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Amazing Grace: How grace periods influence innovation

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Amazing Grace: How grace periods influence innovation

By Jack Gregory

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Grace is the disclosure of an innovation without losing its exclusive rights. It encourages disclosure, while potentially foreclosing access to followers. I propose the outline of a model to analyse this tension and its impacts on knowledge flow and welfare. The model is an adaptation of a discrete, real options framework put forward by Hanemann (1989) and Traeger (2014). For single innovations, I demonstrate that leaders are always at least as well-off with grace. For cumulative innovations, I present the outline of a model which incorporates strategic interactions between a leader and follower.

I. Introduction

The *raison d'être* of the patent system is to encourage innovation. As first identified by Norhaus (1969), 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 simple relationship holds assuming isolated invention and unrelated knowledge (Hall and Harhoff, 2012). That is, single-invention models tend to predict a positive, monotonic relationship between patent strength and innovation. In a single-invention framework, patents allow innovators to capture a majority 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 and knowledge are typically cumulative. Cumulative invention complicates the expected effects of patenting on innovation (Green and Scotchmer, 1995; Bessen and Maskin, 2009).

An oft-neglected complication are grace periods. 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 and Japanese 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 intellectual property (IP) harmonisation. And it is broadly accepted that grace is a crucial element of this endeavour. Since the passage of the 2011 America Invents Act (AIA), a renewed effort towards greater integration has emerged (Struve, 2013). Nonetheless, grace period policy and its application remain heterogeneous.

Despite its prominence in international negotiations, grace periods have largely been ignored in the economic literature. In the legal community, however, a vigorous debate over their benefits and costs is ongoing.[1] Ostensibly, grace benefits society by encouraging early dissemination through the optioning of patent rights, but they also harm society through the extension of monopoly protection. Grace periods tend to favour leaders over followers, as they reduce uncertainty for the former, while potentially increasing it for the latter. In general, leaders gain from grace periods; hence, its welfare effect depends on third parties, including followers and society at large (Nagaoka and Nishimura, 2015).

The similarities between patents and grace is a product of their real options nature. As developed by Dixit and Pindyck (1994), investment decisions share

[1] See for example: Roucounas (2006); Metzler (2009); Struve (2013); and, Joachim (2015).

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 acquire more information about the future. Patents are an option to invest in the development of an innovation (Pakes, 1986; Bloom and Van Reenen, 2002), while grace periods are an option to invest in a patent.

Ex ante, an innovator may be uncertain of the value of their invention. This uncertainty may arise from internal factors, such as development costs, or external factors, such as market competitiveness. Grace periods afford an opportunity to resolve this uncertainty prior to undertaking a costly patenting process. However, the reduction in uncertainty for the leader is offset by increasing uncertainty for followers. While grace periods encourage the disclosure of innovations, they also extend the opportunity for access to be foreclosed. It is this tension and its impacts on knowledge flow and welfare which is the focus of this paper. First, I adapt a two-period, real options model following Hanemann (1989) and Traeger (2014) for the purposes of demonstrating that leaders are always at least as well-off with grace. I then present some ideas for how the model may be extended to analyse the implications for followers and society at large.

The paper is organised as follows. Section II reviews the academic literature related to grace. Section III presents a preliminary real options model with and without cumulative innovation. Finally, Section IV summarises the paper, highlights potential issues, and provides possible extensions.

II. Literature Review

IP harmonisation precipitates many law reviews and practitioner 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.

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 upon which econometric analyses are prepared. Consequently, the legal argument for patents, and specifically grace periods, is crucial for parsing the economic theory (Metzler, 2009; Struve, 2013; Joachim, 2015).

Similar to law reviews, the impetus for practitioner surveys stems from wider interest and debate around harmonisation. Since the passage of the AIA, patent offices have attempted to ascertain the views of differing practitioner groups within the major patenting countries.[2] Many of the views expressed in the legal community are echoed by those who directly participate in the patent system. And perhaps unsurprisingly, practitioners tend to be factional either with respect to their jurisdiction or practitioner type.

The Tegernsee Group (2014) prepared the largest such study.[3] The members launched a data collection 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 procured an unbalanced panel of 740 respondents from Europe, Japan, and the US. The results were markedly different between jurisdictions and particularly dependent on access to grace. In the US and Japan, a large majority of respondents supported grace, while only a slim majority favoured it in Europe. The primary motivation for utilising grace also varied depending on national origin. Among Japanese practitioners, the primary motivation was the need to publish in academic journals. In America, practitioners typically applied grace for testing and improving their inventions, while in Europe, most used it out of necessity from either human errors or breach of confidence.

Existing empirical research on grace is limited in large part due to the design

[2] See for example: Edmonson et al. (2013); European Patent Office (2014); and, United Kingdom Intellectual Property Office (2015).

[3] The Tegernsee Group is composed of the patent offices from Denmark, France, Germany, Japan, the UK, the US, and the EU.

of current IP regimes. Most jurisdictions automatically apply a grace period when a disclosure is made, obscuring whether a grace period is utilised or not. Nevertheless, two empirical papers focusing on academia attempt to overcome the absence of data.

Franzoni and Scellato (2010) 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 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. Mean time lags are compared using one-tailed t-tests. On average, US academic inventions are disclosed in journals earlier than European ones, and the time to disclosure is longer when international coverage of inventions is required. For the grace decision, patent quality encouraged its use, while publication quality discouraged it. These results support the notion that, at least in academia, grace is an option. Researchers can disseminate their results, obtain feedback, and submit a patent once they anticipate a sufficient return. Notably, author type does not significantly affect grace period usage. However, this may be misleading as all patents included at least one academic author. For disclosure lag, the authors find the desire for international coverage and the presence of a corporate author delay dissemination. Publication lags are shorter when priority of the patent is claimed in the US rather than in Europe, which suggests the absence of grace delays academic publication.

In general, the results suggest grace increases knowledge flow in the US as compared to Europe. However, the paper suffers from a couple of limitations. First, the data are narrow, which limits the analyses to US and European academic patents.[4] Second, patent-publication delay does not necessarily identify the relationship between grace and knowledge flow. Crucially, there is no way to disentangle early disclosure from patent filing delay.

Nagaoka and Nishimura (2015) utilise data from Japan, leveraging mandatory disclosure notification. They assess: (1) whether grace periods accelerate disclosure, (2) the major determinants of grace period use; and, (3) the major determinants of their effects on knowledge flow. Their basic model assumes three reasons for exercising grace:

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

Case 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.

Case 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. The cases neatly align with the primary motivations highlighted in Tegernsee Group (2014): Case 1 relates to the need for academic disclosure most widely used in Japan; Case 2 relates to the possibility of testing and improving inventions most widely used in the US; and, Case 3 relates to necessity from either human error or incautious disclosure most widely used in Europe. Case 1 is, thus, likely to dominate given Nagaoka and Nishimura (2015) rely on Japanese data. And this is indeed what the authors find, suggesting grace periods enhance knowledge diffusion and social

[4] Moreover, the authors utilise scientific publications and conference proceedings as their only forms of academic disclosure.

welfare.

Through the use of novel data sets, Franzoni and Scellato (2010) and Nagaoka and Nishimura provide modest empirical evidence that grace periods improve knowledge flow and welfare. Law reviews elucidate the costs and benefits applied in the econometric studies, but lack the necessary rigour to prove their claims. Similarly, practitioner surveys echo many of the claims put forward by the legal community. However, their main contribution is to highlight the heterogeneity regarding grace periods both in opinion, application, and purpose. Clearly, grace periods lack a robust economic treatment. At present, the literature does not provide a sufficient basis on which to evaluate its impacts. Hence, my aim is to develop a theoretical model capable of evaluating the welfare implications of grace.

III. Model

A. Single Innovation

The single-innovation setting follows Hanemann (1989) and Traeger (2014). I assume a two-period model, where an innovator decides whether or not to patent an invention. In the first period, the innovator faces the discrete decision to either patent or disclose. The latter automatically invokes the grace period. I denote patenting in the first period by $x_0 = 1$ and disclosure by $x_0 = 0$. If the innovator utilises grace, they again have the option to patent $x_1 = 1$ or not $x_1 = 0$ in the second period. Thus, the first period represents the commencement of the grace period, while the second period denotes its conclusion.

If the innovator patents in the first period, the decision is irreversible. In period 0, the innovator faces uncertainty over the value of their invention; however, it is resolved by the beginning of period 1. I abstract away from the nature of the uncertainty – that is, whether it is internal, external, or both – as it does not impact the single-innovation results. The decision variable x, therefore, specifies a sunk investment garnering an uncertain future payoff. The innovator can either patent irreversibly in the first period or, if not, they can do so in the second period. Consequently, the model satisfies the three characteristics of real options identified by Dixit and Pindyck (1994).

The function $V(x_0, x_1, \tilde{\theta}) = \pi_0(x_0) + \pi_1(x_0, x_1, \tilde{\theta})$ characterises the value of the invention. Profit functions for the first period $\pi_0(\cdot)$ and the second period $\pi_1(\cdot)$ are in first period dollars.[5] The random variable $\tilde{\theta}$ represents the uncertain component, such as development costs or market competitiveness. The true value θ is revealed between period 0 and period 1.

A sophisticated innovator anticipates that the decision in the second period will be based on better information. That is, the innovator will learn between period 0 and period 1. Once in the second period, they will $\max_{x_1 \in \{x_0, 1\}} \pi_1(x_0, x_1, \theta)$ for a given x_0 and realisation $\tilde{\theta} = \theta$. The irreversibility constraint restricts his second period choice variable to the set $\{x_0, 1\}$, i.e. if $x_0 = 1$ the invention has already been patented. Anticipating the second period decision, the innovator optimises the expected payoff in the first period over x_0:

$$\begin{aligned} &\max_{x_0 \in \{0,1\}} E_0 \left[\max_{x_1 \in \{x_0, 1\}} V(x_0, x_1, \tilde{\theta}) \right] \\ &\qquad = \max_{x_0 \in \{0,1\}} \left\{ \pi_0(x_0) + E_0 \left[\max_{x_1 \in \{x_0, 1\}} \pi_1(x_0, x_1, \tilde{\theta}) \right] \right\} \end{aligned}$$

Hence, the innovator first optimises period 1 welfare over x_1 for every possible realisation of $\tilde{\theta}$ and x_0, and then takes expectations and optimises over the period 0 choice variable x_0.

I now develop a set of net present values (NPV) differing in sophistication.[6] First, the innovator considers the possibility of patenting in period 0 only. This is the "now or never" case, where the value of patenting and not patenting are

[5] This permits a reduction in notation, as the discount factor $\frac{1}{1+r}$ is subsumed within the expression for $\pi_1(\cdot)$. Here r is the discount rate.

[6] Sophistication, in this context, refers to the amount of information the innovator incorporates into their decision making.

respectively:[7]

$$V(1) = \pi_0(1) + E\left[\pi_1(1,1,\tilde{\theta})\right]$$
$$V(0) = \pi_0(0) + E\left[\pi_1(0,0,\tilde{\theta})\right]$$

This describes a naive innovator who uses the traditional NPV rule: $V(1)-V(0) > 0$.

Second, the innovator anticipates learning through the grace period. This is the "learning" case, where the value of patenting and not patenting are respectively:

$$V^*(1) = \pi_0(1) + E\left[\max_{x_1\in\{1\}} \pi_1(1,x_1,\tilde{\theta})\right] = \pi_0(1) + E\left[\pi_1(1,1,\tilde{\theta})\right]$$
$$V^*(0) = \pi_0(0) + E\left[\max_{x_1\in\{0,1\}} \pi_1(0,x_1,\tilde{\theta})\right]$$

This describes a sophisticated innovator who makes use of the additional information revealed during the grace period. Learning is represented here by the realisation of $\tilde{\theta}$. The sophisticated innovator utilises the following decision rule: $V^*(1) - V^*(0) > 0$.

Given the NPVs defined above, it is now possible to define the Dixit and Pindyck (1994) option value (OV):

$$OV \equiv \max\{V^*(1), V^*(0)\} - \max\{V(1), V(0)\} \geq 0$$

In plain language, the OV is the value of exercising grace: the maximal value derived from the option to patent under learning less the maximal value derived from the possibility to patent now or never. The OV is always non-negative, since $V^*(0) \geq V(0)$ and $V(1) = V^*(1)$, where the equality is derived from the fact that patenting in the first period implies no decision in the second. The option to use grace cannot reduce value as it is only an option, not an obligation. If the now-

[7] Note that the notation for $V(x_0, x_1, \tilde{\theta})$ has been reduced to $V(x_0)$ for simplicity.

or-never value is negative, the OV characterizes the value of grace under learning. If the now-or-never value is positive, it captures only the collectible value of the grace period. Therefore, the OV represents a net value of grace conditional on learning.

Given this setup, I can now apply Proposition 2 from Traeger (2014), where the sophisticated decision maker who anticipates learning is

(i) weakly better off patenting in period 0 if:

$$\max\{V(1), V(0)\} > 0 \quad \text{and} \quad OV = 0$$

(ii) strictly better off patenting in period 1 if:

$$OV > 0$$

(iii) (weakly) better off never patenting otherwise.

In a single-innovation context, the innovator is clearly better off with access to grace. Since there is only one actor to consider, this result also coincides with the welfare maximisation problem for the social planner.

B. Cumulative Innovation

While grace is unambiguously beneficial for the innovator or leader, the simplistic single-innovation model cannot discern its impacts on third parties. I now extend the single-innovation model described above to include cumulative innovation. It should be noted that the material below is preliminary and I have not drawn any formal conclusions.

I assume one follower, who may enter the market in period 1 at the end of the grace period. Uncertainty is again fully resolved in the second period, so the follower optimises with certainty. As there are now two agents, the private benefits of the innovator will no longer necessarily correspond to those of the social planner. As such, I develop the decision model for the leader and follower before addressing that of the social planner. From this point forward, I adopt the convention that superscript l represents the leader and superscript f the follower.

A sophisticated innovator, anticipating the second period action, optimises the expected value in the first period over x_0:

$$\max_{x_0 \in \{0,1\}} E_0 \left[\max_{x_1 \in \{x_0,1\}} V(x_0, x_1, \tilde{\theta}, \tilde{\alpha}) \right]$$
$$= \max_{x_0 \in \{0,1\}} \left\{ \pi_0^l(x_0) + E_0 \left[\max_{x_1 \in \{x_0,1\}} \pi_1^l(x_0, x_1, \tilde{\theta}, \tilde{\alpha}) \right] \right\}$$

where I now separate the internal and external uncertainty by introducing the random variable $\tilde{\alpha}$ representing market size or competition. Essentially, the level of competition between leader and follower is dependent on industry characteristics. Greater competition could lead the innovator to patent in the first period. Contrastingly, less competition could encourage the innovator to exercise grace in the hopes that positive feedbacks generate greater returns. For example, innovation in the pharmaceutical industry typically leads to direct competition between firms, as new drugs tend to be designed for a single use. Whereas, innovation in the technology industry may lead to whole new markets being developed (Gambardella, Harhoff and Nagaoka, 2012). I foresee competition defined as the product of two random variables: $\tilde{\alpha} = Y \cdot Z$, where $Y \sim Bernoulli(p)$ and $Z \sim H(t)$. The random variable Y represents the follower's decision to enter the market and can assume the values $\{0, 1\}$, while the random variable Z represents the level of market competition conditional on entry. I assume the internal uncertainty $\tilde{\theta}$ and the external uncertainty $\tilde{\alpha}$ are independent.

A follower optimises the expected value of imitation over y_1, their decision to enter in the second period:

$$\max_{y_1 \in \{0,1-x_0\}} \pi_1^f(y_1, \tilde{\theta}, \tilde{\alpha})$$

The irreversibility constraint restricts the follower's choice variable to the set $\{0, 1 - x_0\}$, i.e. if $x_0 = 1$ the invention has already been patented and it is assumed the follower will have insufficient information and incentive to enter the

Table 1—Questions to be resolved

No.	Question
1	Is it more appropriate to have discrete or continuous choice variables? If continuous, what convexity assumptions or functional forms are appropriate?
2	Are market size/competitiveness and learning the most appropriate random variables? If so, what are the most appropriate distributions?
3	How do the returns for the leader & follower depend on each other? That is, how does $\tilde{\alpha}$ affect the π^l and π^f functions? Should $\tilde{\alpha}$ be exogenously or endogenously determined?
4	How should consumer impacts be incorporated into the model? Are they inferred from the level of competition α existing in the market?
5	Are the assumptions regarding leader choices appropriate? That is, should they also have the option of keeping their invention secret in the first period?
6	Are the assumptions regarding follower entry appropriate?
7	Are the assumptions regarding knowledge flow realistic? Can they be relaxed?

market. The social planner then optimises the expected value in the first period over x_0:

$$\begin{aligned}
&\max_{x_0\in\{0,1\}} E_0\left[\max_{\substack{x_1\in\{x_0,1\}\\ y_1\in\{0,1-x_0\}}} W(x_0,x_1,y_1,\tilde{\theta},\tilde{\alpha})\right]\\
&\qquad = \max_{x_0\in\{0,1\}}\left\{\pi_0^l(x_0)+E_0\left[\max_{\substack{x_1\in\{x_0,1\}\\ y_1\in\{0,1-x_0\}}} \pi_1^l(x_0,x_1,\tilde{\theta},\tilde{\alpha})+\pi_1^f(y_1,\tilde{\theta},\tilde{\alpha})\right]\right\}
\end{aligned}$$

Given the optimisations above, a similar procedure to the single-innovation model could be undertaken. The NPV expressions under now-or-never and learning would be defined for both the innovator and the social planner. Those for the innovator are almost equivalent to the single-innovation model, except for the more structured definition of uncertainty. Option values and optimisation rules may then be derived. I leave these for future iterations of the paper.

IV. Summary

Innovation is abstruse, and consequently, IP policy is complex and at times contradictory. Its benefit to society is context dependent, causing considerable debate over the best strategy to incentivise R&D activity.[8] Therefore, understanding the tradeoffs inherent in the application of grace are crucial for designing better IP policy. As innovation and productivity are such crucial determinants of living standards, society must better understand the costs and benefits of particular patent policies.

I anticipate my main contribution to this debate will be a theoretical analysis of grace under learning. I have presented a discrete, real options framework, which I hope will become the foundation for a larger model. Through the single-innovation model, I have shown that the innovator unambiguously benefits from grace. The cumulative innovation model was presented in brief and requires further work. Some issues yet to be resolved are summarised in Table 1.

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[8] For example, see Hall and Harhoff (2012) for a literature review on topics including patents as incentives for innovation, their effectiveness for invention disclosure, and patent system design.

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