International Journal of Industrial Organization 39 (2015) 81–89

Contents lists available at ScienceDirect

International Journal of Industrial Organization

journal homepage: www.elsevier.com/locate/ijio

International harmonization of the patent-issuing rules☆

Kaz Miyagiwa [a,b], Yuka Ohno [c,*]

[a] Florida International University, Department of Economics, 11200 SW 8th Street, Miami, FL 33199, USA
[b] ISER, Osaka University, Japan
[c] Hokkaido University, Department of Economics, Kita 9 Nishi 7, Sapporo 060-0809, Japan

ARTICLE INFO

Article history:
Received 9 August 2014
Received in revised form 17 February 2015
Accepted 18 February 2015
Available online 27 February 2015

JEL classification:
O3
O34
F1

Keywords:
R&D competition
Patent laws and legislation
Intellectual property rights
Patent priority rules
Sequential innovation
Management of technological innovation and R&D

ABSTRACT

Using a dynamic model of patent races for two sequential innovations, Scotchmer & Green (1990) compared the effect on R&D incentives of the two patent-issuing rules, first-to-invent and first-to-file, and found first-to-file more conducive to R&D. We show that their result depends on their assumption of fixed innovation probabilities. When innovation probabilities are endogenous for the intermediate invention, their result can be reversed. Our analysis has the obvious implications on the evaluation of the Leahy–Smith America Invents Act (2011), whereby the U.S. switched from first-to-invent to first-to-file.

1. Introduction

The Leahy–Smith America Invents Act (2011) ("AIA") came into effect on March 16, 2013. The central feature of this landmark reform in U.S. patent laws is the change in the patent-issuing rules. Previously, to award patents, the U.S. used the first-to-invent rule whereas the rest of the world used the first-to-file rule. The U.S. had naturally been under constant pressure to adopt a first-to-file rule as part of worldwide efforts to internationally harmonize patent laws, but failed to make a change due to the powerful opposition.

Opponents to reform have espoused two reasons why the U.S. should not adopt a first-to-file rule. The first reason is based on the notion that first-to-file handicaps individual and small-scale corporate inventors, who take longer times to prepare patent applications, against large corporate inventors. Despite the iconic image of the garage inventor, however, most significant inventions in the U.S. have been discovered by corporations (Cohen and Ishii, 2005). Further, first-to-invent requires disputes over priority of invention to be settled in a legal proceeding called "interference," at a hearing before the U.S. Patent and Trademark Office ("USPTO") Board.[1] In one estimate, the mean adjudication cost of interference stands at $656,306 (Hart, 2007). Since interference costs are borne equally by the parties involved, first-to-invent still disadvantages financially constrained small inventors against large corporations.[2]

The second reason against a first-to-file rule is based on the fact that the U.S. has led the world in R&D for more than a century. Opponents attribute this remarkable achievement to the first-to-invent feature of the U.S. patent law that has existed since 1836.[3] Although the opposition never provided any logical connection between the two facts, this second reason is more difficult to refute satisfactorily than the first. However, Scotchmer and Green (1990) developed a dynamic model of patent

☆ Errors and opinions expressed are the authors'.
* Corresponding author.
E-mail address: yuka_ohno@econ.hokudai.ac.jp (Y. Ohno).

[1] See Cohen and Ishii (2005) for a detailed study of the interference process.
[2] See Cohen and Ishii (2005) for evidence supporting this point. They also show that most significant inventions are discovered by large corporate inventors.
[3] For example, "It should be understood that it is because the U.S. has a first to invent structure and the rest of the world has a first to file structure that the U.S. is the production and employment machine that it is." (See http//www.piausa.org/layout/set/print/patent_reform_issue.)

http://dx.doi.org/10.1016/j.ijindorg.2015.02.004

races and found first-to-file more conducive to R&D than first-to-invent, thereby refuting the opposition's second reason.[4]

The finding of Scotchmer and Green (1990) can be explained as follows. In their model, two symmetric firms engage in patent races for two sequential innovations — the intermediate and the final innovation — under fixed R&D intensity. In first-to-file, the first firm that discovers the intermediate innovation has a stronger incentive to patent it because not doing so exposes the innovator to the risk of losing the innovation to the rival. In first-to-invent, by contrast, the innovator faces no such risk because it can establish priority of invention when the rival makes a discovery later. Thus, in contrast to first-to-invent, first-to-file promotes patenting of the intermediate innovation. We call this *the Scotchmer–Green effect*. But patenting the intermediate innovation intensifies competition for the final innovation and speeds its discovery.

The Scotchmer–Green ("SG") result is derived under the assumption that discovery probabilities are fixed for both innovations; that is, firms chase innovations with fixed R&D intensity.[5] This is in sharp contrast to much of the patent race literature, which regards discovery probabilities as dependent on the levels of investment firms make in R&D. Thus the primary objective of this paper is to examine how crucial their assumption of fixed R&D intensity is for the SG result. Also, since we are motivated by the recent enactment of the AIA Act, we are interested in its effect in the global context. Thus, the second objective of this paper is to study the effect of the change in the patent-issuing rule in a two-country model with one country representing the U.S. and the other the rest of the world.

We thus consider a two-country model in which two ex ante symmetric firms chase two inventions sequentially. Both inventions can be patented separately in each country. We assume that probabilities (hazard rates) of discovering the first innovation depend on the firms' investments in R&D in the sense of Lee and Wilde (1980). In such environments we compare the incentive to invent between the two scenarios. In one, which we call the pre-AIA world, the U.S. uses first-to-invent while the rest of the world uses first-to-file. In the other, which we call the post-AIA world, both countries use first-to-file.

Our main findings can be summarized as follows. First, when the U.S. switches to first-to-file, there is a greater risk of losing rights to the invention in the U.S. unless the invention is patented. However, avoidance of such risk reduces the profit from winning the race to be the first discoverer of the first invention. An absence of such risks also narrows the difference in profit between winner and loser of the first race. These effects are absent in the SG model because of their assumption of fixed R&D intensity. With endogenous R&D intensity, however, they both decrease the incentive to innovate and delay discovery of the first invention when the U.S. switches to first-to-file. If firms never patent in both the pre-AIA and the post-AIA world, delay in the first invention also slows down discovery of the second invention. We show further that such a delay is more likely to occur in industries in which the U.S. has a large market share. An example of such industries is the pharmaceutical industry, where the U.S. leads the world with its share around 36%.[6] In the semiconductor industry and aircraft manufacturing the U. S. also remains dominant.

However, our model also exhibits the SG effect; firms are more likely to patent the first invention in first-to-file than in first-to-invent so that first-to-file intensifies competition for the second invention, accelerating its discovery, given the date of discovery of the first invention. In this case, it is possible that, although discovery of the first invention is delayed, the second invention is discovered sooner in first-to-file than in first-to-invent. To throw light on this analytically ambiguous case, we use numerical analysis.

The remainder of the paper is organized in seven sections. The next section presents the model in detail. In Section 3 we describe a race for the first invention. Section 4 depicts a pre-AIA world, in which the U.S. uses first-to-invent while the rest of the world uses first-to-file. Section 5 describes a post-AIA world, in which both countries use first-to-file. In Section 6 we compare the equilibrium levels of investment in R&D between the pre-AIA and the post-AIA world. Section 7 presents numerical analysis results. We conclude in Section 8.

2. Model

We consider a patent race between two agents (firms) for two inventions A and B. Inventions are sequential in that firms must discover A before discovering B. Firms compete in two countries; country U (= the U.S.) and country W (= the rest of the world). Both inventions are patentable separately in each country. As it becomes clear, however, the nationalities of firms do not affect our results because today patent laws do not discriminate against foreign firms. To keep things simple, we also assume that the patent authorities in each country issue patents immediately on receiving patent applications. Also, we disregard the patent application fees and the legal fees agents incur during the interference hearing when the first-to-invent rule is in use in the U.S.

Let V represent the worldwide (combined) value of the two inventions. We can decompose V in two ways. First, we can write $V \equiv \alpha V + \beta V$, where $\alpha, \beta > 0$, and $\alpha + \beta = 1$. In this decomposition, αV and βV denote the worldwide values of inventions A and B, respectively.[7] The second decomposition is to write $V \equiv V_U + V_W$, where V_U and V_W denote the total valuations of both inventions in country U and in country W, respectively. Letting $\mu \equiv V_U/V$, we can also write this identity as $V \equiv \mu V + (1 - \mu)V$. With this system of notation, we can, for example, write the value of the U.S. patent on invention A as $\alpha\mu V$.

The model is set in an infinite time horizon, where time flows continuously from zero. At time $t = 0$, two firms start an R&D race for invention A. R&D is risky in that a discovery date τ_A of invention A is stochastic and is given by the exponential distribution function,

$$\text{Prob}(\tau_A \le t) = 1 - \exp[-g(x_i)t].$$

Here, $g(x_i)$ denotes the hazard rate function, which depends on x_i, firm i's R&D investment. We assume that $g(x_i)$ is concave and satisfies the Inada conditions. Further, firms' distribution functions are independent.

Given the above setup, invention A is eventually discovered at a random date τ_A. Call its discoverer the "leader" and the other firm the "follower." For clarity of exposition, we use the feminine pronouns to denote a leader and the masculine pronouns to denote a follower. On discovery of A, the leader immediately starts an R&D process for invention B. Assume that a discovery date τ_B of invention B is also exponentially distributed. For simplicity we assume constant hazard rate λ for invention B:

$$\text{Prob}(\tau_B \le t) = 1 - \exp(-\lambda t).$$

Given the constant hazard rate for discovery of B, there is no loss of generality in assuming zero R&D cost for it.[8]

[4] There are also some empirical studies on the relative effect of the two rules on R&D. See, for example, Lo and Sutthiphisal (2009) and Abrams and Wagner (2013) investigated the issue using Canada' s switch to first-to-file in 1989 as a natural experiment.

[5] Another crucial feature of the SG model is perfect information; a firm knows it when the rival innovates, whether the innovation is patented or not. Miyagiwa (forthcoming) develops a model in which firms chase a 'single innovation' under imperfect information — a firm learns of the rival's innovation only if it is patented — and finds that first-to-invent is more conducive to innovation than first-to-file.

[6] Standard & Poor's, Industry Surveys — Healthcare: Pharmaceuticals, June 2, 2011, p.11. [c.f. Saftlas (2011)].

[7] While we treat the shares α and β as exogenous to keep things simple, other authors such as Chang (1995) have used Nash bargaining to determine them. In a related work, Kao (2009) has considered strategic licensing of sequential innovations by two non-producing inventors.

[8] The implications of positive R&D costs for invention B are discussed in Appendix D.