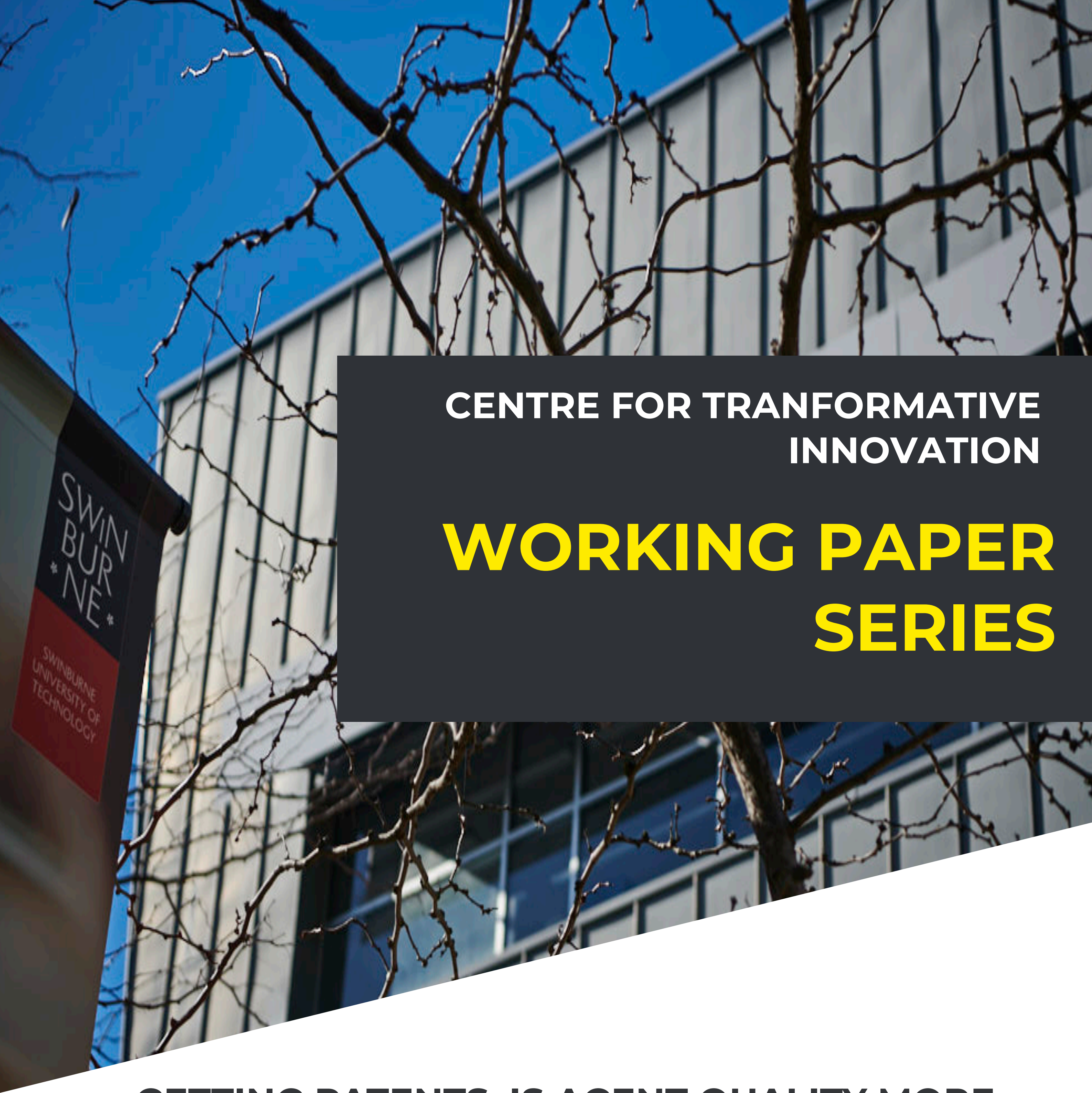

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GETTING PATENTS: IS AGENT QUALITY MORE IMPORTANT THAN INVENTION QUALITY?

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Getting patents: Is agent quality more important than invention quality?

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Abstract

For a patent system to be socially efficient, it should only grant patents to inventions that are non-obvious. We analyse patent examination decisions at the U.S. Patent Office (with comparisons to four other major patent offices) and find evidence that agent quality is a more important determinant of patent grant than the quality of the invention. Agent quality is particularly important in less codified and more rapidly changing technology areas such as software and ICT. Moreover, agent quality is more important when invention quality is low. The surprisingly large importance of agent quality suggests that the patent system may help maintain the uneven playing field rather than levelling it.

Keywords: appropriation; innovation; patent law firm; patent system

1. INTRODUCTION

Patents are legal rights designed to provide pecuniary incentives for people to invest in non-excludable and non-rivalrous 'creations of the mind.' The grantee receives a temporary right to exclude others from exploiting their idea, thus enabling the grantee to earn a (temporarily) higher price. It is well-known that these monopolies amount to static inefficiencies, but this is tolerated provided the deadweight loss is offset by the dynamic efficiency of encouraging invention (Arrow 1962, Nordhaus 1969). These static monopoly costs can be considerable as

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inventions are non-rivalrous goods. Nonetheless, improving this static-dynamic trade-off is at the heart of better and more effective innovation systems.

Optimising this trade-off necessitates that only ideas that are not obvious to a person 'skilled in the art' are granted a patent. In practice, this non-obviousness threshold is defined as the size of the 'inventive step.' Inconsistencies in the translation of the theoretical intent of the non-obviousness clause into practice diminish the power of innovation systems to stimulate innovation and undermine the intent of the law (Merges 1999). Empirical research has uncovered several such inconsistencies e.g. the importance of examiner characteristics (Cockburn *et al.* 2002, Lemley and Sampat 2012, Kim and Oh 2017, Tabakovic and Wollmann 2018, Righi and Simcoe 2019), applicant behaviour (Palangkaraya *et al.* 2008, Harhoff and Wagner 2009, Webster *et al.* 2014), and examination timing (Frakes and Wasserman 2017, Kovács 2017).[1] Recent work by Schankerman and Schuett (2017) has demonstrated that patent offices are not effective at weeding out low-quality patent applications.

We contribute to this literature by considering the impact of the patent agent (also known as patent attorney in some jurisdictions) on the grant decision vis-à-vis the inventive step of the invention (which we call 'invention quality'). Agents are quasi-legal entities acting on behalf of the applicant (or inventor) to prosecute the application through the patent office. We provide evidence that the quality of the patent agent has a large influence on the probability that a patent application will be granted. By focussing on the role of patent agents in patent examination outcomes, this paper brings to the fore a potentially important source of distortion in the execution of patent law.[2]

More generally, our study contributes to the recent literature on law firm expertise (Krishnan and Masulis 2013, Krishnan *et al*. 2016, 2017, Bates *et al*. 2018, Westbrock *et al*. 2019). The study also contributes to the more mature literature that exploits patent statistics to study innovation (Griliches 1990). Particularly for firm level studies, as also suggested by Krishnan and Masulis (2013), our evidence indicates that failing to account for heterogeneity in the quality of patent agent may lead to biased econometric estimates of the underlying economic

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[1] See also Eckert and Langinier (2014), Bessen and Meurer (2008).

[2] As far as we can ascertain, there has been very little prior interest shown in the role of patent attorneys (Reitzig 2004 and Suzeroglu-Melchiors *et al.* 2017 are notable exceptions).

relationships of interest such as firm market value and innovation (Hall *et al.* 2007, Nicholas 2008, Simeth and Cincera 2016) or firm behavior and intellectual property holding (Griffith *et al.* 2014, Chen *et al.* 2016, Bena *et al*. 2017) when patent count measures are used.

Our estimating sample consists of 40,696 patent applications filed at the United States Patent and Trademark Office (USPTO) during the period 2000–2006 for which applications were also filed in at least two of the other 'IP5' offices—that is, European Patent Office (EPO), Japanese Patent Office (JPO), Korean Intellectual Property Office (KIPO) and National Intellectual Property Administration of China (CNIPA, formerly SIPO). We construct the sample based on metadata and examination outcome information of a population of 1.2 million patent applications (equating to more than 400,000 patent application families). For our analysis, we construct proxies for the unobserved invention quality and agent quality by employing high-dimensional fixed-effects models (Abowd *et al.* 1999, Guimaraes and Portugal 2010).

Our results confirm the importance of patent agent quality even after we control for invention quality. In fact, the quality of the patent agent is more important at the USPTO than the quality of the invention. In addition, we find that agent quality is less important in highly codified technologies such as chemical/pharmaceutical and more important in less codified or newer/more rapidly changing technologies such as ICT and software.

The next section provides background on the role of patent agents and summarises the main forces affecting the grant decision; Section 3 outlines the empirical strategy; Section 4 provides a description of the data; Section 5 presents the baseline results and extends the analysis to account for the interaction between agent quality and invention quality; and Section 6 concludes.

2. BACKGROUND

Patent rights are a significant component of national innovation systems, complementing other public policies designed to augment the commercialisation of ideas such as public grants, public provision and civil society institutions. In recent decades, national governments have enacted changes to their patent systems to reduce the static inefficiency of the system, for example by raising the required inventive step threshold, reducing the probability of injunctions for infringement, sharing information across offices and introducing faster and cheaper courts. The aim of these changes is to maximise the likelihood that low-quality patent applications are weeded out of the system (either by the patent office or the courts).

The patent examination process is a long drawn-out negotiation between the applicant—as represented by the patent agent—and the patent examiner (Lemley and Sampat 2010).[3] As the assessment of inventiveness is difficult, there is some room for the patent agent to influence the examiner (Langinier and Marcoul 2016).[4] This paper seeks to quantify the nature and size of the agent's influence on examination outcomes.[5] For this, we must measure the quality of the agent (where quality indicates experience, skill, expertise and the power of persuasion). Ideally, this would be observed at the individual agent level, but our data only permits us to observe collections of agents in the form of firms.

Patent agent quality may affect the examination decision directly or in combination with other factors. Although almost all agents are local to the office, some are in-house agents and others are external (public) agents who are contracted to prosecute the patent application through the examination process.[6] It is plausible that external agents (97 percent of our sample) could be less effective in assessing and arguing for the patentability of the inventions than in-house agents. They have less access to the scientists and engineers who invented the technology, making for a less nuanced patent specification (see also Somaya *et al*. 2007). Agent quality is also likely to be more important in technology areas that are newer or experiencing rapid progress and therefore have fuzzier technological boundaries. In contrast, technologies such as biotechnology and chemical/pharmaceutical—which are relatively codified—should offer more limited scope for the agent to influence the examination outcome.

The effect of the agent may also depend on the filing route used. Prosecuting multi-nation patent applications by filing a single application under the Patent Cooperation Treaty (PCT) is

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[3] Although patent attorneys receive instructions from their clients, attorneys are usually in charge of drafting the patent document and orienting the direction of patent examination (Glazier 2000).
[4] The importance of this bilateral negotiation is evidenced by a geographical concentration of Japanese patent attorney firms around the JPO because attorneys need face-to-face communication with patent examiners as they negotiate the drafting of their patent applications (Reiffenstein 2009). In addition, recently released office action data from the USPTO of more than 2 million patent applications filed in 2008-2017 show that virtually every applicant had to respond to a non-final rejection office action from the examiners (Lu *et al.* 2017).
[5] Quantifying the effect of different professional intermediary bodies has also been done by Krishnan and Masulis (2013), Bates *et al*. (2018).
[6] In our dataset, we find that close to 100 per cent of patent attorneys are local to the office of application.

simpler than filing patent applications individually to each patent office via the 'Paris route.' The former involves filing the priority patent application at any member office of the PCT and designating an international search authority to perform the preliminary search report on the patentability of the invention. Therefore, the PCT application route reduces the complexity faced by patent applicants (and their agents) and improves the chance of obtaining a grant decision.

Of course, there are other factors that may affect patent application outcomes beside agent and invention quality which should be controlled for in a model. For example, there is evidence of discrimination against foreign applicants at the EPO and JPO (Webster et *al.* 2014) which may also be prevalent at the USPTO. Any such bias may be mitigated using a higher quality patent agent.

3. EMPIRICAL STRATEGY

Using USPTO utility patent application and examination data for each invention i in our estimating sample, we estimate the probability of invention i to be granted a U.S. patent as specified in the following reduced form model:

$$grant_{ik} = f(x_i'\beta + \alpha\ AGENT_k + \theta\ INVENTION_i) + \epsilon_{ik} \quad (1)$$

where $AGENT_k$ is agent quality, $INVENTION_i$ is invention quality, and the x_i vector contains application i's specific characteristics such as application year, technology area, and whether the applicant is a local resident of the examining patent office's jurisdiction. Our parameters of interest are α (average marginal effect of agent quality) and θ (average marginal effect of patent quality or the patentability of the underlying invention).

Because neither $AGENT$ nor $INVENTION$ are directly observable from the data, we use proxies constructed using revealed measures of patent agent quality and invention patentability, respectively. As detailed below, exploiting the observed identity of the patent agent firm that prepared each patent application, we measure the revealed agent quality based on the conditional success rates of the agent in getting a granted patent for the clients. Similarly, we measure revealed invention patentability based on the conditional success rate of the invention in getting patents in other jurisdictions. Our contention here is that, all else being equal, an *ex-ante* higher quality agent will have a higher chance of success in prosecuting another patent application and that an *ex ante* higher quality invention is associated with higher grant probability at another patent office. Our main empirical challenge is to ensure that these proxies are not trivially correlated with the error terms in equation (1).

Revealed agent quality

We randomly split our sample of patent application families[7] in two: S_1 and S_2, while ensuring that no family is separated into the two subsamples.[8] The first sample is used to construct the agent quality proxy and the second sample is used to construct the invention quality proxy and estimate the baseline model in equation (1). In this set-up, a common $AGENT_k$ may be employed to prepare distinct patent application families in both sub-samples. Hence, the revealed measure of quality of an agent handling a patent family in S_1 can be used as proxy for agent quality in S_2 while, by construction, the measure is uncorrelated to the patent office decision on families in subsample S_2.[9]

To construct the agent quality proxy, we estimate the conditional average grant rate of each agent based on the observed patent examination outcomes in S_1. An important source of heterogeneity that we need to control for is invention quality. To do this, we exploit the family dimension of our data. For each patent application examined by the USPTO, we find the equivalent patent applications in at least two of the other IP5 patent jurisdictions. Econometrically, this is equivalent to estimating the following panel model with two high-dimensional fixed effects (corresponding to patent agent k and invention family i) using the S_1 sample:[10]

$$grant_{ijk} = x_{ij}'\gamma + AGENT_k + INVENTION_i + \epsilon_{ijk} \quad i \in S_1 \qquad (2)$$

[7] We define a patent family as a set of patent applications that protect the same invention in at least one other different jurisdiction where each secondary filing claims a one-to-one priority link with a focal priority filing.
[8] We can confirm that our findings are robust to this sample splitting process (Online Appendix Table 1).
[9] That is, we assume that patent attorneys' preparation of inventions in S_1 and S_2 subsamples are uncorrelated. To account for the possibility that a patent applicant may exist in both subsamples and employ the same attorney and may lead to a violation of this assumption, we test the robustness of our analysis to the inclusion of applicant fixed effect in equation (1).
[10] That is, for each invention *i*, there is a family of patent applications submitted to each of the *j*-th patent office.

where j indexes the patent office. The patent office dimension in equation (2) identifies the patent office examining each respective member of the invention family i. We use the estimated agent fixed effects as our measure of revealed patent agent quality.

Revealed invention quality

The same approach applies to the construction of revealed invention quality. Because our focus is on the USPTO, we use examination outcomes in other offices to infer the revealed patentability of each invention i. Econometrically, we estimate invention fixed effects from the following panel model using examination data from all other offices:

$$grant_{ijk} = x_{ij}'\delta + AGENT_k + INVENTION_i + \varepsilon_{ijk} \quad , \; i \in S_2 \; and \; j \neq USPTO \quad (3)$$

where we use the revealed agent quality obtained from equation (2) in place of $AGENT_k$. The resulting estimated invention fixed effects from equation (3) represent our revealed invention quality measure. The estimated $INVENTION_i$ fixed effects from (3) are uncorrelated with ϵ_{ik} in equation (1) under the reasonable assumption that the decisions of other offices are uncorrelated with UPSTO's decision except for the underlying invention quality.[11]

4. DATA AND DESCRIPTIVE STATISTICS

Estimating sample

The estimation sample is extracted from a total population of applications that had one-to-one equivalents in at least two of the IP5 offices (priority years 2000–2006) which was 1,264,735 applications relating to 461,961 invention families. All these applications had been examined.[12]

After randomly splitting the sample into two subsamples, dropping families with unknown/missing agent code, dropping agents (and the families of patent applications they handled) that handled fewer than two applications (for agent quality proxy construction) and

[11] To assess the sensitivity of this assumption, we consider alternative panel model specifications by stacking patent office examination data where we wipe out the invention quality in equation (1) by treating it as an invention family fixed effect (Online Appendix Table 5). The alternative specifications confirm that the attorney quality marginal effects as robust. Unfortunately, wiping the invention family fixed effect means we cannot make any inference about the relative importance of invention quality.

[12] In an online appendix, we provide further details on the data construction and how patent attorney firms are identified.

keeping families with applications that have been examined in at least three offices, our main estimating sample contains families corresponding to 40,696 patent applications examined by the USPTO.

Sample descriptive statistics

Table 1 provides a descriptive summary of this estimating sample in terms of key variables and for each family size classification. From Table 1, about 93 per cent of the patent applications examined by USPTO in the estimating sample were granted. However, only 72 per cent of the applications were granted by all other IP5 offices, indicating inter-office variation in patent examination outcomes. Most importantly, the variation in family size does not appear to result in statistically significant variation in our key variables. Because we infer invention quality from a proxy measure derived from the average conditional grant rate in all other offices, one may suspect that the proxy and the estimation results are sensitive to the family size. Relatedly, one may be concerned with the short panel dimension to derive the invention quality fixed effect estimates. Fortunately, Table 1 indicates that these concerns are unlikely to be of significance, as we will confirm later.

[Table 1 about here]

5. RESULTS

Table 2 presents the estimated marginal effects of agent quality and invention quality on the probability of USPTO grant based on the estimation of equation (1), substituting the estimates of $ATTORNEY_k$ from equation (2) for $ATTORNEY_k$ and the estimates of $INVENTION_i$ from equation (3) for $INVENTION_i$, using all observations within the estimating sample of 40,696 patent families as well as within the subsamples according to the size of the family. Because we use the normalised quality measure, the logit estimates presented in the third column for agent quality means that a one standard deviation increase in agent quality is associated with 2.0 percentage points average increase in the probability of grant. This estimate appears to be insensitive to the size of the family and applicant fixed effect. Note that because our sample only includes applications made by repeat applicants to multiple offices, our sample is biased towards higher quality inventions from large firms. We expect therefore that the patent agent quality effects are likely to be larger if the tail of low-quality inventions and smaller firms were modelled.

[Table 2 about here]

Most pertinently, compared to agent quality, invention quality is a less important determinant of grant. The average marginal effect of invention quality is only about 25–30 per cent of that of agent quality and appears to be less sensitive to the same sample/model variation considered above. Figure 1 provides further comparison of the two marginal effects along the possible values of the quality measures. It is clear from the figure that the effect of having higher quality agent at the USPTO is much more significant in magnitude compared to having a higher quality of invention particularly for those applications at the bottom of the distribution.

[Figure 1 about here]

Table 3 shows how the marginal effects of agent quality and invention quality vary across six technology groupings. The estimates suggest that agent quality is more important for inventions in new/less mature technology areas such as ICT and Software and less important in highly codified areas such as Chemical/Pharmaceutical and Biotechnology. The latter seems to be sensitive to applicant fixed effects and especially the interaction effects of invention quality.

[Table 3 about here]

Finally, Table 4 presents the separate logit estimates of equation (1) using data from each of the other four IP5 offices to see if the findings discussed above are specific to USPTO or common across offices.[13] First, the average marginal effects of agent quality at the EPO and JPO (and to a much lesser extent at the KIPO) are higher at 2.5–5.1 percentage points. However, the most important finding is that it is only at the USPTO that agent quality is more

[13] Estimates based on OLS model with applicant fixed effect are presented in the accompanying online appendix (Appendix Table 3). For both attorney quality and invention quality, the results are roughly similar between the two specifications.

important than invention quality.[14] One other important difference between the USPTO and the other offices relates to PCT filings. They are associated with higher grant probability at the EPO, KIPO and CNIPA but with at lower grant probability at the USPTO.

[Table 4 about here]

6. CONCLUSION

A rich body of theoretical work has derived the conditions under which the patent system promotes innovation. Patents should encourage business to invest in the creation and commercialisation of ideas, especially when the creator needs to sell the idea to a third party. Yet, the system's effectiveness in attaining that goal rests on the assumption that optimal patentability criteria are implemented appropriately in patent law and executed properly by patent offices. This paper documents an important source of potential distortion in the patent examination process, namely the influence of patent agents, which may lead low quality (*i.e.* obvious) inventions to be granted and high-quality inventions to be refused a patent.

Our results suggest that having a higher quality patent agent firm can raise the probability of a grant significantly. We find that the effect of agent quality is larger than the effect of invention quality at the USPTO and its absolute impact is greatest at the EPO and JPO. Furthermore, agent quality matters more when the invention is of lower quality. This effect is even greater if the application is in a technology field that is less codified such as ICT or software.

Scholars and policy analysts should not assume that worthwhile inventions will be granted a patent—or, conversely, that low-quality inventions will be refused a patent. Previous literature has shown that distortions exist in the examination process, mainly through the random allocation of patent applications to patent examiners with different stringency levels—and that this effect has real-world consequences (Sampat and Williams 2019, Farre-

[14] To check if the differences between the attorney and invention quality marginal effects for USPTO sample and other patent offices are sensitive to the fact that the invention quality proxies are derived from different sets of non-focal offices, we reconstruct the proxies based on a common set of non-focal offices. For example, if we compare USPTO and EPO, we use JPO, KIPO and CNIPA as the common benchmark offices. The comparison results (Online Appendix Table 4) are roughly similar.

Mensa *et al*. 2017). We add to this literature by showing that the choice of patent agent firm has a strong effect on the probability of grant.

From a social welfare viewpoint, there should not be an effect of agent quality on examination outcome: patent laws stipulate that a patent application should be assessed on the technical merit of the invention, not on the arguments of the patent agent. However, the reality is that the patent application process is complex to navigate and our results suggest that the ability of agents matters to a surprisingly large extent. The distortion that we observe has potentially harmful welfare consequences because firms that can afford high-quality agents are presumably also more powerful in other dimensions. In that sense, the patent system may help maintain the uneven playing field rather than levelling it.

Although our results are limited to the patent examination process, the benefits of high-quality patent agents are likely to extend well beyond that. This is because the description of the claimed invention in the granted patent document matters in court proceedings, should the validity of the patent be challenged in a court of law. In this respect, high-quality agents are also more likely to write solid patent claims that will stand up if tested in a court of law. Alternatively, if unwarranted patents are more likely to end up in litigation, this can be more socially wasteful than a more stringent patent examination system. Without information on the deleterious effects to low quality patents in force, we are not able to quantify the effects on the economy.

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Table 1. Univariate statistics of USPTO patent application sample by family size (N_f), priority years 2000–2006

Variable	All		$N_f = 5$		$N_f = 4$		$N_f = 3$	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Granted by USPTO	0.932	0.251	0.913	0.281	0.930	0.255	0.936	0.245
Granted by *all* other offices	0.720	0.449	0.655	0.476	0.712	0.453	0.734	0.442
Rejected by *all* other offices	0.031	0.173	0.002	0.043	0.006	0.079	0.048	0.215
Agent quality	-0.017	0.095	-0.024	0.087	-0.021	0.093	-0.014	0.098
Invention quality	0.003	0.246	0.001	0.187	0.002	0.200	0.007	0.274
Local inventor	0.193	0.394	0.195	0.396	0.179	0.383	0.199	0.399
External	0.978	0.146	0.974	0.158	0.977	0.149	0.979	0.142
PCT filing	0.223	0.416	0.289	0.454	0.258	0.438	0.194	0.396
Biotech	0.007	0.084	0.005	0.073	0.006	0.079	0.008	0.088
ICT	0.208	0.406	0.206	0.405	0.189	0.391	0.219	0.413
Software	0.046	0.210	0.047	0.212	0.038	0.190	0.051	0.219
Electrical	0.225	0.418	0.210	0.407	0.252	0.434	0.214	0.410
Instruments	0.168	0.343	0.116	0.320	0.145	0.352	0.188	0.390
Chemical/Pharma	0.064	0.245	0.113	0.316	0.074	0.261	0.052	0.222
Process engineering	0.082	0.274	0.120	0.325	0.090	0.286	0.071	0.257
Mechanical engineering	0.211	0.408	0.182	0.386	0.207	0.405	0.216	0.412
Sample size	40,696		3,783		12,564		24,312	

Table 2. Average marginal effect on grant probability at the USPTO, priority years 2000–2006

Variable	**OLS**	**Logit**	**Family size (N_f)**			**Applicant† FE**
			$N_f = 5$	$N_f = 4$	$N_f = 3$	
Agent quality	0.023***	0.020***	0.021***	0.019***	0.020***	0.024***
	(0.002)	(0.002)	(0.005)	(0.002)	(0.002)	(0.004)
Invention quality	0.008***	0.007***	0.005	0.006***	0.007***	0.007***
	(0.001)	(0.001)	(0.005)	(0.002)	(0.002)	(0.002)
Local inventor	0.015***	0.021***	0.008	0.033***	0.017***	0.018**
	(0.003)	(0.003)	(0.012)	(0.006)	(0.004)	(0.007)
PCT filing	-0.079***	-0.074***	-0.124***	-0.064***	-0.071***	-0.060***
	(0.003)	(0.004)	(0.013)	(0.006)	(0.005)	(0.007)
External Agent	0.003	-0.012	-0.007	-0.022	-0.007	0.019
	(0.007)	(0.009)	(0.036)	(0.020)	(0.011)	(0.015)
Constant	0.958***					0.934***
	(0.005)					(0.017)
Technology fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Applicant fixed effect	No	No	No	No	No	Yes
Method	OLS	Logit	Logit	Logit	Logit	OLS
N	40,696	40,696	3,783	12,564	24,312	40,162
Adj./Pseudo/Overall R^2	0.042	0.079	0.117	0.070	0.085	0.038

Note: Agent quality and invention quality are normalised to mean = 0 and standard deviation = 1. () = bootstrap standard errors.; ***/**/* statistically significant at 1/5/10 per cent respectively. Dependent variable: Grant = 1 if granted; 0 if refused.

†There are 5,229 unique applicants; the fixed effects account for 48.1 per cent of variance.

Table 3. Confounders of agent *quality*'s and *invention quality*'s effect, priority years 2000–2006

Confounders	**× Agent quality**		**× Invention quality**	
	Logit	**OLS (Applicant FE)**	**Logit**	**OLS (Applicant FE)**
Local inventor	-0.001***	-0.010	-0.007	0.002
	(0.000)	(0.008)	(0.008)	(0.003)
PCT filing	0.005	-0.003	0.019***	0.010*
	(0.005)	(0.008)	(0.001)	(0.005)
Electrical	-0.004	-0.006	-0.008	-0.002
	(0.004)	(0.006)	(0.001)	(0.002)
Instruments	-0.018	-0.018***	-0.015***	0.000
	(0.014)	(0.006)	(0.006)	(0.003)
Chemical/Pharmaceutical	-0.013**	-0.010	-0.003	0.006
	(0.006)	(0.008)	(0.008)	(0.008)
Biotechnology	-0.041**	-0.056	0.015	-0.025
	(0.021)	(0.047)	(0.010)	(0.027)
ICT	0.025***	0.034***	0.010***	0.001
	(0.005)	(0.006)	(0.002)	(0.004)
Software	0.027***	0.032**	0.014***	-0.006
	(0.008)	(0.013)	(0.003)	(0.005)
N	40,696	40,162	40,696	40,162

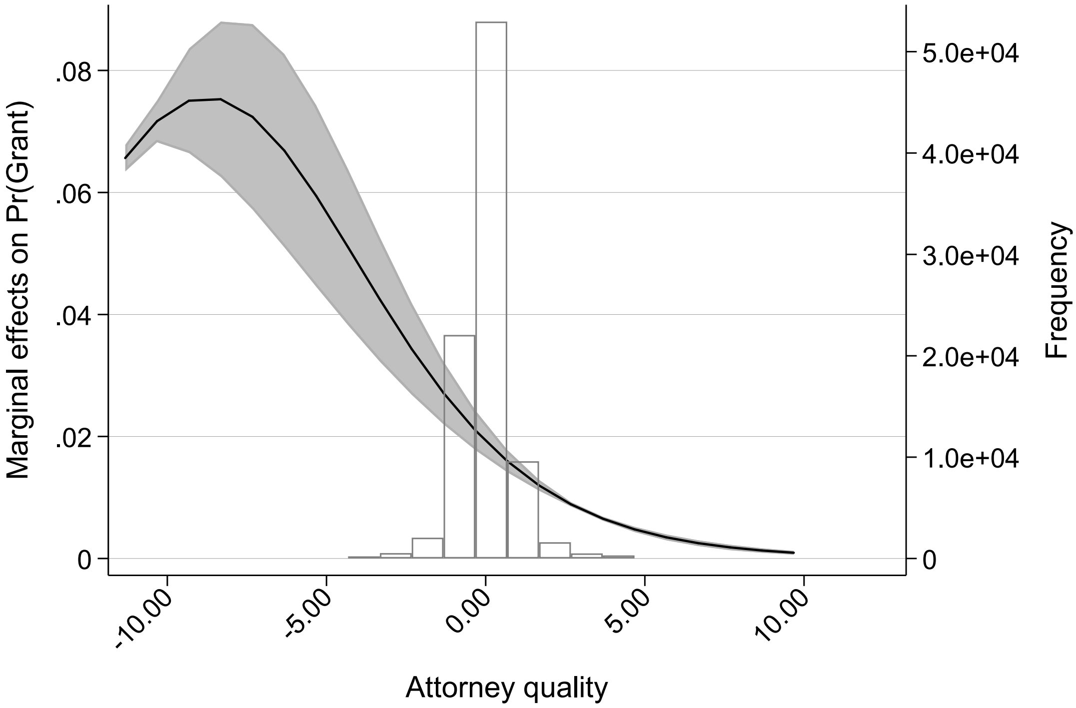
Note: () = bootstrap standard errors. ***/**/* statistically significant at 1/5/10 per cent respectively. Regression estimates are based on separate regression of each interacted technology class and attorney quality; all regressions include the regressors in the baseline non-interacted models. Dependent variable: Grant = 1 if granted; 0 if refused.

Table 4. Average marginal effect on grant probability at the USPTO and other IP5 offices, priority years 2000–2006

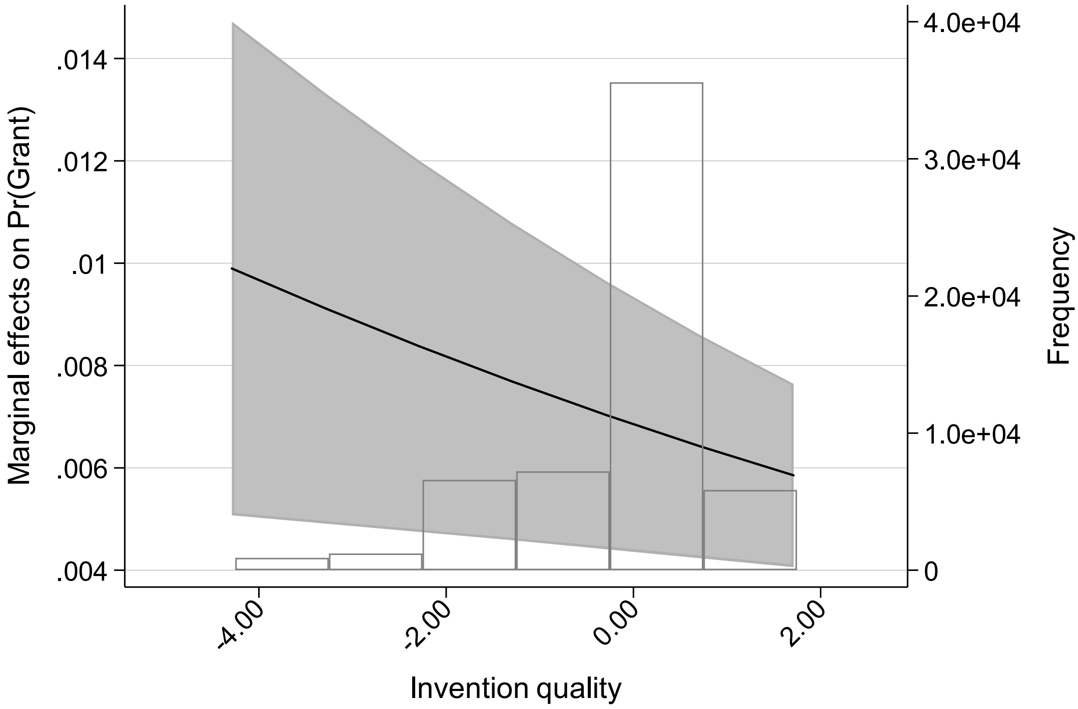
Variables	**USPTO**	**EPO**	**JPO**	**KIPO**	**CNIPA**
Agent quality	0.020***	0.051***	0.040***	0.025***	0.011***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
Invention quality	0.007***	0.061***	0.073***	0.053***	0.012***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)
Local inventor	0.021***	0.070***	0.097***	0.055***	0.012*
	(0.003)	(0.005)	(0.005)	(0.004)	(0.007)
PCT filing	-0.074***	0.072***	0.007	0.087***	0.020***
	(0.004)	(0.004)	(0.006)	(0.005)	(0.002)
External attorney	-0.012	0.016	0.003	-0.079***	-
	(0.009)	(0.012)	(0.013)	(0.016)	
Technology fixed effect	Yes	Yes	Yes	Yes	Yes
Applicant fixed effect	No	No	No	No	No
Method	Logit	Logit	Logit	Logit	Logit
N	40,696	26,407	40,060	19,433	30,302
Pseudo-R^2	0.079	0.156	0.059	0.098	0.088

Note: Agent quality and invention quality are normalised to mean = 0 and standard deviation = 1. () = bootstrap standard errors.; ***/**/* statistically significant at 1/5/10 per cent respectively. Regression estimates are based on separate regression of each patent office's decision. Dependent variable: Grant = 1 if granted; 0 if refused (and, for EPO, withdrawn with EPO XY citation). Estimation method: Logistic regression model.

Figure 1. Marginal effect of attorney quality (a) and invention quality (b) on probability of grant at the USPTO, priority years 2000–2006



(a)



(b)

Note: Shaded area is the 95% confidence intervals. Standard errors are bootstrapped.

APPENDICES

A – Dataset Construction

The construction of the dataset involved complex data extraction and linking from distinct sources. The main data source is PATSTAT, which provides information on priority filings and their equivalent(s); inventor/applicant country of residence; technological fields (use of International Patent Classification codes); and filing route (PCT/Paris Convention). We used the OECD Harmonised Applicant Names (HAN) database for PATSTAT to improve on the identification of applicants within jurisdictions.[15]

The application status in each of the five offices were collected from the EPO's INPADOC PRS table for PATSTAT, JPO's public access on-line Industrial Property Digital Library Database, KIPO's public access on-line IPR Information Service, and USPTO Public Pair on-line database.

Agent information was collected from Espacenet; the USPTO Bulk Downloads of Patent Application Information Retrieval (PAIR) Data; the Japanese Platform for Patent Information and the Japan Patent Attorneys Association; the Korean Intellectual Property Rights Information Service on-line search platform; and the Chinese on-line patent search tool, Patent Search and Analysis of CNIPA and the All-China Patent Attorneys Association (ACPAA).[16] The patent agent or patent attorney information from the JPO, the KIPO and the CNIPA was largely clean—accordingly this information was harmonised using a simple string match. EPO patent agent information was collected from Espacenet with additional information extracted from patent applications provided directly by the EPO. USPTO and EPO patent agent firms were identified and harmonised using a bigram matching as per the procedure used in Julius and de Rassenfosse (2014).[17] We selected the patent agent firm and not the individual agent because applications can be jointly produced by several individuals within a workplace. For 19.6 per cent of applications to the JPO this was not possible and the

[15] Ninety-two per cent of applications had only one applicant. Where there was more than one applicant per family, we selected the applicant with the most applications in our dataset. The rationale is that these companies would be the most sophisticated in filing patent applications and would therefore be the most likely to take the lead.

[16] These sources are available at the following URLs: https://worldwide.espacenet.com/, https://www.google.com/googlebooks/uspto-patents-pair.html, https://www.j-platpat.inpit.go.jp, http://www.jpaa.or.jp/, http://eng.kipris.or.kr/, http://www.pss-system.gov.cn/sipopublicsearch/portal/uiIndex.shtml, http://www.acpaa.cn/

[17] http://melbourneinstitute.unimelb.edu.au/downloads/working_paper_series/wp2014n15.pdf

agent identifier represented the individual rather than the agent firm (see the online Appendix for details).

To identify whether a patent agent was in-house or not, we estimated the number of applicants each agent had represented in our dataset. If an agent had had only one client, we deemed it an in-house agent (this was 2.8 per cent of our sample). As such, this approximation will overstate the number of in-house agents.

The total population of applications that had one-to-one equivalents in at least two of the IP5 offices (priority years 2000–2006) was 1,264,735 applications which related to 461,961 invention families. All these applications had been examined.[18]

About 240,000 have equivalents in two of the five offices, whereas approximately 24,000 families have equivalents in all offices. As expected, these equivalent patents do not all have identical patent examination outcome across the IP5 offices. About 17 per cent of families filed and examined only in two offices were refused in both offices, 50 per cent were granted in both offices and 33 per cent were granted in one office and refused in the other. The percentage of families with mixed grant outcome jumps to 59 for 'quintuplet' families. The estimating sample for the fixed-effect binary logit estimation will differ from that for the fixed-effect linear regression model. The conditional likelihood estimation of the model requires heterogeneity in the grant decision. In other words, the fixed effect would fully explain the grant outcome if all the patent applications in the family are either rejected or granted. Of those invention families with an examination outcome (either refused or granted), 41.1 per cent have a mixed outcome.

[18] We exclude applications that are pending or have no recorded outcome. Lazaridis and van Pottelsberghe (2007) have argued that applications to the EPO that were withdrawn after an 'X' or 'Y' citation should be regarded as 'quasi-refusals' as they were probably withdrawn in response to the negative feedback from the examiner. In our presented estimating model, we classify these EPO quasi-refusals as refusals.

B - Method for identifying the patent agent firm

The percentage of applications with a non-blank address field in the EPO, USPTO, JPO, KIPO and CNIPA were 88.3, 84.9, 95.4, 99.6 and 90.5 respectively. In the EPO, USPTO and KIPO the entity name was identified from this address field. In KIPO address variables, the firm (office) is always in parentheses at the end of the variable. For CNIPA, 2 applications had missing agent firm fields, and for these two applications, the agent ID tracks the name of the individual agent. The remainder had complete agent firm names.

Information for JPO applications is less complete. There are 862 individual agents with no agent firm affiliation (compared with 2972 agents with an agent firm affiliation). For these 862 individual agents, the agent ID tracks the name of the individual agent. This means 19.6 per cent of applications has an agent ID rather than an agent firm.

In all cases, the Latin names of the agent firms were harmonised using a bigram match as per the procedure used in Julius and de Rassenfosse (2014).[19]. A business executive, fluent in Japanese and Chinese, Ms Helen Szaday, reviewed the method of firm name identification.

Appendix Table 1. Summary statistics of baseline model (equation 2) coefficient estimates from linear panel estimations of 100 sets of random samples

	Obs.	**Mean**	**Std. Dev.**	**Min**	**Max**
Agent quality	100	0.461	0.009	0.439	0.481
Local inventor	100	0.058	0.002	0.053	0.061
PCT	100	0.009	0.002	0.003	0.014
External agent	100	0.012	0.005	-0.001	0.025

Appendix Table 2. Average marginal effect on grant probability at the USPTO

Variable	**All**		**Family size** (N_f)		
	OLS	FE	$N_f = 5$	$N_f = 4$	$N_f = 3$
Agent quality	0.023***	0.024***	0.029*	0.024***	0.026***
	(0.002)	(0.004)	(0.016)	(0.006)	(0.005)
Invention quality	0.008***	0.007***	0.003	0.006**	0.007***
	(0.001)	(0.002)	(0.004)	(0.003)	(0.002)
Local inventor	0.015***	0.018**	-0.017	0.035**	0.009
	(0.003)	(0.007)	(0.031)	(0.013)	(0.010)
PCT filing	-0.079***	-0.060***	-0.098***	-0.042***	-0.065***
	(0.003)	(0.007)	(0.022)	(0.011)	(0.011)
External agent	0.003	0.019	0.016	-0.002	0.034
	(0.007)	(0.015)	(0.020)	(0.019)	(0.023)
Constant	0.958***	0.934***	0.951***	0.937***	0.928***
	(0.005)	(0.017)	(0.022)	(0.023)	(0.025)
Method	OLS	OLS	OLS	OLS	OLS
Technology fixed effect	Yes	Yes	Yes	Yes	Yes
Applicant fixed effect	No	Yes	Yes	Yes	Yes
N	40,696	40,162	3,762	12,444	23,956
No. of applicants	-	5,229	982	2,281	3,707
Rho	-	0.481	0.540	0.490	0.475
Adj./Overall R2	0.042	0.038	0.050	0.032	0.037

Note: Agent quality and invention quality are normalised to mean = 0 and standard deviation = 1. () = bootstrap standard errors.; ***/**/* statistically significant at 1/5/10 per cent respectively. Regression estimates are based on separate regression of each patent office. Dependent variable: Grant = 1 if granted; 0 if refused/withdrawn with EPO XY citation. Estimation method: Logistic regression model.

Appendix Table 3. Average marginal effect on grant probability at the USPTO and other IP5 offices, Applicant Fixed Effect

Variables	**USPTO**	**EPO**	**JPO**	**KIPO**	**SIPO**
Agent quality	0.024***	0.037***	0.028***	0.025***	0.025***
	(0.004)	(0.006)	(0.003)	(0.007)	(0.003)
Invention quality	0.007***	0.071***	0.080***	0.058***	0.015***
	(0.002)	(0.003)	(0.013)	(0.007)	(0.002)
Local inventor	0.018**	0.024***	0.083***	0.009	0.011
	(0.007)	(0.014)	(0.013)	(0.029)	(0.009)
PCT filing	-0.060***	0.083***	0.039***	0.103***	-0.001
	(0.007)	(0.014)	(0.012)	(0.013)	(0.004)
External agent	0.019	-0.021	0.020	-0.071	-0.008
	(0.015)	(0.030)	(0.015)	(0.159)	(0.033)
Constant	0.934***	0.821***	0.713***	0.970***	0.984***
	(0.017)	(0.031)	(0.019)	(0.160)	(0.033)
Method	OLS	OLS	OLS	OLS	OLS
Technology fixed effect	Yes	Yes	Yes	Yes	Yes
Applicant fixed effect	Yes	Yes	Yes	Yes	Yes
N	40,162	25,979	39,541	19,229	30,115
R-sq. overall	0.038	0.129	0.062	0.058	0.023

Note: Agent quality and invention quality are normalised to mean = 0 and standard deviation = 1. () = bootstrap standard errors.; ***/**/* statistically significant at 1/5/10 per cent respectively. Regression estimates are based on separate regression of each patent office. Dependent variable: Grant = 1 if granted; 0 if refused (and, for EPO, withdrawn with EPO XY citation). Estimation method: OLS with applicant dummy variables.

Appendix Table 4. Average marginal effect on grant probability; comparison of USPTO vs. EPO and USPTO vs. JPO based on common set of third countries to infer invention quality.

Variables	Comparison 1		Comparison 2	
	USPTO	**EPO**	**USPTO**	**JPO**
Agent quality	0.023***	0.052***	0.021***	0.024***
	(0.002)	(0.003)	(0.002)	(0.001)
Invention quality	0.008***	0.056***	0.010***	0.078***
	(0.001)	(0.002)	(0.002)	(0.001)
Local inventor	0.021***	0.050***	0.033***	0.027***
	(0.005)	(0.006)	(0.004)	(0.003)
PCT filing	-0.080***	0.060***	-0.077***	0.019***
	(0.005)	(0.006)	(0.005)	(0.003)
External agent	-0.020**	0.026*	-0.010	0.018***
	(0.010)	(0.016)	(0.012)	(0.006)
Method	Logit	Logit	Logit	Logit
Technology fixed effect	Yes	Yes	Yes	Yes
Applicant fixed effect	No	No	No	No
N	27,975	13,806	20,954	17,732
Pseudo-R2	0.075	0.160	0.078	0.792

Note: For Comparison 1, Patentability is based on outcomes in JPO, KIPO and SIPO. For Comparison 2, Patentability is based on outcomes in EPO, KIPO and SIPO. Agent quality and invention quality are normalised to mean = 0 and standard deviation = 1. () = bootstrap standard errors.; ***/**/* statistically significant at 1/5/10 per cent respectively. Regression estimates are based on separate regression of each patent office's decision. Dependent variable: Grant = 1 if granted; 0 if refused (and, for EPO, withdrawn with EPO XY citation). Estimation method: Logistic regression model.

Appendix Table 5. Average marginal effect on grant probability at the USPTO (invention family fixed effect model)

Variables	OLS	Logit	OLS†
Agent quality	0.061***	0.109***	0.062***
	(0.001)	(0.004)	(0.002)
Local inventor	0.059***	0.110***	0.055***
	(0.002)	(0.003)	(0.003)
PCT filing	0.008***	0.008	0.009*
	(0.003)	(0.007)	(0.005)
External agent	0.014***	0.011	0.012*
	(0.005)	(0.012)	(0.005)
Constant	0.809***		
	(0.005)		
Technology fixed effect	Yes	Yes	Yes
Invention family fixed effect	Yes	Yes	Yes
Patent office fixed effect	Yes	Yes	Yes
Applicant fixed effect	No	No	Yes
N-applications	279,220	80,097	268,794
N-invention families	107,971	29,182	102,951
R-sq. / Log likelihood	0.073	-19,723.5	0.482

Note: Agent quality and invention quality are normalised to mean = 0 and standard deviation = 1. () = bootstrap standard errors; ***/**/* statistically significant at 1/5/10 per cent respectively. Regression estimates are based on separate regression of each patent office. Dependent variable: Grant = 1 if granted; 0 if refused (and, for EPO, withdrawn with EPO XY citation). †Estimated using reg2hdfe command (Guimaraes and Portugal 2010); standard errors are clustered on 7,790 agent ID.