for each firm:

$$(1-\hat{\omega})^{\eta-1} = \frac{\rho\Psi}{\sigma\nu\Gamma} \Leftrightarrow \hat{\omega} = 1 - \Big(\frac{\rho\Psi}{\sigma\nu\Gamma}\Big)^{\frac{1}{\eta-1}} \quad . \tag{6}$$

Comparative Statics We now analyze the comparative statics of the public goods effect based on retaliation. First of all it is important to realize that we are interested in the overall probability that the applicant's patent is opposed by at least one firm:

$$\Omega = 1 - (1-\hat{\omega})^{\eta} \tag{7}$$

Analyzing how this probability changes with the number of potential opponents we identify two effects:

i) adding a potential opponent increases the overall probability of opposition if individual opposition probabilities are held constant and

ii) each potential opponent's probability of opposition may drop as an additional firm joins the group of potential opponents.

$$\begin{aligned}\frac{\partial\Omega}{\partial\eta} &= \underbrace{-(1-\hat{\omega})^{\eta}\ln(1-\hat{\omega})}_{i} + \underbrace{\eta(1-\hat{\omega})^{\eta-1}\frac{\partial\hat{\omega}}{\partial\eta}}_{ii} \\ &= (1-\hat{\omega})^{\eta-1}\Big(-(1-\hat{\omega})\ln(1-\hat{\omega}) + \eta\frac{\partial\hat{\omega}}{\partial\eta}\Big)\end{aligned} \tag{8}$$

If $\frac{\partial\hat{\omega}}{\partial\eta} < 0$, then it may be the case that the overall probability of opposition Ω falls with the number of potential opposing firms. The individual probability of opposition ($\hat{\omega}$) is affected by the number of potential opponents η as follows:

$$\frac{\partial\hat{\omega}}{\partial\eta} = \frac{1}{(\eta-1)^2}\Big(\frac{\rho\Psi}{\sigma\nu\Gamma}\Big)^{\frac{1}{\eta-1}}\ln\Big(\frac{\rho\Psi}{\sigma\nu\Gamma}\Big) < 0 \quad . \tag{9}$$

This shows that the individual probability of opposition falls as the number of potential opponents grows. The same is true for the overall probability of opposition:

$$\frac{\partial\Omega}{\partial\eta} = \Big(\frac{1}{\eta-1}\Big)^2(1-\hat{\omega})^{\eta-1}\ln\Big(\frac{\rho\Psi}{\sigma\nu\Gamma}\Big)\Big(\frac{\rho\Psi}{\sigma\nu\Gamma}\Big)^{\frac{1}{\eta-1}} < 0. \tag{10}$$

This shows that the public good effect is a separate effect from the retaliation effect, which arises when multiple firms can oppose an applicant and all are equally affected by the threat of retaliation.

The Public Good Effect and Ineffective Opposition

Here we analyze a setting in which each applicant submits multiple patents simultaneously and there is more than one firm that can oppose all of these applications. We assume that firms cannot coordinate on which patents to oppose, rather they pick the proportion of patents to oppose $\tilde{\omega}$ randomly.

Just as in the case of the public good effect derived from retaliation firms benefit from the presence of other opponents. Here it is because their cost of opposition falls. We now show that this leads each firm to reduce its opposition efforts by too much, leading to an overall reduction of opposition as the number of potential opponents increases.

Payoffs from opposing a fraction $\tilde{\omega}_i$ of the applicant's τ patent applications are:

$$\left[(1-\sigma)+\sigma\tilde{\omega}_i\nu+\sigma(1-\tilde{\omega}_i)\nu(1-(1-\tilde{\omega}_{\not i})^{\eta-1})\right]^{\tau}\pi \\ \left(1-\left[(1-\sigma)+\sigma\tilde{\omega}_i\nu+\sigma(1-\tilde{\omega}_i)\nu(1-(1-\tilde{\omega}_{\not i})^{\eta-1})\right]^{\tau}\right)(\pi-\Gamma)-\tilde{\omega}_i\tau C \quad (11)$$

The optimal proportion of applications which each firm will choose to oppose is given by:

$$\sigma\nu\left(1-\hat{\tilde{\omega}}\right)^{\eta-1}\left[(1-\sigma)+\sigma\nu(1-(1-\hat{\tilde{\omega}})^{\eta})\right]^{\tau-1}\Gamma-C=0 \quad (12)$$

This is an implicit function which defines the proportion of the applicant's patents that is opposed by each one of the η opponents.

Comparative Statics

The total probability of opposition $(\tilde{\Omega})$ for each of the τ simultaneous patent applications is:

$$\tilde{\Omega}=1-(1-\hat{\tilde{\omega}})^{\eta} \quad . \quad (13)$$

Just as previously the effect of increasing the number of potential opponents on the total probability of opposition per patent application is:

$$\frac{\partial\Omega}{\partial\eta}=(1-\hat{\omega})^{\eta-1}\left(-(1-\hat{\omega})\ln(1-\hat{\omega})+\eta\frac{\partial\hat{\omega}}{\partial\eta}\right) \quad . \quad (14)$$

The derivative of the individual probability of opposition w.r.t. η is:

$$\frac{\partial\hat{\tilde{\omega}}}{\partial\eta}=-\left(1-\hat{\tilde{\omega}}\right)\ln(1-\omega)\frac{([(1-\sigma)+\sigma\nu-\tau\sigma\nu(1-\hat{\tilde{\omega}})^{\eta})}{\sigma\nu\left[-(\eta-1)\left[\frac{(1-\sigma)}{\sigma\nu}+1\right]+\left(1-\hat{\tilde{\omega}}\right)^{\eta}(\tau\eta-1)\right]} \quad (15)$$

We can now show that the public goods effect exists in the context of futile opposition as well.

$$\frac{\partial \Omega}{\partial \eta} = -(1-\hat{\omega})^{\eta-1}(1-\hat{\omega})\ln(1-\hat{\omega})\left(1 - \frac{\eta}{\eta-1}\frac{\left[\frac{(1-\sigma)}{\sigma\nu}+1\right] - \tau(1-\hat{\tilde{\omega}})^{\eta}}{\left[\left[\frac{(1-\sigma)}{\sigma\nu}+1\right] - (1-\hat{\tilde{\omega}})^{\eta}(\tau\frac{\eta}{(\eta-1)} - \frac{1}{(\eta-1)})\right]}\right)$$

$$= (1-\hat{\omega})^{\eta-1}(1-\hat{\omega})\ln(1-\hat{\omega})\left[\frac{\left[\frac{(1-\sigma)}{\sigma\nu}+1\right] - (1-\hat{\tilde{\omega}})^{\eta}}{(\eta-1)\left[\left[\frac{(1-\sigma)}{\sigma\nu}+1\right] - (1-\hat{\tilde{\omega}})^{\eta}(\tau\frac{\eta}{(\eta-1)} - \frac{1}{(\eta-1)})\right]}\right] \tag{16}$$

This expression can only have a positive sign if the denominator of the term in square brackets is negative. This requires that $\sigma \to 1$ and that the number of simultaneous applications (τ) be large while the number of potential other opponents (η) be small. As the number of other opponents rises, the sign of the expression will eventually turn negative.

References

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Table A.1: Descriptive Statistics

Variables	Unit of observation	Mean	S.D.	Median	Min	Max
Opposition (0/1)	P	0.06	---	0.00	0.00	1.00
Number of area triples	YA	668.06	1343.45	147.00	0.00	7526.00
Number of own triples	FYA	27.89	76.90	0.00	0.00	610.00
Number of rivals' triples	FYA	640.17	1294.54	141.00	0.00	7526.00
Concentration of rivals' patents x100	FYA	1.05	0.97	0.68	0.15	11.66
Fragmentation x100	FYA	68.83	42.97	95.08	0.00	100.00
Patent applications per area and year	YA	3600.93	2448.24	3008.00	139.00	13608.00
Cum. number of patents /1000	FY	1.09	2.55	0.06	0.00	20.43
Company applicant (0/1)	F	0.89	---	1.00	0.00	1.00
Individual applicant (0/1)	F	0.07	---	0.00	0.00	1.00
University applicant (0/1)	F	0.01	---	0.00	0.00	1.00
Government applicant (0/1)	F	0.02	---	0.00	0.00	1.00
Generality	P	0.10	0.20	0.00	0.00	1.00
Originality	P	0.29	0.34	0.20	0.00	1.00
Duration of examination	P	4.79	1.96	4.39	0.23	24.16
Total references	P	3.89	2.83	4.00	0.00	123.00
Citations received within 5 years	P	0.82	1.61	0.00	0.00	100.00
Share of X relative to total references	P	0.19	0.30	0.00	0.00	1.00
Share of Y relative to total references	P	0.10	0.22	0.00	0.00	1.00
Share of other relative to total references	P	0.11	0.22	0.00	0.00	1.00
Number of equivalents	P	7.52	5.96	6.00	1.00	346.00
PCT filing (0/1)	P	0.35	---	0.00	0.00	1.00
Number of claims	P	13.49	10.45	11.00	0.00	476.00
EU applicant (0/1)	F	0.54	---	1.00	0.00	1.00
US applicant (0/1)	F	0.23	---	0.00	0.00	1.00
Japanese applicant (0/1)	F	0.19	---	0.00	0.00	1.00
Applicant ROW (0/1)	F	0.04	---	0.00	0.00	1.00

Note: A correlation table for all independent and the dependent variable is available from the authors upon request. Unit of observation is indicated in the second column: F- firm, Y - year, A - area, P – patent.

Table A.2: Results from Probit Regressions – Dependent Variable: Opposition (0/1)

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
Number of area triples	YA			-0.0096***	-0.0010***	-0.0027**	-0.0008***				
				[0.001]	[0.000]	[0.001]	[0.000]				
Number of rivals' triples /100	FYA							-0.0069***	-0.0007***	-0.0070***	-0.0008***
								[0.001]	[0.000]	[0.001]	[0.000]
Number of own triples/100	FYA							-0.1051***	-0.0113***	-0.0178	-0.0065
								[0.010]	[0.001]	[0.059]	[0.003]
Number of triples (in column 9 own triples)/100 x number of patents (log)						-0.0012***				-0.0107	
						[0.000]				[0.007]	
Concentration of rivals' patents	FYA			4.7258***	0.5082***	4.6593***	0.5008***	4.1634***	0.4474***	4.1175***	0.4425***
				[0.589]	[0.063]	[0.590]	[0.064]	[0.587]	[0.063]	[0.585]	[0.063]
Fragmentation	FYA			0.1368***	0.0147***	0.1342***	0.0144***	0.1327***	0.0143***	0.1310***	0.0141***
				[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]
Grant duration	P	0.1432***	0.0154***	0.1530***	0.0165***	0.1524***	0.0164***	0.1529***	0.0164***	0.1529***	0.0164***
		[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Applications in area	AY	0.0022	0.0002	0.0358***	0.0038***	0.0321***	0.0035***	0.0348***	0.0037***	0.0348***	0.0037***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
Cum. number of patents (log)	FY	-0.0173***	-0.0019***	-0.0310***	-0.0033***	-0.0243***	-0.0032***	-0.0236***	-0.0025***	-0.0233***	-0.0027***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Individual applicant (0/1)	F	-0.2775***	-0.0299***	-0.2587***	-0.0278***	-0.2519***	-0.0271***	-0.2465***	-0.0265***	-0.2459***	-0.0264***
		[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]
University applicant (0/1)	F	-0.3629***	-0.0391***	-0.3567***	-0.0384***	-0.3575***	-0.0384***	-0.3649***	-0.0392***	-0.3636***	-0.0391***
		[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]
Government applicant (0/1)	F	-0.3473***	-0.0374***	-0.3386***	-0.0364***	-0.3399***	-0.0365***	-0.3489***	-0.0375***	-0.3486***	-0.0375***
		[0.017]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]
Generality	P	0.1304***	0.0141***	0.1350***	0.0145***	0.1332***	0.0143***	0.1294***	0.0139***	0.1299***	0.0140***
		[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]
Originality	P	0.0723***	0.0078***	0.0780***	0.0084***	0.0770***	0.0083***	0.0747***	0.0080***	0.0749***	0.0081***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ citations rec. within 5 years)	P	0.2235***	0.0241***	0.2238***	0.0241***	0.2243***	0.0241***	0.2257***	0.0243***	0.2255***	0.0242***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
ln(1+total references)	P	-0.0166***	-0.0018***	-0.0149***	-0.0016***	-0.0149***	-0.0016***	-0.0156***	-0.0017***	-0.0156***	-0.0017***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
Share of X relative to total references	P	0.1246***	0.0134***	0.1217***	0.0131***	0.1211***	0.0130***	0.1221***	0.0131***	0.1222***	0.0131***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Share of Y relative to total references	P	0.0204	0.0022	0.0183	0.0020	0.0176	0.0019	0.0178	0.0019	0.0180	0.0019
		[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Share of other refs relative to total references	P	0.0240*	0.0026*	0.0222*	0.0024*	0.0192	0.0021	0.0198	0.0021	0.0198	0.0021
		[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Number of equivalents	P	0.0082***	0.0009***	0.0082***	0.0009***	0.0082***	0.0009***	0.0083***	0.0009***	0.0082***	0.0009***
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
PCT filing (0/1)	P	-0.0479***	-0.0052***	-0.0459***	-0.0049***	-0.0461***	-0.0050***	-0.0440***	-0.0047***	-0.0437***	-0.0047***
		[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]
Number of claims	P	-0.0006*	-0.0001*	-0.0006*	-0.0001*	-0.0006*	-0.0001*	-0.0006*	-0.0001*	-0.0006*	-0.0001*
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
US applicant (0/1)	F	-0.2749***	-0.0296***	-0.2821***	-0.0303***	-0.2859***	-0.0307***	-0.2861***	-0.0307***	-0.2875***	-0.0309***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Japanese applicant (0/1)	F	-0.3919***	-0.0423***	-0.3973***	-0.0427***	-0.3982***	-0.0428***	-0.3964***	-0.0426***	-0.3970***	-0.0427***
		[0.009]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Applicant ROW (0/1)	F	-0.3381***	-0.0365***	-0.3377***	-0.0363***	-0.3413***	-0.0367***	-0.3360***	-0.0361***	-0.3374***	-0.0363***
		[0.021]	[0.002]	[0.021]	[0.002]	[0.022]	[0.002]	[0.021]	[0.002]	[0.021]	[0.002]
Time fixed effects (application years)	F	YES		YES		YES		YES		YES	
Area fixed effects		YES		YES		YES		YES		YES	
Log-likelihood	P	-196594		-196047		-195928		-195895		-195891	
Observations		966,974		966,974		966,974		966,974		966,974	

Note: Standard errors in parentheses. Standard errors have been clustered by firm, area and year and are reported in brackets.
*** p<0.001, ** p<0.01, * p<0.05. Source of variation is indicated in the second column: F- firm, Y - year, A - area, P – patent.
Marginal effects are average marginal effects calculated using Stata's margins command.

Table A.3: Results from Probit Regressions – Dependent Variable: Opposition (0/1) – additionally controlling for portfolio characteristics of patent applicant.

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
Number of area triples (t-2)	ya			-0.0098***	-0.0011***	-0.0028**	-0.0008***				
				[0.001]	[0.000]	[0.001]	[0.000]				
Number of area triples (t-2) x number of patents (ln)	fya					-0.0012***					
						[0.000]					
Number of rivals' triples (t-2)	fya							-0.0071***	-0.0008***	-0.0072***	-0.0008***
								[0.001]	[0.000]	[0.001]	[0.000]
Number of own triples (t-2)	fya							-0.1062***	-0.0114***	-0.0271	-0.0070*
								[0.010]	[0.001]	[0.059]	[0.003]
Number of own triples (in column 9 own triples) (t-2) x number of patents (ln)	fya									-0.0097	
										[0.007]	
Concentration of rivals' patents	fya			4.5656***	0.4907***	4.4904***	0.4824***	4.0040***	0.4300***	3.9611***	0.4254***
				[0.590]	[0.063]	[0.591]	[0.064]	[0.588]	[0.063]	[0.585]	[0.063]
Fragmentation (t-2)	fya			0.1339***	0.0144***	0.1317***	0.0142***	0.1299***	0.0140***	0.1285***	0.0138***
				[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]
Number of applications in area	ya	0.0018	0.0002	0.0364***	0.0039***	0.0325***	0.0035***	0.0353***	0.0038***	0.0352***	0.0038***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
ln (Cum. number of patents)	fy	-0.0176***	-0.0019***	-0.0320***	-0.0034***	-0.0255***	-0.0033***	0.1613***	0.0173***	0.1613***	0.0173***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Individual applicant (0/1)	f	-0.2731***	-0.0300***	-0.2539***	-0.0273***	-0.2470***	-0.0265***	-0.0246***	-0.0026***	-0.0243***	-0.0028***
		[0.009]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.002]	[0.000]	[0.002]	[0.000]
University applicant (0/1)	f	-0.3493***	-0.0383***	-0.3412***	-0.0367***	-0.3407***	-0.0366***	-0.2416***	-0.0260***	-0.2412***	-0.0259***
		[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.010]	[0.001]	[0.010]	[0.001]
Government applicant (0/1)	f	-0.3374***	-0.0370***	-0.3301***	-0.0355***	-0.3310***	-0.0356***	-0.3496***	-0.0375***	-0.3483***	-0.0374***
		[0.016]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]
Generality	p	0.1322***	0.0145***	0.1343***	0.0144***	0.1328***	0.0143***	-0.3406***	-0.0366***	-0.3403***	-0.0366***
		[0.011]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.018]	[0.002]	[0.018]	[0.002]
Originality	p	0.0641***	0.0070***	0.0762***	0.0082***	0.0753***	0.0081***	0.1286***	0.0138***	0.1291***	0.0139***
		[0.007]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ citations received within 5 years)	p	0.2143***	0.0235***	0.2119***	0.0228***	0.2123***	0.0228***	0.2131***	0.0229***	0.2128***	0.0229***
		[0.005]	[0.000]	[0.005]	[0.001]	[0.005]	[0.001]	[0.005]	[0.001]	[0.005]	[0.001]
ln(1+total references)	ya	-0.0322***	-0.0035***	-0.0247***	-0.0027***	-0.0249***	-0.0027***	-0.0254***	-0.0027***	-0.0254***	-0.0027***
		[0.004]	[0.000]	[0.005]	[0.001]	[0.005]	[0.001]	[0.005]	[0.001]	[0.005]	[0.001]
Share of X relative to total references	fya	0.0968***	0.0106***	0.1030***	0.0111***	0.1047***	0.0112***	0.1039***	0.0112***	0.1042***	0.0112***
		[0.009]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]
Share of Y relative to total references	fya	0.0320**	0.0035**	0.0342**	0.0037**	0.0338**	0.0036**	0.0340**	0.0036**	0.0340**	0.0037**
		[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]
Share of other refs relative to total references	fya	-0.0172	-0.0019	-0.0092	-0.0010	-0.0099	-0.0011	-0.0106	-0.0011	-0.0105	-0.0011
		[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]
Duration of examination	p	0.1516***	0.0166***	0.1613***	0.0173***	0.1611***	0.0173***	0.0085***	0.0009***	0.0085***	0.0009***
		[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Number of equivalents	p	0.0081***	0.0009***	0.0084***	0.0009***	0.0084***	0.0009***	-0.0180*	-0.0019*	-0.0176*	-0.0019*
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.008]	[0.001]	[0.008]	[0.001]
PCT filing (0/1)	fya	-0.0325***	-0.0036***	-0.0201**	-0.0022**	-0.0178*	-0.0019*	-0.0010***	-0.0001***	-0.0010***	-0.0001***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
Number of claims	fya	-0.0012***	-0.0001***	-0.0010***	-0.0001***	-0.0009**	-0.0001**	-0.2773***	-0.0298***	-0.2786***	-0.0299***
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.008]	[0.001]	[0.008]	[0.001]
US applicant (0/1)	fy	-0.2774***	-0.0304***	-0.2734***	-0.0294***	-0.2759***	-0.0296***	-0.3818***	-0.0410***	-0.3824***	-0.0411***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]
Japanese applicant (0/1)	f	-0.3814***	-0.0419***	-0.3826***	-0.0411***	-0.3833***	-0.0412***	-0.3303***	-0.0355***	-0.3314***	-0.0356***
		[0.009]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]	[0.021]	[0.002]	[0.021]	[0.002]
Applicant ROW (0/1)	f	-0.3355***	-0.0368***	-0.3321***	-0.0357***	-0.3345***	-0.0359***	0.2131***	0.0229***	0.2128***	0.0229***
		[0.020]	[0.002]	[0.021]	[0.002]	[0.022]	[0.002]	[0.005]	[0.001]	[0.005]	[0.001]
Portfolio characteristics	**f**	**YES**		**YES**		**YES**		**YES**		**YES**	
Time fixed effects (Grant years)	y	YES		YES		YES		YES		YES	
Area fixed effects	a	YES		YES		YES		YES		YES	
Log-likelihood	p	-215868		-195903		-195780		-195749		-195746	
Observations		1,044,292		966,974		966,974		966,974		966,974	

Note: Standard errors in parentheses. SEs have been clustered by firm, area and year and are reported in brackets. *** p<0.001, ** p<0.01, * p<0.05
Source of variation is indicated in the second column: f - firm, y - year, a - area, p – patent.
Marginal effects are average marginal effects calculated using STATA's margins command.

Table A.4: Results from Probit Regressions – Dependent Variable: Opposition (0/1) – only patents granted between 1980 and 2000 are considered.

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ Number of area triples)	ya			-0.0228***	-0.0025***	0.0056	-0.0017***				
				[0.003]	[0.000]	[0.004]	[0.000]				
ln(1 +Number of triples) x ln(number of patents)	fya					-0.0055***					
						[0.001]					
ln(1+ Number of rivals' triples)	fya							-0.0200***	-0.0022***	-0.0204***	-0.0022***
								[0.003]	[0.000]	[0.003]	[0.000]
ln(1+Number of own triples)	fya							-0.0819***	-0.0090***	0.2309	0.0090
								[0.024]	[0.003]	[0.164]	[0.009]
ln(1+Number of own triples (in column 9 own triples)) x ln(number of patents)	fya									-0.0394	
										[0.021]	
Concentration of rivals' patents	fya			3.1164***	0.3429***	2.9474***	0.3242***	2.8142***	0.3096***	2.7492***	0.3025***
				[0.802]	[0.088]	[0.805]	[0.088]	[0.814]	[0.090]	[0.816]	[0.090]
Fragmentation	fya			0.1408***	0.0155***	0.1386***	0.0152***	0.1405***	0.0155***	0.1382***	0.0152***
				[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]
Number of applicants in area	ya	-0.0370**	-0.0042**	0.0015	0.0002	-0.0045	-0.0005	0.0011	0.0001	0.0008	0.0001
		[0.011]	[0.001]	[0.015]	[0.002]	[0.015]	[0.002]	[0.015]	[0.002]	[0.015]	[0.002]
ln (Cum. number of patents)	Fy	0.2137***	0.0243***	0.2212***	0.0243***	0.2208***	0.0243***	0.2213***	0.0244***	0.2212***	0.0243***
		[0.002]	[0.000]	[0.003]	[0.000]	[0.003]	[0.000]	[0.003]	[0.000]	[0.003]	[0.000]
Individual applicant (0/1)	F	-0.0252***	-0.0029***	-0.0419***	-0.0046***	-0.0342***	-0.0045***	-0.0400***	-0.0044***	-0.0397***	-0.0047***
		[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
University applicant (0/1)	F	-0.2887***	-0.0329***	-0.2741***	-0.0302***	-0.2663***	-0.0293***	-0.2706***	-0.0298***	-0.2701***	-0.0297***
		[0.012]	[0.001]	[0.014]	[0.002]	[0.014]	[0.002]	[0.014]	[0.002]	[0.014]	[0.002]
Government applicant (0/1)	F	-0.2791***	-0.0318***	-0.2755***	-0.0303***	-0.2772***	-0.0305***	-0.2759***	-0.0304***	-0.2738***	-0.0301***
		[0.037]	[0.004]	[0.039]	[0.004]	[0.039]	[0.004]	[0.039]	[0.004]	[0.039]	[0.004]
Generality	P	-0.3136***	-0.0357***	-0.2972***	-0.0327***	-0.2989***	-0.0329***	-0.2992***	-0.0329***	-0.2987***	-0.0329***
		[0.022]	[0.003]	[0.025]	[0.003]	[0.025]	[0.003]	[0.025]	[0.003]	[0.025]	[0.003]
Originality	P	0.1227***	0.0140***	0.1214***	0.0134***	0.1186***	0.0130***	0.1199***	0.0132***	0.1207***	0.0133***
		[0.014]	[0.002]	[0.016]	[0.002]	[0.016]	[0.002]	[0.016]	[0.002]	[0.016]	[0.002]

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ citations received within 5 years)	P	0.2576***	0.0293***	0.2549***	0.0281***	0.2545***	0.0280***	0.2550***	0.0281***	0.2547***	0.0280***
		[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]
ln(1+total references)	P	-0.0179***	-0.0020***	-0.0082	-0.0009	-0.0084	-0.0009	-0.0082	-0.0009	-0.0083	-0.0009
		[0.005]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]
Share of X relative to total references	P	0.1342***	0.0153***	0.1324***	0.0146***	0.1320***	0.0145***	0.1324***	0.0146***	0.1324***	0.0146***
		[0.012]	[0.001]	[0.013]	[0.001]	[0.013]	[0.001]	[0.013]	[0.001]	[0.013]	[0.001]
Share of Y relative to total references	P	0.0396**	0.0045**	0.0397**	0.0044**	0.0394**	0.0043**	0.0396**	0.0044**	0.0397**	0.0044**
		[0.014]	[0.002]	[0.015]	[0.002]	[0.015]	[0.002]	[0.015]	[0.002]	[0.015]	[0.002]
Share of other refs relative to total references	P	0.0072	0.0008	0.0006	0.0001	-0.0015	-0.0002	0.0004	0.0000	0.0005	0.0001
		[0.014]	[0.002]	[0.015]	[0.002]	[0.015]	[0.002]	[0.015]	[0.002]	[0.015]	[0.002]
Duration of examination	P	0.2137***	0.0243***	0.2212***	0.0243***	0.2208***	0.0243***	0.2213***	0.0244***	0.2212***	0.0243***
		[0.002]	[0.000]	[0.003]	[0.000]	[0.003]	[0.000]	[0.003]	[0.000]	[0.003]	[0.000]
Number of equivalents	P	0.0040***	0.0005***	0.0046***	0.0005***	0.0045***	0.0005***	0.0046***	0.0005***	0.0045***	0.0005***
		[0.001]	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]	[0.001]	[0.000]
PCT filing (0/1)	P	-0.0652***	-0.0074***	-0.0515***	-0.0057***	-0.0539***	-0.0059***	-0.0513***	-0.0056***	-0.0515***	-0.0057***
		[0.009]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]
Number of claims	P	-0.0040***	-0.0005***	-0.0043***	-0.0005***	-0.0044***	-0.0005***	-0.0043***	-0.0005***	-0.0043***	-0.0005***
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
US applicant (0/1)	F	-0.3115***	-0.0355***	-0.3133***	-0.0345***	-0.3156***	-0.0347***	-0.3144***	-0.0346***	-0.3161***	-0.0348***
		[0.009]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]
Japanese applicant (0/1)	F	-0.3765***	-0.0429***	-0.3701***	-0.0407***	-0.3691***	-0.0406***	-0.3698***	-0.0407***	-0.3709***	-0.0408***
		[0.010]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Applicant ROW (0/1)	F	-0.3615***	-0.0411***	-0.3689***	-0.0406***	-0.3699***	-0.0407***	-0.3684***	-0.0405***	-0.3687***	-0.0406***
		[0.021]	[0.002]	[0.024]	[0.003]	[0.024]	[0.003]	[0.024]	[0.003]	[0.024]	[0.003]
Time fixed effects (Grant years)	F	YES		YES		YES		YES		YES	
Area fixed effects		YES		YES		YES		YES		YES	
Log-likelihood	p	-110746		-91484		-91433		-91459		-91476	
Observations		519,015		443,159		443,159		443,159		443,159	

Note: Standard errors in parentheses. SEs have been clustered by firm, area and year and are reported in brackets. *** p<0.001, ** p<0.01, * p<0.05
Source of variation is indicated in the second column: f - firm, y - year, a - area, p – patent.
Marginal effects are average marginal effects calculated using STATA's margins command.

Table A.5: Results from Probit Regressions – Dependent Variable: Opposition (0/1) – additionally controlling for the contemporaneous area-year opposition rate.

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
Opposition rate (t)	ya	6.9763***	0.7624***	6.9707***	0.7468***	6.9397***	0.7431***	6.9330***	0.7422***	6.9263***	0.7415***
		[0.209]	[0.023]	[0.254]	[0.027]	[0.254]	[0.027]	[0.255]	[0.027]	[0.255]	[0.027]
Number of area triples (t-2)	ya			-0.0075***	-0.0008***	-0.0007	-0.0006***				
				[0.001]	[0.000]	[0.001]	[0.000]				
Number of area triples (t-2) x number of patents (ln)	fya					-0.0012***					
						[0.000]					
Number of rivals' triples (t-2)	fya							-0.0048***	-0.0005***	-0.0049***	-0.0005***
								[0.001]	[0.000]	[0.001]	[0.000]
Number of own triples (t-2)	fya							-0.1005***	-0.0108***	-0.0360	-0.0072*
								[0.009]	[0.001]	[0.059]	[0.003]
Number of own triples (t-2) x number of patents (ln)	fya									-0.0079	
										[0.007]	
Concentration of rivals' patents	fya			5.1368***	0.5503***	5.0779***	0.5437***	4.5977***	0.4922***	4.5648***	0.4887***
				[0.583]	[0.063]	[0.584]	[0.063]	[0.581]	[0.062]	[0.579]	[0.062]
Fragmentation (t-2)	fya			0.1371***	0.0147***	0.1345***	0.0144***	0.1331***	0.0142***	0.1318***	0.0141***
				[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]
Number of applications in area	ya	0.0106**	0.0012**	0.0387***	0.0041***	0.0352***	0.0038***	0.0377***	0.0040***	0.0377***	0.0040***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
ln (Cum. number of patents)	fy	-0.0169***	-0.0018***	-0.0310***	-0.0033***	-0.0245***	-0.0032***	-0.0238***	-0.0025***	-0.0236***	-0.0026***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Individual applicant (0/1)	f	-0.2787***	-0.0305***	-0.2608***	-0.0279***	-0.2542***	-0.0272***	-0.2490***	-0.0267***	-0.2486***	-0.0266***
		[0.009]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]
University applicant (0/1)	f	-0.3749***	-0.0410***	-0.3691***	-0.0395***	-0.3701***	-0.0396***	-0.3775***	-0.0404***	-0.3765***	-0.0403***
		[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]
Government applicant (0/1)	f	-0.3491***	-0.0382***	-0.3417***	-0.0366***	-0.3430***	-0.0367***	-0.3518***	-0.0377***	-0.3516***	-0.0376***
		[0.016]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]
Generality	p	0.1385***	0.0151***	0.1412***	0.0151***	0.1393***	0.0149***	0.1357***	0.0145***	0.1361***	0.0146***
		[0.011]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]
Originality	p	0.0634***	0.0069***	0.0754***	0.0081***	0.0744***	0.0080***	0.0722***	0.0077***	0.0724***	0.0077***
		[0.007]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ citations received within 5 years)	P	0.2257***	0.0247***	0.2233***	0.0239***	0.2236***	0.0239***	0.2251***	0.0241***	0.2249***	0.0241***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
ln(1+total references)	P	-0.0229***	-0.0025***	-0.0180***	-0.0019***	-0.0180***	-0.0019***	-0.0187***	-0.0020***	-0.0186***	-0.0020***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
Share of X relative to total references	P	0.1260***	0.0138***	0.1209***	0.0129***	0.1203***	0.0129***	0.1213***	0.0130***	0.1213***	0.0130***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Share of Y relative to total references	P	0.0237*	0.0026*	0.0227*	0.0024*	0.0221*	0.0024*	0.0222*	0.0024*	0.0224*	0.0024*
		[0.010]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Share of other refs relative to total references	P	0.0256*	0.0028*	0.0217*	0.0023*	0.0188	0.0020	0.0194	0.0021	0.0194	0.0021
		[0.010]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Duration of examination	P	0.1464***	0.0160***	0.1532***	0.0164***	0.1526***	0.0163***	0.1531***	0.0164***	0.1531***	0.0164***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Number of equivalents	P	0.0078***	0.0008***	0.0081***	0.0009***	0.0080***	0.0009***	0.0081***	0.0009***	0.0081***	0.0009***
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
PCT filing (0/1)	P	-0.0648***	-0.0071***	-0.0567***	-0.0061***	-0.0569***	-0.0061***	-0.0548***	-0.0059***	-0.0546***	-0.0058***
		[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]
Number of claims	P	-0.0006**	-0.0001**	-0.0006*	-0.0001*	-0.0006*	-0.0001*	-0.0006*	-0.0001*	-0.0006*	-0.0001*
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
US applicant (0/1)	F	-0.2811***	-0.0307***	-0.2834***	-0.0304***	-0.2871***	-0.0307***	-0.2873***	-0.0308***	-0.2883***	-0.0309***
		[0.007]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Japanese applicant (0/1)	F	-0.3916***	-0.0428***	-0.3955***	-0.0424***	-0.3964***	-0.0425***	-0.3948***	-0.0423***	-0.3952***	-0.0423***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Applicant ROW (0/1)	F	-0.3341***	-0.0365***	-0.3372***	-0.0361***	-0.3409***	-0.0365***	-0.3359***	-0.0360***	-0.3368***	-0.0361***
		[0.020]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.021]	[0.002]	[0.021]	[0.002]
Time fixed effects (Grant years)	F	YES		YES		YES		YES		YES	
Area fixed effects		YES		YES		YES		YES		YES	
Log-likelihood	p	-215035		-195313		-195201		-195169		-195167	
Observations		1,044,292		966,974		966,974		966,974		966,974	

Note: Standard errors in parentheses. SEs have been clustered by firm, area and year and are reported in brackets. *** p<0.001, ** p<0.01, * p<0.05
Source of variation is indicated in the second column: f - firm, y - year, a - area, p – patent.
Marginal effects are average marginal effects calculated using STATA's margins command.

Table A.6: Results from Probit Regressions – Dependent Variable: Opposition (0/1) – additionally controlling for lagged area-year opposition rates.

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
Opposition rate (t-4)	ya	1.6614***	0.1801***	1.5152***	0.1639***	1.5063***	0.1628***	1.5670***	0.1672***	1.5628***	0.1667***
		[0.244]	[0.026]	[0.244]	[0.026]	[0.244]	[0.026]	[0.279]	[0.030]	[0.279]	[0.030]
Opposition rate (t-5)	ya	0.6745**	0.0731**	0.4135*	0.0447*	0.3933	0.0425	0.0924	0.0099	0.0861	0.0092
		[0.209]	[0.023]	[0.210]	[0.023]	[0.210]	[0.023]	[0.251]	[0.027]	[0.251]	[0.027]
Opposition rate (t-6)	ya	0.0436	0.0047	-0.0757	-0.0082	-0.0814	-0.0088	-0.2447	-0.0261	-0.2478	-0.0264
		[0.124]	[0.013]	[0.125]	[0.014]	[0.125]	[0.014]	[0.171]	[0.018]	[0.171]	[0.018]
Number of area triples (t-2)	ya			-0.0088***	-0.0010***	-0.0017	-0.0007***				
				[0.001]	[0.000]	[0.001]	[0.000]				
Number of area triples (t-2) x number of patents (ln)	fya					-0.0012***					
						[0.000]					
Number of rivals' triples (t-2)	fya							-0.0061***	-0.0007***	-0.0062***	-0.0007***
								[0.001]	[0.000]	[0.001]	[0.000]
Number of own triples (t-2)	fya							-0.1041***	-0.0111***	-0.0230	-0.0067*
								[0.010]	[0.001]	[0.059]	[0.003]
Number of own triples (t-2) x number of patents (ln)	fya									-0.0100	
										[0.007]	
Concentration of rivals' patents	fya			5.2388***	0.5667***	5.0725***	0.5484***	4.5372***	0.4841***	4.4788***	0.4779***
				[0.695]	[0.075]	[0.697]	[0.075]	[0.709]	[0.076]	[0.705]	[0.075]
Fragmentation (t-2)	fya			0.1381***	0.0149***	0.1357***	0.0147***	0.1344***	0.0143***	0.1328***	0.0142***
				[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]
Number of applications in area	ya	0.0004	0.0000	0.0315***	0.0034***	0.0281***	0.0030***	0.0305***	0.0033***	0.0305***	0.0033***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
ln (Cum. number of patents)	fy	-0.0162***	-0.0018***	-0.0300***	-0.0032***	-0.0234***	-0.0031***	-0.0230***	-0.0025***	-0.0228***	-0.0026***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Individual applicant (0/1)	f	-0.2780***	-0.0301***	-0.2600***	-0.0281***	-0.2531***	-0.0274***	-0.2478***	-0.0264***	-0.2473***	-0.0264***
		[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]
University applicant (0/1)	f	-0.3736***	-0.0405***	-0.3650***	-0.0395***	-0.3660***	-0.0396***	-0.3710***	-0.0396***	-0.3697***	-0.0394***
		[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]
Government applicant (0/1)	f	-0.3425***	-0.0371***	-0.3330***	-0.0360***	-0.3348***	-0.0362***	-0.3465***	-0.0370***	-0.3462***	-0.0369***
		[0.017]	[0.002]	[0.017]	[0.002]	[0.017]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]
Generality	p	0.1330***	0.0144***	0.1379***	0.0149***	0.1360***	0.0147***	0.1313***	0.0140***	0.1318***	0.0141***
		[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]
Originality	p	0.0689***	0.0075***	0.0752***	0.0081***	0.0742***	0.0080***	0.0751***	0.0080***	0.0753***	0.0080***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ citations received within 5 years)	P	0.2259***	0.0245***	0.2260***	0.0244***	0.2264***	0.0245***	0.2262***	0.0241***	0.2259***	0.0241***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
ln(1+total references)	P	-0.0212***	-0.0023***	-0.0191***	-0.0021***	-0.0192***	-0.0021***	-0.0170***	-0.0018***	-0.0170***	-0.0018***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
Share of X relative to total references	P	0.1235***	0.0134***	0.1204***	0.0130***	0.1199***	0.0130***	0.1185***	0.0126***	0.1186***	0.0127***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Share of Y relative to total references	P	0.0197	0.0021	0.0167	0.0018	0.0161	0.0017	0.0179	0.0019	0.0181	0.0019
		[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Share of other refs relative to total references	P	0.0253*	0.0027*	0.0239*	0.0026*	0.0210	0.0023	0.0222*	0.0024*	0.0222*	0.0024*
		[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Duration of examination	P	0.1452***	0.0157***	0.1543***	0.0167***	0.1538***	0.0166***	0.1521***	0.0162***	0.1521***	0.0162***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Number of equivalents	P	0.0080***	0.0009***	0.0080***	0.0009***	0.0080***	0.0009***	0.0083***	0.0009***	0.0083***	0.0009***
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
PCT filing (0/1)	P	-0.0565***	-0.0061***	-0.0530***	-0.0057***	-0.0532***	-0.0058***	-0.0471***	-0.0050***	-0.0468***	-0.0050***
		[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]
Number of claims	P	-0.0004	-0.0000	-0.0005	-0.0001	-0.0005	-0.0001	-0.0005	-0.0000	-0.0005	-0.0000
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
US applicant (0/1)	F	-0.2868***	-0.0311***	-0.2938***	-0.0318***	-0.2978***	-0.0322***	-0.2913***	-0.0311***	-0.2927***	-0.0312***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Japanese applicant (0/1)	F	-0.4050***	-0.0439***	-0.4099***	-0.0443***	-0.4110***	-0.0444***	-0.4050***	-0.0432***	-0.4056***	-0.0433***
		[0.009]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]
Applicant ROW (0/1)	F	-0.3414***	-0.0370***	-0.3412***	-0.0369***	-0.3449***	-0.0373***	-0.3382***	-0.0361***	-0.3394***	-0.0362***
		[0.021]	[0.002]	[0.021]	[0.002]	[0.021]	[0.002]	[0.021]	[0.002]	[0.021]	[0.002]
Time fixed effects (Grant years)	F	YES		YES		YES		YES		YES	
Area fixed effects		YES		YES		YES		YES		YES	
Log-likelihood	p	-201549		-201045		-200920		-188509		-188506	
Observations		986,729		986,729		986,729		937,213		937,213	

Note: Standard errors in parentheses. SEs have been clustered by firm, area and year and are reported in brackets. *** p<0.001, ** p<0.01, * p<0.05
Source of variation is indicated in the second column: f - firm, y - year, a - area, p – patent.
Marginal effects are average marginal effects calculated using STATA's margins command.

Table A.7: Results from Probit Regressions – Dependent Variable: Opposition (0/1) – Regressions removing the largest applicants.

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ Number of area triples)	ya			-0.0092***	-0.0010***	-0.0018*	-0.0007***				
				[0.001]	[0.000]	[0.001]	[0.000]				
ln(1 +Number of triples) x ln(Cum. number of patents)	fya					-0.0013***					
						[0.000]					
ln(1+ Number of rivals' triples)	fya							-0.0060***	-0.0006***	-0.0061***	-0.0007***
								[0.001]	[0.000]	[0.001]	[0.000]
ln(1+Number of own triples)	fya							-0.1250***	-0.0135***	0.0545	-0.0034
								[0.010]	[0.001]	[0.065]	[0.004]
ln(1+Number of own triples) x ln(Cum. number of patents)	fya									-0.0228**	
										[0.008]	
Concentration of rivals' patents	fya										
Fragmentation	fya			4.8728***	0.5256***	4.7635***	0.5135***	4.5037***	0.4854***	4.4399***	0.4785***
				[0.596]	[0.064]	[0.598]	[0.065]	[0.592]	[0.064]	[0.590]	[0.064]
Number of applicants in area	ya			0.1397***	0.0151***	0.1375***	0.0148***	0.1372***	0.0148***	0.1343***	0.0145***
				[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]
ln (Cum. number of patents)	Fy	0.0009	0.0001	0.0331***	0.0036***	0.0288***	0.0031***	0.0311***	0.0033***	0.0310***	0.0033***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
Individual applicant (0/1)	F	-0.0193***	-0.0021***	-0.0341***	-0.0037***	-0.0269***	-0.0035***	-0.0266***	-0.0029***	-0.0260***	-0.0031***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
University applicant (0/1)	F	-0.2807***	-0.0309***	-0.2617***	-0.0282***	-0.2545***	-0.0274***	-0.2491***	-0.0268***	-0.2480***	-0.0267***
		[0.009]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]	[0.010]	[0.001]
Government applicant (0/1)	F	-0.3517***	-0.0387***	-0.3469***	-0.0374***	-0.3475***	-0.0375***	-0.3567***	-0.0384***	-0.3546***	-0.0382***
		[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]	[0.022]	[0.002]
Generality	P	-0.3356***	-0.0370***	-0.3275***	-0.0353***	-0.3291***	-0.0355***	-0.3388***	-0.0365***	-0.3385***	-0.0365***
		[0.016]	[0.002]	[0.017]	[0.002]	[0.017]	[0.002]	[0.018]	[0.002]	[0.018]	[0.002]
Originality	P	0.1362***	0.0150***	0.1383***	0.0149***	0.1361***	0.0147***	0.1319***	0.0142***	0.1328***	0.0143***
		[0.011]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ citations received within 5 years)	P	0.2271***	0.0250***	0.2252***	0.0243***	0.2258***	0.0243***	0.2278***	0.0246***	0.2274***	0.0245***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
ln(1+total references)	P	-0.0243***	-0.0027***	-0.0196***	-0.0021***	-0.0196***	-0.0021***	-0.0203***	-0.0022***	-0.0202***	-0.0022***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
Share of X relative to total references	P	0.1278***	0.0141***	0.1225***	0.0132***	0.1219***	0.0131***	0.1228***	0.0132***	0.1228***	0.0132***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Share of Y relative to total references	P	0.0181	0.0020	0.0165	0.0018	0.0157	0.0017	0.0158	0.0017	0.0160	0.0017
		[0.010]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Share of other refs relative to total references	P	0.0324**	0.0036**	0.0277*	0.0030*	0.0247*	0.0027*	0.0252*	0.0027*	0.0252*	0.0027*
		[0.010]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Duration of examination	P	0.1458***	0.0161***	0.1535***	0.0166***	0.1529***	0.0165***	0.1533***	0.0165***	0.1534***	0.0165***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Number of equivalents	P	0.0080***	0.0009***	0.0083***	0.0009***	0.0083***	0.0009***	0.0085***	0.0009***	0.0084***	0.0009***
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
PCT filing (0/1)	P	-0.0509***	-0.0056***	-0.0430***	-0.0046***	-0.0433***	-0.0047***	-0.0414***	-0.0045***	-0.0412***	-0.0044***
		[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]	[0.006]	[0.001]
Number of claims	P	-0.0007**	-0.0001**	-0.0007**	-0.0001**	-0.0007**	-0.0001**	-0.0007**	-0.0001**	-0.0007**	-0.0001**
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
US applicant (0/1)	F	-0.2710***	-0.0298***	-0.2715***	-0.0293***	-0.2755***	-0.0297***	-0.2749***	-0.0296***	-0.2774***	-0.0299***
		[0.007]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Japanese applicant (0/1)	F	-0.3772***	-0.0415***	-0.3788***	-0.0409***	-0.3794***	-0.0409***	-0.3756***	-0.0405***	-0.3759***	-0.0405***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Applicant ROW (0/1)	F	-0.3301***	-0.0364***	-0.3302***	-0.0356***	-0.3334***	-0.0359***	-0.3271***	-0.0353***	-0.3294***	-0.0355***
		[0.020]	[0.002]	[0.021]	[0.002]	[0.022]	[0.002]	[0.021]	[0.002]	[0.021]	[0.002]
Time fixed effects (Grant years)	F	YES		YES		YES		YES		YES	
Area fixed effects		YES		YES		YES		YES		YES	
Log-likelihood	p	-207,239		-187,739		-187,606		-187,553		-187,541	
Observations		998,912		923,366		923,366		923,366		923,366	

Note: Standard errors in parentheses. SEs have been clustered by firm, area and year and are reported in brackets. *** p<0.001, ** p<0.01, * p<0.05
Source of variation is indicated in the second column: f - firm, y - year, a - area, p – patent.
Marginal effects are average marginal effects calculated using STATA's margins command.

Table A.8: Results from Probit Regressions – Dependent Variable: Opposition (0/1) – Regressions restricted to only company applicants.

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ Number of area triples)	ya			-0.0099***	-0.0011***	-0.0026**	-0.0009***				
				[0.001]	[0.000]	[0.001]	[0.000]				
ln(1 +Number of triples) x ln(Cum. number of patents)	fya					-0.0013***					
						[0.000]					
ln(1+ Number of rivals' triples)	fya							-0.0071***	-0.0008***	-0.0072***	-0.0008***
								[0.001]	[0.000]	[0.001]	[0.000]
ln(1+Number of own triples)	fya							-0.1067***	-0.0117***	-0.0201	-0.0071*
								[0.010]	[0.001]	[0.059]	[0.003]
ln(1+Number of own triples) x ln(Cum. number of patents)	fya									-0.0106	
										[0.007]	
Concentration of rivals' patents	fya			4.1630***	0.4576***	4.0874***	0.4491***	3.5523***	0.3902***	3.5034***	0.3848***
				[0.614]	[0.068]	[0.615]	[0.068]	[0.612]	[0.067]	[0.609]	[0.067]
Fragmentation	fya			0.1361***	0.0150***	0.1330***	0.0146***	0.1318***	0.0145***	0.1300***	0.0143***
				[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]
Number of applicants in area	ya	0.0010	0.0001	0.0372***	0.0041***	0.0336***	0.0037***	0.0364***	0.0040***	0.0364***	0.0040***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.005]	[0.001]	[0.004]	[0.000]	[0.004]	[0.000]
ln (Cum. number of patents)	Fy	-0.0166***	-0.0019***	-0.0306***	-0.0034***	-0.0238***	-0.0032***	-0.0230***	-0.0025***	-0.0227***	-0.0027***
		[0.001]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Generality	P	0.1240***	0.0139***	0.1268***	0.0139***	0.1246***	0.0137***	0.1206***	0.0132***	0.1212***	0.0133***
		[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]	[0.012]	[0.001]
Originality	P	0.0694***	0.0078***	0.0813***	0.0089***	0.0801***	0.0088***	0.0776***	0.0085***	0.0779***	0.0086***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]

VARIABLES		(1) Coeff.	(2) dx/dy	(3) Coeff.	(4) dx/dy	(5) Coeff.	(6) dx/dy	(7) Coeff.	(8) dx/dy	(9) Coeff.	(10) dx/dy
ln(1+ citations received within 5 years)	P	0.2215***	0.0249***	0.2199***	0.0242***	0.2205***	0.0242***	0.2220***	0.0244***	0.2217***	0.0243***
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
ln(1+total references)	P	-0.0153***	-0.0017***	-0.0093*	-0.0010*	-0.0093*	-0.0010*	-0.0101*	-0.0011*	-0.0100*	-0.0011*
		[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]	[0.004]	[0.000]
Share of X relative to total references	P	0.1227***	0.0138***	0.1181***	0.0130***	0.1175***	0.0129***	0.1185***	0.0130***	0.1186***	0.0130***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Share of Y relative to total references	P	0.0191	0.0022	0.0182	0.0020	0.0174	0.0019	0.0176	0.0019	0.0178	0.0020
		[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Share of other refs relative to total references	P	0.0242*	0.0027*	0.0209	0.0023	0.0178	0.0020	0.0185	0.0020	0.0185	0.0020
		[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]	[0.011]	[0.001]
Duration of examination	P	0.1457***	0.0164***	0.1546***	0.0170***	0.1540***	0.0169***	0.1546***	0.0170***	0.1546***	0.0170***
		[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]	[0.002]	[0.000]
Number of equivalents	P	0.0075***	0.0008***	0.0077***	0.0009***	0.0077***	0.0008***	0.0078***	0.0009***	0.0078***	0.0009***
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
PCT filing (0/1)	P	-0.0408***	-0.0046***	-0.0340***	-0.0037***	-0.0343***	-0.0038***	-0.0319***	-0.0035***	-0.0316***	-0.0035***
		[0.006]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]	[0.007]	[0.001]
Number of claims	P	-0.0008**	-0.0001**	-0.0007**	-0.0001**	-0.0007**	-0.0001**	-0.0007*	-0.0001*	-0.0007*	-0.0001*
		[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
US applicant (0/1)	F	-0.2754***	-0.0310***	-0.2771***	-0.0305***	-0.2811***	-0.0309***	-0.2814***	-0.0309***	-0.2829***	-0.0311***
		[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]	[0.008]	[0.001]
Japanese applicant (0/1)	F	-0.3853***	-0.0433***	-0.3885***	-0.0427***	-0.3895***	-0.0428***	-0.3881***	-0.0426***	-0.3887***	-0.0427***
		[0.008]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]	[0.009]	[0.001]
Applicant ROW (0/1)	F	-0.3326***	-0.0374***	-0.3326***	-0.0366***	-0.3372***	-0.0370***	-0.3307***	-0.0363***	-0.3323***	-0.0365***
		[0.024]	[0.003]	[0.026]	[0.003]	[0.026]	[0.003]	[0.025]	[0.003]	[0.025]	[0.003]
Time fixed effects (Grant years)	F	YES		YES		YES		YES		YES	
Area fixed effects		YES		YES		YES		YES		YES	
Log-likelihood	p	-196,462		-179,284		-179,165		-179,132		-179,128	
Observations		929,313		866,431		866,431		866,431		866,431	

Note: Standard errors in parentheses. SEs have been clustered by firm, area and year and are reported in brackets. *** p<0.001, ** p<0.01, * p<0.05
Source of variation is indicated in the second column: f - firm, y - year, a - area, p – patent.
Marginal effects are average marginal effects calculated using STATA's margins command.

Appendix 3: Spider in the Web: A Legal Innovation Affecting the Frequency of Opposition at EPO.

Here we show that a new doctrine in European patent law arising in 1998 affected the probability of opposition against patents belonging to dutch applicants and more importantly, that it moderated the retaliation – but not the public good effects in a predictable way. We provide this additional analysis as a robustness check that demonstrates that our results are unlikely to be affected by significant endogeneity.

As briefly discussed in the main body of the paper, European Patents (EP) are examined by the EPO but turn into a bundle of national patent rights after being granted. In European patent law there has long been a debate about whether a national court, enforcing a national patent that is based on a European Patent (EP), could grant injunctions that would have validity in those other states in which the EP has also been validated. In the early 1990's the Dutch Supreme Court (Hoge Raad) began to argue that cross-border injunctions were supported by European patent Law. In 1998 the Court of Appeal of The Hague clarified, that Dutch courts should only grant cross-border injunctions, if the defendant or their parent company were domiciled in the Netherlands (Fasseur-Varr et al., 1998; Straus, 2000). This anchoring to the parent company gave rise to the "Spider-in-the-Web" doctrine (Véron, 2002).

Where firms anticipated that Dutch courts would have enforced a cross-border injunction whilst courts in other EU countries would not have, patents of Dutch applicants became a more significant threat than those of applicants from other jurisdictions. This suggests that the effect of the "Spider-in-the-Web" doctrine should be identifiable using a difference-in-differences approach. In particular, the coefficient of an interaction of a dutch owner dummy variable with a post 1998 dummy variable should identify the effect of the "Spider-in-the-Web" doctrine on the probability of opposition for dutch patents. We test this using the linear probability models[1] provided in columns 2 and 4 of Table A2 below. The advantage of the difference-in-differences approach proposed here is its robustness to endogeneity (Imbens and Wooldridge, 2009).

Next, consider how this doctrine can be expected to have moderated the patent thicket – and the public good effects. First, the increased threat of injunctions that a dutch patent presented for affected rival firms can be represented as an increase in the cost of the patent (Γ) for these rivals. This implies that the average dutch patent should have been more likely to face opposition than patents belonging to applicants from other countries after 1998. Turning to the retaliation effect the question is whether this is likely to have been weakened by the new doctrine or possibly even strengthened? It seems likely that once a patent thicket is sufficiently dense, the new doctrine would have made very little difference to the parties as the

[1] We use a linear probability model here to avoid the complexities that arise when a difference in differences specification is estimated using a non-linear model such as the probit model (Puhani, 2012).

possibility of cross-border injunctions is just one more option among many in the arsenal of firms operating within the patent thicket. If the probability of opposition for dutch patents in a patent thicket remains the same while the probability of opposition for other dutch patents increases, then the interaction of the thicket measure with the dummy for the Netherlands and the dummy for the period after the 1998 shock should have a negative sign. This effect would capture the greater marginal effect of additional triples for dutch patents after the shock.

Turning to the public good effect it is less clear that we can expect the "Spider-in-the-Web" doctrine to moderate this effect in a specific way. If the first prediction provided above is correct, then this new doctrine will increase incentives for all firms that might oppose a dutch patent in the same way. This means that both the focal firm and those it might rely on to oppose in its place would have greater incentives to oppose a dutch patent. Therefore we would not be surprised to see that the "Spider-in-the-Web" doctrine had no statistically significant impact on the public goods effect.

This leads to two (and a half)[2] predictions for the difference-in-differences regressions:

i. The interaction of the dummy for the Netherlands with the dummy for the post 1998 period will have a positive sign, indicating a higher risk of opposition for dutch patents post 1998;

ii. The interaction of the dummy for the Netherlands with the dummy for the post 1998 period and the triples measure should have a negative sign;

iii. The interaction of the dummy for the Netherlands with the dummy for the post 1998 period and the concentration measure should not be statistically significant.

As the results set out in column 2 of Table A2 (see below) demonstrate there is indeed a statistically significant increase in the probability of opposition against patents of dutch applicants after 1998. In addition, the interaction between the dummy for the Netherlands with the dummy for the post 1998 period and the triples measure has the expected negative sign and is statistically significant, while the interaction of the dummy for the Netherlands with the dummy for the post 1998 period and the concentration measure is not statistically significant. This shows that none of the above hypotheses can be rejected in the specification with area triples. Column 4 indicates that the shock interacts with rivals' and own triples in the way predicted at *ii.* above, however the effects are less precisely estimated in this case and are no longer significant. The same is true for the interaction of the shock with the dummy for the Netherlands and the dummy for the post 1998 period , as predicted at *i* above.

These results show that an exogenous shock affects the magnitude of the retaliation effect as predicted by

[2] The prediction that there is no effect is always open to the critique that the model is not able to distinguish zero from a sufficiently small positive or negative effect. What we can show is that any interaction of the public good effect with the "spider in the web" dummies has no effect that is of economic significance.

our theoretical model. The shock we analyze here is quite weak. Nonetheless it provides some additional support for a causal interpretation of the effects set out in Table 4 of the paper. If the main effects were to have arisen due to endogeneity, then it is unlikely that we would observe the kind of systematic effects that we document in Table A2 below. Notice finally, that all our main hypotheses from the paper cannot be rejected based on results in this table.

Table A.9

VARIABLES		(1) Coeff.	(2) Coeff.	(3) Coeff.	(4) Coeff.
Netherlands (0/1)	f	0.0010	0.0100*	0.0013	0.0096*
		(0.0022)	(0.0039)	(0.0022)	(0.0039)
Spider in the Web (0/1)	y	-0.0030*	-0.0037*	-0.0031*	-0.0037*
		(0.0015)	(0.0017)	(0.0015)	(0.0017)
Netherlands (0/1) * Spider in the Web (0/1)	fy		**0.0130***		**0.0113**
			(0.0066)		**(0.0066)**
Number of area triples	ya	-0.0012***	-0.0012***		
		(0.0001)	(0.0001)		
Netherlands (0/1) * Number of area triples	ya		-0.0002*		
			(0.0001)		
Spider in the Web (0/1) * Number of area triples	ya		0.0004***		
			(0.0001)		
Netherlands (0/1) * Spider in the Web (0/1) * Number of area triples	ya		**-0.0004*** **(0.0002)**		
Number of rivals' triples	fya			-0.0010***	-0.0011***
				(0.0001)	(0.0001)
Netherlands (0/1) * Number of rivals' triples	fya				0.0000
					(0.0002)
Spider in the Web (0/1) * Number of rivals' triples	fya				0.0004***
					(0.0001)
Netherlands (0/1) * Spider in the Web (0/1) * Number of rivals' triples	fya				**-0.0000** **(0.0003)**
Number of own triples	fya			-0.0058***	-0.0056***
				(0.0006)	(0.0008)
Netherlands (0/1) * Number of own triples	fya				-0.0043
					(0.0025)
Spider in the Web * Number of own triples	fya				0.0001
					(0.0010)
Netherlands (0/1) * Spider in the Web * Number of own triples	fya				**-0.0048** **(0.0038)**
Concentration of rivals' patents	fya	0.1513**	0.2342***	0.1114*	0.1913***
		(0.0544)	(0.0551)	(0.0542)	(0.0550)
Netherlands (0/1) * Concentration of rivals' patents	fya		-0.7027***		-0.8552***
			[0.178]		(0.1882)
Spider in the Web * Concentration of rivals' patents	fya		-0.6388***		-0.3946***
			[0.086]		(0.0817)
Netherlands (0/1) * Spider in the Web (0/1) * Concentration of rivals' patents	fya		**-0.0428** **(0.4026)**		**0.1577** **(0.3959)**
ln(cum. number of patents)	fy	-0.0034***	-0.0034***	-0.0029***	-0.0029***
		(0.0002)	(0.0002)	(0.0002)	(0.0002)
Fragmentation	fya	0.0162***	0.0162***	0.0160***	0.0160***
		(0.0008)	(0.0008)	(0.0008)	(0.0008)
Number of applications in area	ya	0.0081***	0.0082***	0.0080***	0.0081***
		(0.0004)	(0.0004)	(0.0004)	(0.0004)

VARIABLES		(1) Coeff.	(2) Coeff.	(3) Coeff.	(4) Coeff.
Individual applicant (0/1)	f	-0.0277***	-0.0275***	-0.0267***	-0.0266***
		(0.0010)	(0.0010)	(0.0010)	(0.0010)
University applicant (0/1)	f	-0.0377***	-0.0377***	-0.0381***	-0.0381***
		(0.0020)	(0.0020)	(0.0020)	(0.0020)
Government applicant (0/1)	f	-0.0322***	-0.0323***	-0.0330***	-0.0330***
		(0.0015)	(0.0015)	(0.0015)	(0.0015)
Generality	p	0.0176***	0.0177***	0.0173***	0.0174***
		(0.0016)	(0.0016)	(0.0016)	(0.0016)
Originality	p	0.0078***	0.0078***	0.0076***	0.0075***
		(0.0008)	(0.0008)	(0.0008)	(0.0008)
ln(1+ citations received within 5 years)	p	0.0267***	0.0267***	0.0269***	0.0268***
		(0.0006)	(0.0006)	(0.0006)	(0.0006)
ln(1+total references)	p	-0.0026***	-0.0026***	-0.0027***	-0.0027***
		(0.0005)	(0.0005)	(0.0005)	(0.0005)
Share of X relative to total references	p	0.0113***	0.0112***	0.0113***	0.0112***
		(0.0009)	(0.0009)	(0.0009)	(0.0009)
Share of Y relative to total references	p	-0.0007	-0.0007	-0.0007	-0.0007
		(0.0011)	(0.0011)	(0.0011)	(0.0011)
Share of other refs relative to total references	p	0.0015	0.0015	0.0013	0.0013
		(0.0012)	(0.0012)	(0.0012)	(0.0012)
Duration of examination	p	0.0227***	0.0228***	0.0227***	0.0228***
		(0.0003)	(0.0003)	(0.0003)	(0.0003)
Number of equivalents	p	0.0015***	0.0015***	0.0015***	0.0015***
		(0.0001)	(0.0001)	(0.0001)	(0.0001)
PCT filing (0/1)	p	-0.0107***	-0.0109***	-0.0107***	-0.0107***
		(0.0007)	(0.0007)	(0.0007)	(0.0007)
Number of claims	p	-0.0001***	-0.0001***	-0.0001***	-0.0001***
		(0.0000)	(0.0000)	(0.0000)	(0.0000)
US applicant (0/1)	f	-0.0347***	-0.0347***	-0.0350***	-0.0350***
		(0.0009)	(0.0009)	(0.0009)	(0.0009)
Japanese applicant (0/1)	f	-0.0448***	-0.0451***	-0.0447***	-0.0450***
		(0.0008)	(0.0008)	(0.0008)	(0.0008)
Applicant ROW (0/1)	f	-0.0361***	-0.0360***	-0.0358***	-0.0356***
		(0.0017)	(0.0017)	(0.0017)	(0.0017)
Constant		-0.0241***	-0.0244***	-0.0254***	-0.0257***
		(0.0041)	(0.0041)	(0.0041)	(0.0041)
Area fixed effects		YES	YES	YES	YES
Time fixed effects (Grant years)		YES	YES	YES	YES
Observations		966974	966974	966974	966974
R-squared		0.0499	0.0500	0.0499	0.0501

Robust standard errors in brackets

*** p<0.001, ** p<0.01, * p<0.05

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