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Grace Period Literature Review

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By Jack Gregory

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I. Introduction

Grace is the disclosure of an innovation without loss of the right to patent. It refers to a period of time, before a patent application is filed, in which an invention may be disclosed without losing its novelty. Grace is applied disparately across countries. It is a prominent characteristic of the American, Japanese, and Australian patent regimes, while for all practical purposes it is absent from Europe. Notably, grace differs to such an extent that employing it in one jurisdiction may preclude successful patenting in another. As such over the past few decades, sections of the international community have pushed for greater patent law harmonisation. And it is broadly accepted that grace is a crucial element of this endeavour.

In 1983 through potential amendments to the Patent Cooperation Treaty (PCT), the primary patenting jurisdictions – comprising the US, Europe and Japan – initiated debate surrounding a universal grace period. While movement on the issue failed to materialise, greater international cooperation gradually evolved into the Patent Law Treaty (PLT). The Treaty, signed in 2000, streamlined patent application procedures, but did not directly address major policy differences. Shortly thereafter, the desire amongst its members for a standardised legal framework encouraged the World Intellectual Property Organization (WIPO) to begin discussions on the Substantive Patent Law Treaty (SPLT). WIPO produced a draft in 2003; however, differences emerged and further discussions on the SPLT were

suspended indefinitely from 2006 onwards. The abortive result was partly a consequence of the misalignment of member interests and the uncertain effects of various policies, including grace periods. Harmonisation efforts were reinvigorated with the passage of the 2011 America Invents Act (AIA), which included substantial changes to US law governing grace (Joachim, 2015). Since its passage, a renewed effort towards greater integration has emerged. Negotiations are ongoing; though, grace period policy and application remain heterogeneous.

Given this fitful history, it is remarkable how sparse the academic literature is regarding grace. While much effort has been expended on patents and innovation generally, there is a paucity of academic work focusing specifically on grace periods. The remainder of this report endeavours to summarise the main contributions, while also drawing links to the related streams of economic research. It is organised as follows. Section II presents the academic literature specifically covering grace. Section III addresses economic thought related to innovation more generally, while Section IV explores the relationship between patents and options theory. Finally, Section V summarises the major trends in the academic literature.

II. Grace Period Papers

The focus on harmonisation precipitates many law reviews and user surveys. The former tend to debate the merits of grace periods and their underlying characteristics, while the latter capture the panoply of opinions in major patenting countries. In the economic literature – to the author's knowledge – there have yet to be any papers presenting a formalised theory of grace periods. There is, however, a nascent interest in econometric analyses. This section addresses each body of literature in turn, namely: law reviews, user surveys and econometric papers.

A. Law Reviews

Grace period law reviews tends to centre around four major subjects: (1) legislative history; (2) national comparisons; (3) recommendations for standardisation; and finally, (4) substantive costs and benefits.

The discourse surrounding grace period policy predates the current focus on harmonisation. Straus (2001) provides an excellent narrative of the debate from a European perspective, retracing as far back as 1968. Joachim (2015) discusses the major legislative events leading to the AIA, commencing with the Patent Act of 1952. Bodkin (2008) provides a history of patents and grace in Australian law. At an international level, Roucounas (2006) contains an excellent summary of the various harmonisation efforts as they relate to grace periods. Finally, Struve (2013) discusses recent failures towards the adoption of a universal grace period and the potential for a breakthrough following the AIA.

Grace period comparisons and recommendations tend to be coupled. Bagley (2006) authors a relatively narrow treatment, focusing on how the US patent system may be adapted to better support academia. She argues that patent law forces scholars to choose between patenting and open discourse. Grace periods alleviate this tension by permitting disclosure and discussion of ideas while retaining the right to patent. She proposes an opt-in system for a two-year grace period, in exchange for the abrogation of the normal eighteen-month pre-publication period. In essence, academics would agree to the publication of their patent applications immediately after the filing date.

In a more expansive piece, Metzler (2009) advocates for a universal grace period based upon four standard elements: types of disclosure, range of medium, disclosure source, and duration. Legal regimes are categorised on a spectrum with the extremes identified as either pro-inventor or pro-society. Pro-inventor regimes tend to have broad definitions of the standard elements, permitting greater access to grace periods. On the other hand, pro-society regimes tends to be more restrictive, ensuring quick public access. Hybrid regimes – those with less predilection

towards either extreme – are classified as 'harmonising'. They attempt to balance inventor and societal interests by narrowly defining one or more of the standard elements. This leads to the author's preferred universal regime. To support disclosure and further innovation, pro-inventor policies are favoured for types of disclosure, range of media and duration. That is, grace would be applied to any form of written or oral disclosures, the range of media would not be restricted, and a grace period length twelve months would be adopted. However, the disclosure source would be limited to the applicant themselves.

Struve (2013) also advocates for global reform; however, he suggests a more modest, incremental approach. His paper is a reaction to the ineffectual negotiations over a universal grace period. He argues that there are too many stakeholders with interests too diverse to bring about substantive patent-law harmonization among all WIPO members. Instead, he advocates for a piecemeal strategy. The major patenting countries should agree to best practices which may be adopted by individual jurisdictions. He identifies plausible best practises by contrasting grace period regimes in the US and other major patenting jurisdictions, including: Europe, Japan, Korea, and China. To narrow the gap between pro-inventor regimes, as the US, and pro-society ones, as in Europe, he proposes movement towards a 'safety-net' grace period. That is, a system which appropriately balances the concern of larger users in determining what constitutes prior art, while protecting academic publications and unsophisticated applicants from being disproportionately punished with a total loss of rights. Similar to Metzler, the most effective grace period would be twelve months and would protect all acts deemed to be a disclosure.

The attenuation of ambition, as represented by the transition to a decentralised approach between the Metzler and Struve papers, is striking. It is even more remarkable given these works are separated by only four years. In contrast to the differing approaches towards a universal grace period, there has been the widespread agreement over their costs and benefits (see for example: Roucounas

Table 1—Offsetting costs and benefits of grace periods

	Scope	Benefits	Costs
1	Society	Accelerated knowledge dissemination	Longer period of monopoly rents
2	Practitioners	Reduced uncertainty for inventors	Greater uncertainty for followers
3	Practitioners	Reduced risk for inventors	Greater risk for followers
4	Patent Offices	Decreased patenting costs	Increased patenting costs

(2006); Struve (2013); and, Joachim (2015)). In fact, many law reviews present the economic implications as axiomatic. While most authors extol the virtues of grace periods, the economic implications are typically invoked rather than justified.

The *raison d'être* of the patent system is to encourage innovation. Its underpinning is the inherent tradeoff between the disclosure of an innovation and the exclusive rights to its commercialisation. By granting property rights to the inventor, innovation is incentivised through the extraction of monopoly rents. Society tolerates this distortion, as it gains from the dissemination of new ideas. This tension was first identified by Norhaus (1969):

> *On one hand, increasing patent duration benefits society by eliciting R&D activity that would otherwise not have been conducted, which yields socially valuable inventions. On the other hand, increasing patent duration harms society by giving additional monopoly protection to the inventions that society would have enjoyed even absent the increase in protection, which leads to socially harmful supra-competitive pricing.*

The costs and benefits of grace periods naturally mirror this dichotomy. Grace benefits society by encouraging early dissemination through the optioning of patent rights, but they also harm society through the extension of monopoly protection. This is the first of four offsetting benefits and costs associated with grace periods, which are enumerated in Table 1.

Grace periods tend to favour inventors over followers, as they reduce uncertainty and risk for the former, while increasing it for the latter. In general, inventors gain from grace periods; hence, its welfare effect depends on third parties, including

followers and society at large (Nagaoka and Nishimura, 2015). With respect to followers, grace periods increase legal uncertainty and the risk of unintentional infringement. Their application discourages early investment decisions as the status of intellectual property (IP) rights may be ambiguous, as novelty searches may not be conclusive. For inventors, the benefits are not distributed evenly amongst the various types. They are geared towards assisting academics and small and medium enterprises (SMEs), rather than large corporations. Large corporations typically have access to the requisite resources and expertise to access the patent system and to manage uncertainty associated with an invention. In contrast, academics and SMEs may be ill-equipped to absorb such uncertainty. They often require time to evaluate, develop, and seek funding before deciding whether to seek patent rights. Presumably, their expertise is concentrated in their particular subject matter, and thus, they may be poorly informed about the complexities of international patent law. The opportunity to prepare a better patent application – either through improvements to their invention or improved awareness of patent system – can reduced the risk an application is rejected. Finally, grace removes the risk of accidental or incautious disclosure, which may destroy novelty.

Bagley (2006) and Metzler (2009) highlight the practitioner benefits of grace specific to the "publish or perish" academic environment. As described by Tessensohn and Yamamoto (2007), "[a]cademic researchers have historically been compelled to publish the fruits of their scientific research, as publications are the primary basis for promotion, tenure and research funding." Thus, academic success from the ability to publish, as publications lead to funding, funding permits further research, and more research leads to more publications, all aiding the pursuit of tenure. Due to the pressure of publishing and the likelihood academics are unfamiliar with patent law, a publication may forfeit the right to a patent. Therefore, grace periods are crucial for aligning the academic process with the patent system.

For patent offices, grace periods have an ambiguous effect on their costs. On the one hand, grace may eliminate patents lacking novelty or sufficient net benefits. Grace may reduce the quantity of submitted applications, as inventors have more opportunity to assess the benefits of patenting. On the other, however, search and examination are necessarily more complex, adversely affecting operational efficiency. Hence, grace may increase costs for those applications which are submitted.

As patents are a legal mechanism, law reviews provide critical incite into their motivation and application. In fact, law reviews tend to define the modeling assumptions under which associated econometric analyses are prepared. Consequently, a good understanding of the legal argument for patents, and specifically grace periods, is important to parse the economic theory.

B. Practitioner Surveys

Similar to law reviews, the impetus for the practitioner surveys stems from wider interest and debate around harmonisation. Since the passage of the AIA, there has been an effort to ascertain the views of differing practitioner groups within the major patenting countries. Many of the views expressed in the legal community are echoed by those who participate in the patent system itself. And perhaps unsurprisingly, practitioners tend to be factional either with respect to their jurisdiction or practitioner type.

The Tegernsee Group (2014), composed of the patent offices from Denmark, France, Germany, Japan, the UK, the US, and the EU, prepared the largest such study. The members launched a data collecting process in their respective jurisdictions to assess opinion surrounding harmonisation. They identified six key issues related to the substantive patent law harmonisation process, including grace periods. The ad hoc survey gathered 412 respondents in Japan, 194 in the US, and 134 in Europe. The results were markedly different between jurisdictions and particularly dependent on access to grace. In the US and Japan, the large

majority of the respondents supported a grace period, while only a slim majority favored it in Europe. Moreover, most respondents in the US and Japan believed grace to be beneficial for academics and SMEs. A minority of the European respondents acknowledged these positive impacts. In Europe, respondents believed grace periods undermine and complicate the legal certainty of the patent system, while such views were in the minority in the US and Japan. Universities, research institutions, and SMEs tended to support grace, regardless of their geographic location. Notably, majorities in all countries believed grace balanced the purposes of the patent system against the needs of the scientific community. There was also widespread support for the view grace protected inventors against involuntary disclosure. On the other hand, there was little support to the opinion that grace enables inventors to conduct market research and obtain financing before filing.

A study prepared by the European Patent Office (2014) built on the work completed by the Tegernsee Group. The EPO focused on the potential effects of introducing a grace period in Europe. Specifically, the study sought to identify the main benefits and costs of introducing a grace period and to assess their relative importance. They conducted an online survey, which garnered 820 responses among practitioners in Japan, the US and Europe, and supplemented it with 30 structured interviews. Similar to the results from the Tegernsee Group (2014), the extent to which respondents supported grace is dependent on both geographic location and practitioner type. Interestingly, even though European users were relatively less supportive of grace, their views varied significantly by type. Whilst only 39% of European corporations were in favour of a grace period, the majority of European universities and SMEs supported it in principle. The motivations for applying grace varied significantly depending on the geographical origin of the practitioner. Almost half of those surveyed in Europe used the grace period out of necessity from either human errors or breach of confidence. US patent users indicated the possibility of testing and improving their invention as their primary

motivation. Among Japanese patent users, the primary motivation was the desire to publish in academic journals. Differences in motivation were somewhat less marked across user types. Large corporations cited necessity as a key motivation for using the grace period. This might be due to the fact that large companies tend to file more patent applications than smaller firms, and so a relatively low frequency of accidental disclosures may still imply a large absolute number of instances necessitating the grace period. SMEs indicated the ability to test and improve inventions as their primary motivation. And finally, universities and public research organisations suggested their main driver was the ability to publish in academic journals.

Edmonson et al. (2013) and United Kingdom Intellectual Property Office (2015) undertook more tailored studies, focusing on universities and businesses respectively. The former conducted a survey seeking the views of technology transfer offices within major European universities. The latter performed interviews of American and British businesses and IP law firms. Many of their findings parallel the two studies discussed above. Academics tended to be in favour of grace, while the private sector was mixed depending on their patenting resources and capabilities. Those in the US favoured grace periods as it facilitates disclosure in academic circles and permits SMEs to find investment partners. Contrastingly, those in the UK opposed grace as it introduces uncertainly into the legal sphere and hampers innovation for followers.

Despite differences in locations, respondents, and methodologies, there are a number of common threads amongst the various surveys. Smaller entities, including universities and SMEs, are the primary users and beneficiaries of grace period legislation. Majorities agree that grace is an acceptable mechanism for balancing corporate and academic needs within the patent system. However, there is widespread acknowledgement that grace creates additional legal burdens on all stakeholders. Common findings amongst the practitioner surveys are summarised in Table 2.

Table 2—Common findings amongst practitioner surveys

Topic	Findings
Regional differences	Practitioners tend to favour the system in their native jurisdiction.
Practitioner differences	Academics and SMEs tend to utilise and support the grace period while corporations tend not to.
Grace period benefits	Most support the notions that grace: (1) balances the purposes of the patent system against the needs of the scientific community; and, (2) protects inventors against accidental or incautious disclosure.
Grace period costs	Most support the notion that grace creates additional legal burdens.
Harmonisation	Most practitioners believe harmonisation would benefit the international community; specifically, Europe should adopt the grace period.

C. Econometric Papers

Existing empirical research on grace is limited in large part due to the design of current regimes. Most jurisdictions automatically apply a grace period when a disclosure is made. As such, there is typically no record of whether a grace period is utilised or not. Two empirical papers, taking vastly different approaches, have attempted to overcome this difficulty.

Franzoni and Scellato (2010) address the lack of data by designing an empirical strategy around academia. They develop a data set of patent-publication pairs through both inventor-author and patent application-scientific article matching. Using 299 pairs from the US and another 62 from Europe, they set out to assess: (1) the frequency of use of the grace period within the US; (2) the average time lag to disclosure in academia with and without the grace period; (3) the determinants of the choice to use grace; and, (4) the determinants of the lag between the patent application and its dissemination.

Through a frequency analysis, the authors estimate around one third of academic inventors in the US use grace, despite risking novelty abroad. They then compare mean time lags – both with and without access to a grace period – using one-tailed t-tests. On average, US academic inventions are disclosed in open science journals quicker than European equivalents. Moreover, the time to dis-

closure is longer in the US when international coverage of inventions is required. Specifically, US domestic patents (i.e. those likely to use grace) are published on average 2.8 months after filing, as opposed to an average of 9.9 months after filing for US patents extended abroad (i.e. those unlikely to use grace) and an average of 16.2 months after filing for European patents (i.e. those unable to use grace). Their differences are all significant at the 5% level. Notably, these results hold when the sample is restricted to large international companies, which the authors suggest could be evidence in support of a grace period.

For the grace decision, the authors apply a probit model with sectoral fixed effects. Patent quality exhibited a positive effect significant at the 10% level, while publication quality demonstrated a slightly negative effect at the 5% level. These results are indicative of grace as an option value.[1] That is, researchers can disseminate their results, obtain feedback, and submit a patent when they anticipate a sufficient return. Similar to the time lag results, author type does not significantly affect grace period usage.

For the delay in disclosure, the authors apply an ordinary least squares (OLS) model with sectoral fixed effects conditioned on not having used grace. They find that the time to disclosure is longer when international coverage is sought and when a firm is among the authors. Furthermore, publication lags are shorter when priority of the patent is claimed in the US rather than in Europe, which demonstrates that the absence of the grace period in Europe makes Europe-based researchers less competitive in obtaining scientific priority. Grace periods are more likely to be used in the US for relatively high-quality patents and for domestic patents.

Some limitations acknowledged by the authors include the fact that data collection is labour and time intensive. The data occupies a specific niche, which limits their analyses to patents of an academic origin from the US and Europe only.[2]

[1] See Bloom and Van Reenen (2002) for an exposition of patents as an option value.

[2] Moreover, the authors utilise scientific publications and conference proceedings as their only forms of academic disclosure. However, the authors argue its necessity as it bolsters their empirical analyses

And crucially, publication-patent delay does not necessarily identify the relationship between grace and knowledge flow (Nagaoka and Nishimura, 2015). Consider an example where a European researcher discloses concurrently with the patent filing, while a US researcher files one year from the disclosure date automatically qualifying for a grace period. In this case, the patent publication delay is zero for the European researcher while it is -12 months for the US researcher. Simplistically, it seems as though the grace period accelerated knowledge spillover. However, if the US researcher simply delayed patent filing by 12 months, there would be no such acceleration effect.

As the example demonstrates, it is challenging to identify knowledge flow effects particularly as grace is invoked by default after disclosure. Japan, however, requires disclosure notification if an applicant wishes to maintain novelty. Nagaoka and Nishimura (2015) leverage this policy to address some of the limitations from Franzoni and Scellato (2010). They assess: (1) whether grace periods accelerate disclosure, (2) the major determinants of grace period usage; and, (3) the major determinants of grace on knowledge flow. They prepare a basic model assuming three reasons for invoking a grace period:

1) Acceleration of disclosure – the inventor uses it for academic disclosure before patenting which takes additional preparation time.

2) Deferral of domestic patent filing – the inventor uses it to delay filing either to better market their invention or to ensure a longer period of patent protection.

3) Promotion of domestic patenting – the inventor uses it to obtain a domestic patent after early disclosure either for academic purposes or accidental release.

Acceleration of disclosure is assumed to increase knowledge stock, while the latter two are assumed to be neutral at best and harmful at worst. According to

through the identification a reliable disclosure date.

Tegernsee Group (2014), the primary motivations for applying grace vary depending on the geographic origin of the patent user. Almost half of those surveyed in Europe used the grace period out of necessity from either human errors or breach of confidence as in Case 3. American patent users indicated the possibility of testing and improving their invention as the primary motivation for using grace as in Case 2. Finally, among Japanese patent users the primary motivation was the need to publish in academic journals as in Case 1. Hence, Case 1 is likely to dominate given Nagaoka and Nishimura (2015) rely on Japanese data. And this is indeed what the authors find, suggesting grace periods likely enhance knowledge diffusion and social welfare.

It should be noted that the paper's theoretical model is comprised of a series of inequalities, which are used to infer comparative static results. Given this setup, it is perhaps generous to describe the inequalities as a model. They are better represented as a set of decision criteria, especially since the comparative statics are inferred rather than derived.

The empirical analysis relies on two linear specifications. The first explores the determinants of grace period usage. They utilise OLS – and a probit model for sensitivity – to regress the grace decision on a set of explanatory variables and fixed effects, including: technology sector, applicant type, and year.[3] They find that patents with concurrent foreign applications and greater numbers of claims both have significant negative relationships, while science intensity has a significant positive one. As foreshadowed above, these results correspond with Case 1: acceleration of disclosure.

The second specification analyses the effect of grace periods on knowledge flow. Due to endogeneity, the authors apply a difference-in-difference approach. The endogeneity derives from the simultaneity between science-intensity and grace period usage. That is, science-related inventions are more likely to use grace. As

[3] OLS with a binary dependent variable results in two major issues: heteroskedasticity and interpretation. Heteroskedasticity can easily be addressed through a feasible general least squares (FGLS) procedure, while a linear regression of a binary variable naturally leads to interpretive difficulties.

the authors use forward citations as a proxy for knowledge flow, they subtract self-forward citations from other-forward citations and consider grace usage as the treatment. They assume self-citations are unaffected by early disclosure which allows them to apply the difference-in-difference approach. Through OLS, they find that the treatment has a significant positive impact on knowledge flow at the 1% level. Hence, Nagaoka and Nishimura demonstrate that grace periods are welfare improving in Japan.

Through the use of novel data sets and simple empirical techniques, both Franzoni and Scellato (2010) and Nagaoka and Nishimura analyse grace periods in the US and Japan, respectively. Their primary inquiries relate to: the determinants of grace period use, and its impact on knowledge flow. Their results tend to be context specific, as Franzoni and Scellato find that testing and improvement are the primary motivation for using grace in the US, while Nagaoka and Nishimura find that publishing academic journals is the primary motivation in Japan. Nonetheless, both papers appear to provide limited empirical evidence that grace periods improve knowledge flow and hence, welfare.

III. Innovation Papers

While grace periods have been more or less ignored in the economic literature, innovation – and the role of patents in particular – is extensively studied. Admittedly, the relationship between innovation and grace is nebulous. However, grace is a component of patents, which represent the lens through which economists analyse innovation. Therefore, to analyse grace, it is necessary to review the theoretical and empirical underpinnings of the innovation literature.

Innovation models tend fall into one of two major categories: those relating to motivation and those relating to dissemination (Mazzoleni and Nelson, 1998; Hall and Harhoff, 2012). Motivation refers to whether patents encourage innovation itself – that is, do patents have a direct effect on the incentive to innovate? Dissemination refers to whether patents encourage diffusion of knowledge – that

Table 3—Innovation theory types

Theory	Brief Description	Potential Issues
Motivation	Patents induce more inventing	In many industries, the prospect of a patent does not seem to significantly increase incentives for inventing
Dissemination	Patents induce more disclosure rather than secrecy	Patents also enable the patent holder to restrict use

Source: Mazzoleni and Nelson (1998).

is, is there an indirect effect whereby more public knowledge facilitates innovation? Some models address both questions. Regardless, their shared impetus is whether patents and various patent policies facilitate innovation. Table 3 summarises the two types, while the remainder of this section addresses the essential literature of each in turn.

A. Innovation Motivation

Innovation motivation is the effectiveness of patents in promoting innovation.[4] It naturally leads to the analysis of optimal patent strength, in the sense of length (Norhaus, 1969; Scherer, 1972) or breadth (Gilbert and Shapiro, 1990; Klemperer, 1990; Scotchmer and Green, 1990). Variations of these models include: patent races, where firms focus on a common research strategy or inventive goal (Loury, 1979; Dasgupta and Stiglitz, 1980*b*); and, patent pools, where firms focus on a broader but still limited "pool" of invention prospects (Barzel, 1968; Dasgupta and Stiglitz, 1980*a*).

Patents encourage innovation, assuming the patent represents a single invention and knowledge is not readily cumulative (Hall and Harhoff, 2012). That is, single-invention models tend to predict a positive, monotonic relationship between patent strength and innovation. Such a result should be expected a priori. In a single-invention framework, patents allow innovators to capture a majority

[4] While it is not covered here, there is a large literature contrasting the incentives and welfare effects of alternative innovation policies, including: prize competitions, trade secrets, etc.

share of the surplus generated by their investment. Through exclusivity, they are afforded the opportunity to earn rents higher than those possible with immediate imitation. So, the patent system provides them with an unambiguous incentive to innovate. However, this simplistic case abstracts from the reality that innovation is cumulative. Final outputs are often the result of many iterated steps of invention, modification, and improvement. Indeed, Hall and Harhoff (2012) note "the 'development' aspect of 'research and development' can be as commercially important as the 'research'." Cumulative invention complicates the expected effects of patenting on innovation. The related theoretical literature produces ambiguous results – including nonmonotonic relationships – with respect to the incentives provided by patents.

The literature has considered two main cases. In the first, known as the "research tool" case, two innovative stages are required to produce a profitable output. In the second, known as the "cumulative" or "quality ladder" case, there is a sequence of outputs each improving on the last. In both cases, an invention may use other inventions as input or may be an input to one or more future inventions itself. Such relationships prove difficult to model and to test (Gallini, 1992).

As first identified by Scotchmer (1991), a first-best incentive system under the research tool case does not exist due to the double-marginalization problem. Green and Scotchmer (1995) address this issue through game-theoretic techniques. Essentially, the first innovator may not have sufficient incentive to invest when competition erodes their profits. If they are unable to recoup the value of their invention – including any applications it facilitates – there may be insufficient private incentive despite the investment being socially optimal. The authors' solution is an ex ante contract between the first and second inventor. Yet such a solution is difficult in practice due to uncertainty surrounding the identity of the second inventor and the expected values of the inventions.

Bessen and Maskin (2009) prepare a quality-ladder model and analyse the effect of patents under two extremes: nonsequential and infinitely sequential in-

novation. In the static nonsequential case, the results mirror those for a single-invention where patenting yields more innovation and greater welfare. In the dynamic sequential case, the equilibrium without patents dominates provided the upper tail of innovation values is sufficiently thick. That is, there exists an adequate probability of developing a high-value innovation. The authors emphasise that empirically-observed distributions for innovation value satisfy this condition. They also show the first innovator may profit from the absence of patents due to spillovers from subsequent inventions.

Overall, theoretical work equivocates regarding the effectiveness of the patent system in encouraging innovation. The remainder of this subsection now turns to the empirical evidence. Unfortunately, its conclusions are also ambiguous. Nevertheless, a couple trends have emerged from this body of work.

First, patent strength unambiguously increases patenting activity (Hall and Ziedonis, 2001; Lerner, 2002). But it remains indeterminate whether patent strength increases innovative activity. Sakakibara and Branstetter (2001) study the effects of patent scope expansion in Japan and find the legal changes in 1988 to have had a negligible effect on R&D activity. Qian (2007) performs a similar analysis for pharmaceutical patents in 85 countries between 1978-1999. She uses matched sampling and country fixed effects to control for the simultaneity between patent protection and R&D intensity. She finds patents do not motivate domestic innovation, and above a particular patent strength, innovation is curtailed. In contrast, the cross-country studies by Park and Ginarte (1997) and Kanwar and Evenson (2003) conclude patent strength is positively correlated with R&D investment in developed countries.

Second, if patents increase innovation, it likely occurs within the pharmaceutical, biotechnology, and medical instrument sectors. Surveys from a number of countries have repeatedly signalled that patents are an ineffective means by which to appropriate returns to innovation, except perhaps in the areas mentioned above (Mansfield, 1986; Levin et al., 1987; Cohen et al., 2002).

In sum, the theoretical and empirical literature regarding innovation motivation is mixed. There is a clear theoretic basis for patents in a single-invention context. However, any additional generality is difficult to resolve and likely context specific. This is also true for empirical papers where patent systems provide clear incentives for innovation in only a handful of sectors. Nevertheless, innovators do respond to its presence, both by making use of the system and by sometimes tailoring their innovative strategies to its presence.

B. Innovation Dissemination

Under innovation motivation, patents induce inventing, yet this is not the case under innovation dissemination. Rather, patents encourage disclosure and represent the instrument through which knowledge is propagated (Mazzoleni and Nelson, 1998). The conventional version of innovation dissemination assumes innovators appropriate returns simply through secrecy. The possibility of patenting, however, encourages disclosure of the essential information (Scotchmer and Green, 1990). Thus, innovations that would remain secret without patents are more likely to be revealed under patent protection. Papers exploring the relationship between trade secrecy and patenting include Anton and Yao (2004), Denicolo and Franzoni (2004), Encaoua and Lefouili (2005), and Bhattacharya and Guriev (2006).

Disclosure must be balanced against the social costs of monopoly, including: under-utilisation of patented inventions; delays in related research; and, legal challenges over infringement. Nevertheless, if patents facilitate knowledge markets, licensing and other sharing arrangements may mitigate the aforementioned costs (Gallini, 1992). Then, to the extent patents facilitate sharing, this both increases returns to inventing and encourages wider use. It should be noted that the key distinction here is how patenting extends use, rather than how it enhances incentives for invention.

In contrast, some economists doubt the strong positive effect between disclo-

sure and welfare (Hall and Harhoff, 2012). If a patent overwhelmingly benefits rivals, secrecy may become the more appealing option for protecting an invention (Levin et al., 1987). Presumably, however, some industries would still disclose valuable information through patenting. So rivals may be able to learn important information from patent documents in these fields, and at the very least avoid duplication. However, willful infringement laws in the US discourage inventors from using patents as sources of information. In fact if the risk is great enough, it could dissuade rivals from using patent information entirely. Applicants may also seek to limit the disclosure of crucial details and may be successful unless challenged during the examination process. As long as the likelihood of rejection is small, the incentive minimise disclosure will be high. And finally, complex claims are not necessarily conducive to clear transmission of technical information and may result in additional litigation over patent boundaries. All of which could adversely impact the strong benefits of dissemination proposed in theory.

Despite these reservations, disclosure is usually assumed to have a strong impact on cumulative innovation (Scotchmer, 1991). However, there is little empirical evidence regarding its economic impact (Hall and Harhoff, 2012). Cohen et al. (2002) averred US companies generally prefer alternative sources of information over patents, while Nagaoka and Walsh (2009) found large differences in the importance of patents between US and Japanese innovators. Gambardella, Harhoff and Nagaoka (2012) estimated cost savings through knowledge of the patent literature. They utilised a practitioner survey covering more than 22,000 respondents in 23 countries. The authors sought qualitative assessments of the importance of patents as a source of information. Similar to studies discussed previously, Gambardella, Harhoff and Nagaoka find patents are important in a few technical areas and particularly in Japan, where inventors utilise them more readily than in either the US or Europe. Inventors were also asked to quantify time savings both with and without access to patent information. Again, considerable heterogeneity exists across sectors, where disclosure effects are greatest for

those with high levels of imitation, such as chemicals and pharmaceuticals.

Innovation dissemination has been far less studied as compared to innovation motivation. This is likely a product of the disagreement over the strength and direction of its effect. Despite the appeal of the dissemination theory, empirical analyses demonstrate that that patents have varied effects conditional on industrial sector and country. And as noted by Gambardella, Harhoff and Nagaoka (2012), the social value of disclosure is likely small when compared to a patent's private asset value.

IV. Options Theory Papers

Moving beyond the traditional innovation literature, there is an accepted recognition that patents function as call options. They grant the inventor the right, but not the obligation, to exercise an exclusivity over a specified time horizon. This interpretation of patents was pioneered by Pakes (1986), who performed an empirical study on the value of patents using annual renewal fees. The association was further developed by Bloom and Van Reenen (2002), who demonstrated empirically how the option nature of patents influence firm performance.

From their foundational treatises on real options,[5] Dixit and Pindyck (1994) note that investment decisions share three important characteristics with financial options: irreversibility, uncertainty, and the possibility of delay. That is, investment is at least partially sunk; there is uncertainty over future returns; and, action may be postponed to accumulate information about the future. Patents mirror these characteristics (Bloom and Van Reenen, 2002). Inventions typically require new capital equipment and training. Moreover, inventors may undertake additional R&D and marketing to bring their products to market. All such expenditures involve sunk costs and are, thus, irreversible. By their very nature,

[5] A similar concept developed independently in environmental and resource economics through the work of Arrow and Fisher (1974), Henry (1974), and Hanemann (1989). The quasi-option value captures the value of learning under investment postponement, while the Dixit-Pindyck option value captures the (net) value of preservation under learning. Further detail on the relationship between the two concepts can be found in Traeger (2014).

inventions have uncertain returns, as there are a myriad of factors which could influence their profitability. But since patents constitute an exclusive right, there exits the option to delay investment and to better assess the invention and its market.

Clearly, patents represent an option to invest in the development of an innovation. And it can be argued analogously that grace periods represent an option to invest in a patent. Similar capital, training, research, and marketing costs may be undertaken irreversibly during the grace period. There exists perhaps more uncertainty over an invention's return as it is earlier in the development. And finally, grace itself is a form of delay. Hence, grace periods afford an opportunity to resolve uncertainty prior to undertaking a costly patenting process.

Option theory typically assumes one decision maker. Often, however, a single decision-maker model is not appropriate. For example, given first-mover advantage, actors with related options may find their ability to delay undermined by the possibility of preemption. Therefore if competition exists, real options are necessarily influenced by strategic interactions (Weeds, 2002).

Strategic options models are uncommon in the literature, as observed by Dixit and Pindyck (1994): "oligopolistic industries in a stochastic dynamic setting present formidable difficulties." Despite the challenge, a few hardy economists have attempted the feat. Grenadier (1996) considered the strategic exercise of options in real estate markets, particularly focused on the timing of development. Lambrechta and Perraudin (2003) introduced a two-player investment game incorporating incomplete information – in the form of private exercise costs – and preemption. They find trigger points located between the monopoly and simple net present value outcomes. Kulatilaka and Perotti (1998) studied the effect of uncertainty on the value of strategic options. They concluded real investment must account for both strategic value and the value of not investing – that is, the value of preemption and flexibility, respectively.

Weeds (2002) deserves special mention, as it is the only strategic options paper

in the context of patents and innovation. The paper studies "the tension between real options and strategic competition in the context of competing investments in R&D." It combines strategic interactions with two forms of uncertainty: irreversible investment under uncertainty and technological uncertainty. Equilibria are found as either a preemptive leader-follower strategy, where option values are undermined, or a cooperative strategy with a continuum of common trigger points. Both solution types are found to be suboptimal compared to a social planner.

Patents are a natural form of options, as their characteristics fit the concept. In fact, it has become fashionable in the literature to describe patents as such. In this section, I have extended the argument by suggesting that grace periods also behave as options. As grace may not necessarily lead to an exclusive right, it is important to consider how strategic interactions could effect their usage.

V. Summary

Despite their long history of application, grace periods lack a robust economic treatment. Instead, grace remains under the purview of the legal community, patent offices, and a few econometricians. Law reviews elaborate on their costs and benefits, but lack the necessary rigour to prove their claims. Practitioner surveys echo many of the claims put forward by the legal community. Their main contribution is to highlight the heterogeneity regarding grace periods both in opinion, application, and purpose.

The econometric literature is sparse. Nevertheless, both Franzoni and Scellato (2010) and Nagaoka and Nishimura have initiated the debate. Through their clever use of data and simple empirical techniques, they suggest that grace periods are likely to improve knowledge flow and welfare. Regardless, the literature does not provide a sufficient basis on which to evaluate grace. Clearly, there is still much to be done, including the development of a tractable economic model. My condensed summary of the innovation and options theory literature provides

perhaps a guide to the nature of the required model.

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