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Innovation and Legal Enforcement for Competition Policy: Theory and international evidence from overseas subsidiaries of the Japanese auto-parts suppliers[1]

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Abstract

Do legal enforcements for competition policy have differential effects on innovative research and development (R&D) activities? Taking into account both strategic R&D competition between incumbent and entrant, and government's optimal choice of legal schemes, we first present a game-theoretic model of innovation and legal enforcement (Glaeser and Shleifer, 2003; Schwartzstein and Shleifer, 2013; Segal and Whinston, 2007). The model suggests that there are in subgame-perfect equilibria some relations concerning average treatment effects of legal enforcement on entrant's R&D or incumbent's deterrence activities, conditional on law and order degree in host countries (World Bank Worldwide Governance Indicators). Second, focusing on overseas subsidiaries of the Japanese auto-parts suppliers that have international deployments with different legal origins in locations, we use a pooled data set of the Basic Survey of Overseas Business Activities and the Basic Survey of Japanese Business Structure and Activities. The average multi-valued treatment effect estimation shows positive results for the model. It suggests that under regulation as a legal enforcement scheme instead of strict liability or negligence, even in countries with low degree of law and order, R&D activities would be more enhanced and R&D-deterrent ones be further suppressed on average. Legal enforcement for competition policy does matter for innovation.

Keywords: Innovation, R&D, Legal enforcement, Law and order

JEL classification: K21, K42, L51

[1]This study is conducted as a part of the Project "East Asian Industry Productivity" undertaken at Research Institute of Economy, Trade and Industry (RIETI). Utilized data is micro data pertaining to the Basic Survey of Overseas Business Activities and the Basic Survey of Japanese Business Structure and Activities, both conducted by Ministry of Economy, Trade and Industry. The author is grateful for helpful comments and suggestions by Masahisa Fujita, Kyoji Fukao, Shin-ichi Fukuda, Masaharu Hanazaki, Hidehiko Ishihara, Masayuki Morikawa, Junichi Nakamura, Mariko Tanaka and Discussion Paper seminar participants at RIETI.
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Introduction

Debates on competition and innovation date back to a great divide between Joseph Schumpeter and Kenneth Arrow. On one hand, Schumpeter(1942) took a stand against competition, saying "The firm of the type that is compatible with perfect competition is in many cases inferior in internal, especially technological, efficiency."(p.106). Schumpeter argued that destroying profits after innovation, competition reduces firms' incentives to innovate to get into the *ex post* market structure. On the other hand, advocating competition for innovation, Arrow(1962) said "The preinvention monopoly power acts as a strong disincentive to further innovation."(p.620). Arrow put emphasis on *ex ante* market structure where more competition destroys profits before innovation and gives firms a greater incentive to innovate to escape from that state.

Making strides across the great divide, the OECD has recently launched indicators of product market regulation, especially a set of indicators on competition law and policies to characterize competition regimes(Alemani, Klein, Koske, Vitale and Wanner, 2013). An intent of the indicators indicates acclaim for Arrow, in that a competitive product market allows new entrants to challenge incumbents, efficient firms to grow and inefficient ones to exit, so that boosting economic growth.

However, concerning a practical issue of how competition policy including antitrust fosters innovation, the great divide still remains unsolved in industrial organization or economic growth fields on roles of antitrust policy (Shapiro, 2012; Baker, 2007). Especially, as Baker(2007) suggested from a viewpoint of the law and economics, "antitrust is not a general-purpose competition intensifier. Rather, antitrust intervention can be focused on industry setting and categories of behavior where enforcement can promote innovation."(p.589). Hence, we have to evaluate roles of antitrust as competition policy(Buccirossi, Ciari, Duso, Spagnolo and Vitale, 2013), based on a dynamic model of *competition for the market*(Evans and Schmalensee, 2002) where to take into account both ex ante and ex post market structure.

There are two related literatures to the motivation we follow. One is a research on dynamic effects of antitrust on innovation. A seminal paper of Segal and Whinston(2007) presents a dynamic model of antitrust in a winner-takes-all competition for product innovation, where antitrust policy has effects of being more protective of entrants from predatory behavior of incumbent reducing entry probability in innovative industries. A dynamic consideration Segal and Whinston(2007) address is front-loading effect of antitrust policy on increased initial profits of potential entrants and on reduced "incumbency advantage"(Gans, 2011), that is discounted expected profits of a continuing incumbent thereafter. Suppose as competition policy, outlawing incumbent's practices that can reduce the probability that an entrant innovates. Profitability of such innovation-deterrence practices depends on a reduction of entrants' innovation, so that it is shown that the competition policy raises rate of the entrants' innovation due to the front-loading effect.

The other strand of the related literature is law and economics of endoge-

nous legal enforcement(Glaeser and Shleifer, 2003; Schwartzstein and Shleifer, 2013). An issue of the theory addresses litigation vs. regulation that legal uncertainty necessitates regulation, instead of litigation. Possible schemes for legal enforcement are either strict liability, negligence or regulation(Shavell, 1980; Kolstad, Ulen and Johnson, 1990; Cooter, 1991). A choice of legal enforcement endogenously generates optimal levels of R&D activities or its deterrence.

Following the literatures, this paper raises a theoretical question: "Do legal enforcements for competition policy have differential effects on innovative R&D activities?" In order to answer the question, we should consider government's optimal choice of legal schemes, as well as strategic R&D competition between an incumbent and entrants.

This paper also empirically evaluates the theoretical question above, especially testable hypotheses derived from a game-theoretic model constructed, on relations between R&D or R&D-deterring activities and the degree of law and order in host countries. Our data is overseas subsidiaries of the Japanese auto-parts suppliers.

Auto-parts industries are innovative ones of products represented by 'hybrid' engines, where "As modularity becomes an established way of doing business, competition among module suppliers will intensify. Assemblers will look for the best-performing or lowest cost modules, spurring these increasingly sophisticated and independent suppliers into a race for innovation similar to the one already happening with computer modules."(Baldwin and Clark, 1997; Frigant, 2009). The Japanese auto-parts suppliers also have made international deployment as literally an entrant in countries maintaining law and order and having legal origin historically transplanted, so that the suppliers face frequent antitrust lawsuits with enormous reparations[1]. From our data of *Basic Survey of Overseas Business Activities* containing country-specific variations in legal enforcement scheme, time-varying international dispersion of host countries is indicated in Figure 1 with the number of samples in parenthesis. Among the top-10 countries from 2003 to 2005, the US, Thailand, India, Malaysia, and UK have common law traditions, while China, Taiwan, and Republic of Korea are under the German legal origin of civil law, or Indonesia and Philippines under the French civil law.

The structure of this paper is as follows: Section 1 exposes a simple model of innovation and legal enforcement for competition policy, mentioning setup, subgame-perfect equilibria and testable hypotheses. Section 2 is an empirical part describing our data and estimation method and reporting estimation results. Finally, we conclude.

[1] We will not deal with actual antitrust lawsuits concerning the Japanese auto-parts suppliers, especially in the US. However, one of intriguing topics would be effects on innovation of a change in corporate leniency policy, which has been introduced in the US in 1978(the first amnesty program) and in 1993(revised for giving more incentives to report spontaneously), in EU in 1996 and in 2002(similarly modified), in Japan in 2006, and in Mexico, Canada, South Korea, Australia etc.over-40 countries. Recently as of this writing, the lawsuits are also rampant in China and India.

Ranking	2003	2004	2005
1	US (262)	US (266)	US (301)
2	Thailand (149)	China (163)	China (225)
3	China (130)	Thailand (142)	Thailand (166)
4	Indonesia (71)	Indonesia (77)	Indonesia (79)
5	Taiwan (48)	Taiwan (47)	India (48)
6	India (44)	Malaysia (45)	Taiwan (47)
7	Republic of Korea (41)	India (41)	Republic of Korea (44)
8	Malaysia (39)	Republic of Korea (41)	Philippines (39)
9	Philippines (39)	UK (37)	Malaysia (36)
10	UK (37)	Philippines (35)	UK (36)
total	1156	1197	1321

Figure 1: Host Countries: Basic Survey of Overseas Business Activities

1 A Simple Model of Innovation and Legal Enforcement for Competition Policy

We present a simple model of legal enforcement in winner-takes-all R&D competition for product innovation, where to consider both strategic R&D competition between an incumbent and a potential entrant, and government's optimal choice of legal schemes for competition policy.

First, we construct a setup of the R&D competition consisting of two equal-sized firms, an incumbent and another potential entrant. They play a R&D-competition game, a winner of which would enjoy monopoly profits. While a potential entrant does R&D activities for raising a probability of successful innovation, an incumbent deters the entrant's R&D activities, preventing the entrant from getting patent license for a purpose of compatibility or standardization, or committing to practices or illegal means difficult for courts or regulators to detect. A benevolent government including judge and regulator, also maximizes expected social profits from innovation, with a choice of a legal scheme among either strict liability, negligence or regulation in a one-period game.

A sequence of the game starts with government choice of a legal scheme at a timing 0, next the incumbent's R&D-deterring activities at a timing 1, then the entrant's R&D activities at a timing 2, and followed by innovation outcome and occurrence of either legal enforcement or subversion at a timing 3. A possibility of subversion at a final stage is incorporated into a model, since an incumbent has to invest a maximum fine enforceable without subversion. If amount of the maximum fine would be lower than the actual fine paid by an incumbent, then the incumbent subverts justice than submits to the law and order.

Next, we show subgame-perfect equilibria of the game, each with or without possible subversion. Without government choice of a legal scheme, there are no Nash (pure-strategy) equilibria concerning strategies of an incumbent and an entrant, assuming that R&D activities of a potential entrant would be socially

efficient without an incumbent's R&D-deterrence. The assumption is a rationale of antitrust policy for potential entrants.

Finally, we induce some testable hypotheses on relationships among observable variables. The model suggests a steplike positive relation between R&D activities and the degree of law and order in host countries, controlling firm's scale and so forth. It also implies a steplike negative relation between R&D deterrence activities and law and order degree. These relations should be in the next section tested using a panel data set of overseas subsidiaries of the Japanese auto-parts suppliers.

1.1 Setup of a Winner-Takes-All R&D Competition

There are two equal-sized firms, one is an incumbent and the other is a potential entrant with the same firm-scale S. Successful innovation makes an entrant who gets patent displace the old incumbent. Otherwise, if innovation fails, then monopoly of the incumbent continues.

In a R&D competition between incumbent and entrant, on one hand, a potential entrant does R&D activities R_1 or R_2 $(> R_1)$ for raising a probability of successful innovation. The investment R_1 costs zero, with a probability of success P_1, while the R_2 does SC with a result of a higher probability $P_2(> P_1)$.

On the other hand, an incumbent does 'R&D-deterring' activities Q_1 or $Q_2(> Q_1)$ with a purpose of preventing patent license, compatibility, standardization, and so forth. The deterrence activities Q_1 take zero cost with no effect on the success probability of the entrant's R&D activities. However, the higher deterrence Q_2 costs SC, lowering the entrant's probability of innovation down to P_1.

A winner of the competition takes all the monopoly profits of the incumbent, defined as $SE = SD-$R&D-deterring or R&D activity costs, where SD denotes social profits of innovation. Each firm maximizes expected profits less R&D or R&D-deterring cost less expected fine for incumbent or entrant.

Note that we assume the paremeters to satisfy a condition:

Condition 1 $(P_2 - P_1)D > C$

It is assumed to be socially efficient for an entrant to take R_2 without incumbent's R&D-deterrence, which should be a rationale of antitrust policy for entrant.

Government also plays a role of choosing a legal enforcement scheme for antitrust. We mean as government judge or regulator, alternatively. Government can detect high R&D-deterring incumbent with an exogenous probability P_D, and do low R&D entrant with another exogenous probability P_L. We assume another condition

Condition 2 $P_D < P_L$

based on an intuitive interpretation of more difficulty in detecting R&D-deterrence than low R&D activities themselves. The probability of detecting incumbent's R&D-deterring activities is also assumed to be low enough that

Condition 3 $(1 - P_1)P_D < P_2 - P_1$

which determines a minimum level of law and order required for attaining the first-best outcome under a legal enforcement scheme of negligence, as will be shown later.

There exist three pure law enforcement schemes, each requiring fine F in case. We define each scheme for legal enforcement as follows:

Definition 4 *Legal Enforcement Schemes*

1. *Strict Liability: Government requires fines for both incumbent and entrant, any time no innovations occur.*

2. *Negligence: Government fines either incumbent or entrant, if no innovations in high R&D-deterring activities or low R&D activities, respectively.*

3. *Regulation: Government fines either incumbent or entrant, if high R&D-deterring activities or low R&D activities found, respectively*

One is 'strict liability', where government requires fines for both incumbent and entrant, any time no innovations occur. Second, 'negligence' fines either incumbent or entrant, if no innovations in high R&D-deterring activities or low R&D activities, respectively. Third, 'regulation' fines either incumbent or entrant, if high R&D-deterring activities or low R&D activities found, respectively[2]. We also call as 'anarchy' a state with neither schemes. Each of the three schemes is chosen by a benevolent government maximizing expected social profits from successful innovation, less R&D and R&D-deterring costs. In this setup, the first-best outcome is generated where an incumbent chooses Q_1 and an entrant does R_2, while the second-best is a combination of Q_2 and R_2.

We next introduce into a model a possibility of subversion, which by paying maximum fine X enforceable without subversion for lobbying or corruption for instance, then-incumbent could obviate for protection from law. If X is lower than the fine actually paid, then-incumbent subvert justice than submit to the law. Higher X possesses higher levels of "law and order".

Finally, a sequence of the R&D competition game is as follows in Figure 2. At a timing 0, government chooses a legal scheme which maximizes the expected social profits from subsequent activities of incumbent's R&D-deterrence and entrant's R&D investment. Until the final stage of timing 3, there remains a possibility of subversion for the incumbent.

[2] In considering effects of corporate leniency policy, we may make changes in legal enforcement in such a way that negligence fines both incumbent and entrant if no innovations either in high R&D-deterring activities or low R&D activities, while if regulation fines both incumbent and entrant if either high R&D-deterring activities or low R&D activities found. It is to do in near future how there might be some changes in relation between R&D or R&D-deterring activities and law & order when introducing corporate leniency policy in concerned countries.

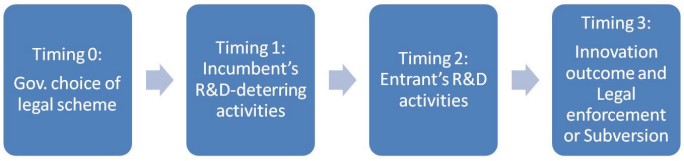

Figure 2: Sequence of One-Period Game

1.2 Subgame-Perfect Equilibria of Incumbent and Entrant Activities

We show subgame-perfect equilibria of the game in each case without or with possible subversion, in due order below. Though our primary interest is in a case with possible subversion, the world free from possible subversion would be a reference case to our reality replete with lobbying or corruption.

1.2.1 Case without Possible Subversion

We start with a state of anarchy where neither litigation nor regulation exists. In anarchy, entrant's best responses at a timing 2 are R_2 to incumbent's Q_1, and R_1 to incumbent's Q_2. Then incumbent's expected profits at a timing 1 are $(1-P_2)SD$ if a lower deterrence level Q_1 chosen, or $(1-P_1)SD-SC$ if Q_2 chosen. It is obtained that $(1-P_1)SD-SC > (1-P_2)SD$ from Condition 1, so that the worst outcome of a choice (Q_2, R_1) is always attained.

Next, we consider best responses under one litigation case of strict liability. Then entrant's best responses at timing 2 are R_2 to incumbent's action Q_1, and R_1 to Q_2. The best responses generate incumbent's expected profit at timing 1, $(1-P_2)(SD-F)$ in case of choice Q_1 or $(1-P_1)(SD-F)-SC$ in the other choice Q_2. The first-best outcome from a pair of choice (Q_1, R_2) is attained if

$$\frac{F}{S} > \frac{(P_2-P_1)D-C}{P_2-P_1}.$$

In the other litigation case of negligence, entrant's best responses at timing 2 are R_2 to incumbent's action Q_1, but when an incumbent takes Q_2, R_1 if

$$\frac{F}{S} < \frac{C}{(1-P_1)P_L}$$

or R_2 otherwise. Then incumbent's expected profits at timing 1 are $(1-P_2)SD$ if an action Q_1 is taken or $(1-P_1)(SD-P_DF)-SC$ if Q_2 is done. As a result, the first-best pair of choice (Q_1, R_2) is attained if

$$\frac{F}{S} > \frac{(P_2-P_1)D-C}{(1-P_1)P_D}.$$

Similarly, we pick up a case of regulation, where entrant's best responses are R_2 to incumbent's choice Q_1, and to incumbent's Q_2, R_1 if

$$\frac{F}{S} < \frac{C}{P_L}$$

or R_2 otherwise. Then incumbent's expected profits are $(1-P_2)SD$ for Q_1 or $(1-P_1)SD-P_DF-SC$ for Q_2. The first-best (Q_1, R_2) is attained if

$$\frac{F}{S} > \frac{(P_2-P_1)D-C}{P_D}.$$

Taking into account the best responses under each legal scheme, a benevolent government decides which schemes are optimal in terms of maximal of the expected social profits.

We summarize the subgame-perfect equilibria in a case without possibility of subversion. We classify the parameters into three cases, case 1: $\frac{C}{P_L} > \frac{(P_2-P_1)D-C}{P_D}$; case 2: $\frac{C}{P_L} < \frac{(P_2-P_1)D-C}{P_D} < \frac{C}{(1-P_1)P_L}$; case 3: $\frac{C}{(1-P_1)P_L} < \frac{(P_2-P_1)D-C}{P_D}$. In each case, depending on some thresholds of the fine relative to firms' scale $\frac{F}{S}$, there exist a different subgame-perfect equilibria.

Proposition 5 *Without any possibility of subversion, there are such subgame-perfect equilibria in each case:*

1. *Case 1:* $\frac{C}{P_L} > \frac{(P_2-P_1)D-C}{P_D}$
   (a) *For* $\frac{F}{S} < \frac{(P_2-P_1)D-C}{P_D}$, *the worst choice* (Q_2, R_1) *under anarchy.*
   (b) *For* $\frac{(P_2-P_1)D-C}{P_D} < \frac{F}{S} < \frac{(P_2-P_1)D-C}{P_2-P_1}$, *the first-best* (Q_1, R_2) *under regulation.*
   (c) *For* $\frac{(P_2-P_1)D-C}{P_2-P_1} < \frac{F}{S} < \frac{(P_2-P_1)D-C}{(1-P_1)P_D}$, *the first-best* (Q_1, R_2) *under regulation or strict liability.*
   (d) *For* $\frac{(P_2-P_1)D-C}{(1-P_1)P_D} < \frac{F}{S}$, *the first-best* (Q_1, R_2) *under either of legal enforcement schemes.*
2. *Case 2:* $\frac{C}{P_L} < \frac{(P_2-P_1)D-C}{P_D} < \frac{C}{(1-P_1)P_L}$
   (a) *For* $\frac{F}{S} < \frac{C}{P_L}$, *the worst choice* (Q_2, R_1) *under anarchy.*

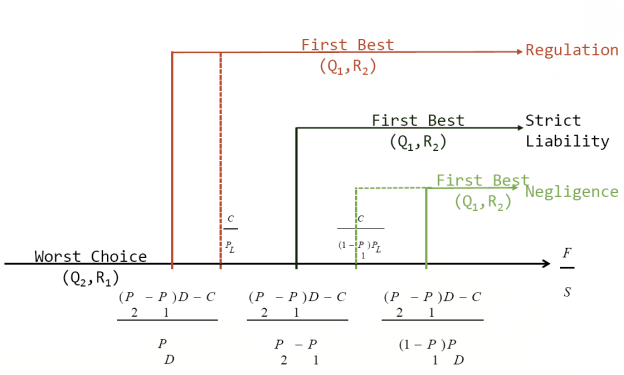

Figure 3: Subgame-Perfect Equilibria without Possible Subversion: Case 1

(b) *For* $\frac{C}{P_L} < \frac{F}{S} < \frac{(P_2-P_1)D-C}{P_D}$, *the second-best* (Q_2, R_2) *under regulation.*

(c) *For* $\frac{(P_2-P_1)D-C}{P_D} < \frac{F}{S} < \frac{(P_2-P_1)D-C}{P_2-P_1}$, *the first-best* (Q_1, R_2) *under regulation.*

(d) *For* $\frac{(P_2-P_1)D-C}{P_2-P_1} < \frac{F}{S} < \frac{(P_2-P_1)D-C}{(1-P_1)P_D}$, *the first-best* (Q_1, R_2) *under regulation or strict liability.*

(e) *For* $\frac{(P_2-P_1)D-C}{(1-P_1)P_D} < \frac{F}{S}$, *the first-best* (Q_1, R_2) *under either of legal enforcement schemes.*

3. *Case 3:* $\frac{C}{(1-P_1)P_L} < \frac{(P_2-P_1)D-C}{P_D}$

(a) *For* $\frac{F}{S} < \frac{C}{P_L}$, *the worst choice* (Q_2, R_1) *under anarchy.*

(b) *For* $\frac{C}{P_L} < \frac{F}{S} < \frac{C}{(1-P_1)P_L}$, *the second-best* (Q_2, R_2) *under regulation.*

(c) *For* $\frac{C}{(1-P_1)P_L} < \frac{F}{S} < \frac{(P_2-P_1)D-C}{P_D}$, *the second-best* (Q_2, R_2) *under regulation or negligence.*

(d) *For* $\frac{(P_2-P_1)D-C}{P_D} < \frac{F}{S} < \frac{(P_2-P_1)D-C}{P_2-P_1}$, *the first-best* (Q_1, R_2) *under regulation.*

(e) *For* $\frac{(P_2-P_1)D-C}{P_2-P_1} < \frac{F}{S} < \frac{(P_2-P_1)D-C}{(1-P_1)P_D}$, *the first-best* (Q_1, R_2) *under regulation or strict liability.*

(f) *For* $\frac{(P_2-P_1)D-C}{(1-P_1)P_D} < \frac{F}{S}$, *the first-best* (Q_1, R_2) *under either of legal enforcement schemes.*

Proof. See Appendix A. Figure 3, 4 and 5 also indicate the results of Proposition 4 graphically. ■

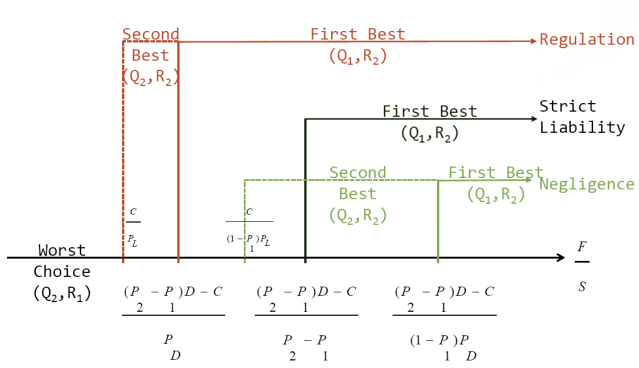

Figure 4: Subgame-Perfect Equilibria without Possible Subversion: Case 2

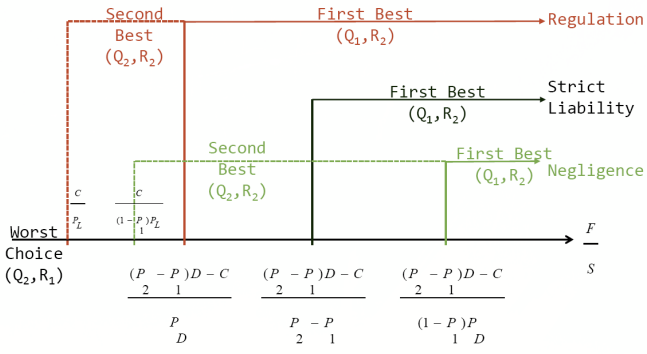

Figure 5: Subgame-Perfect Equilibria without Possible Subversion: Case 3

1.2.2 Case with Possible Subversion

We take into account a possibility of subversion at a timing 3 in a model. If the maximum fine enforceable without subversion X is smaller than actually paid fine F, then then-incumbent would commit to subversion instead of observing law and order. Otherwise, either legal enforcement scheme chosen by government can avoid subversion. Consequently, the possibility of subversion can give us another but similar proposition concerning a case with possible subversion, by simply replacing with X a variable F in Proposition 4. Thus, with possible subversion, properties of subgame-perfect equilibria depend on the degree of law and order relative to firms' scale $\frac{X}{S}$, in such a way indicated in Figure 3 to 5.

1.3 Testable Hypotheses

We induce from our game-theoretic model of R&D competition testable hypotheses on R&D and R&D-deterring activities of firms. Our hypotheses are on average effects of legal enforcement t on R&D or R&D-deterring activities y, conditional on a covariate, law and order variable x, once controlling firms' scale-variable s. Consider each legal enforcement, either regulation, strict liability or negligence as a treatment $k = 1, 2, 3$, respectively. Then with a random variation in law and order $\frac{x}{s}$, we measure average treatment effect on potential outcome y for the treated(thereafter, ATET)

$$E(y_i - y_j \,|\, t = k \,;\, x, s)$$

for $i, j(\neq i), k = 1, 2, 3$.

For instance, let us take Case 1 depicted by Figure 3. When a treatment of regulation is taken, outcome of R&D activities $y_1 = R_2$ is always superior to another outcome y_2 or y_3, what potential outcome were otherwise under strict liability or negligence, conditional on actual choice of regulation, that is in a range of $\frac{(P_2-P_1)D-C}{P_D} < \frac{x}{s}$. If $\frac{(P_2-P_1)D-C}{P_D} < \frac{x}{s} < \frac{(P_2-P_1)D-C}{P_2-P_1}$, then potential outcome y_2 or y_3 would be R_1. If $\frac{(P_2-P_1)D-C}{P_2-P_1} < \frac{x}{s} < \frac{C}{(1-P_1)P_L}$, then it would be that $y_2 = R_2$ but $y_3 = R_1$. If $\frac{C}{(1-P_1)P_L} < \frac{x}{s}$, then either outcome would be R_2. Average potential outcome of y_2 or y_3 conditional on a treatment of regulation $i = 1$ should be strictly smaller than one of y_1, so that ATET

$$\begin{aligned} E(y_1 - y_2 \,|\, t &= 1 \,;\, x, s) > 0 \\ E(y_1 - y_3 \,|\, t &= 1 \,;\, x, s) > 0. \end{aligned}$$

Similarly, we have $E(y_2 - y_3 \,|\, t = 1 \,;\, x, s) > 0$. We summarize in Figure 6 and 7 hypothetical sign conditions on ATET of R&D and R&D-deterring activities.

2 Empirical Analysis

We proceed to empirical analysis to test two hypotheses implied from the theoretical model concerning R&D and R&D-deterrence activities. Sample firms

$E(y_i - y_j \mid t=k)$		Case		
k	(i,j)	1	2	3
1 Regulation	(1,2)	+	+	+
	(1,3)	+	+	+
	(2,3)	+	+	+
2 Strict Liability	(1,3)	+	+	+
	(2,1)	0	0	0
	(2,3)	+	+	+
3 Negligence	(1,2)	0	0	+
	(3,1)	0	0	0
	(3,2)	0	0	+

Figure 6: Hypotheses on Signs on ATET of R&D Activities

$E(y_i - y_j \mid t=k)$		Case		
k	(i,j)	1	2	3
1 Regulation	(1,2)	-	-	-
	(1,3)	-	-	-
	(2,3)	-	-	-
2 Strict Liability	(1,3)	-	-	-
	(2,1)	0	0	0
	(2,3)	-	-	-
3 Negligence	(1,2)	0	0	0
	(3,1)	0	0	0
	(3,2)	0	0	0

Figure 7: Hypotheses on Signs on ATET of R&D-Deterring Activities

should be active in innovative industries facing a-winner-takes-all competition. Our data is on overseas subsidiaries of the Japanese auto-parts suppliers. The source of the panel data is *Basic Survey of Overseas Business Activities* and *Basic Survey of Japanese Business Structure and Activities*, complied by the Ministry of Economy, Trade and Industry, Japan. We cover the corporations belonging to two industrial classifications: motor vehicles, motor vehicle bodies and trailers; and motor vehicle parts and accessories.

As for legal information in each host-country where these corporations are located overseas, we take advantage of indices concerning legal origins(La Porta, Lopez-de-Silanes and Shleifer, 2008) and legal procedures. As well as country-data on the legal procedures, we also use as data of the degree of law and order, some indices in the World Bank *Worldwide Governance Indicators*.

We estimate the steplike functions of either R&D expenses or overseas technical transfers relative to the law and order degree. The method is an estimator on average treatment effects via propensity score matching(Chapter 18 in Wooldridge, 2002). What we should note is our identification of legal enforcement schemes based on indices of both legal origins and efficiency of each judicial system.

2.1 Data

2.1.1 Pooled Data

Our pooled data on overseas subsidiaries of the Japanese auto-parts suppliers, consists of two sources: *Basic Survey of Overseas Business Activities*; and *Basic Survey of Japanese Business Structure and Activities*. 'Auto-parts' mean two categories in industrial classification for the latter data source: motor vehicles, motor vehicle bodies and trailers(no. 1601); and motor vehicle parts and accessories(no. 1602). Our annual sample is from 2003 to 2011.

In the former data source, we use R&D expenses for R_1 or R_2 and some proxies for a local subsidiary's scale s: total sales; and local sales. After matching each individual corporation in both data sources, in the latter source we can identify amount of overseas technical transfer, which indicates parents firm's receipts from patent licensees overseas. It closely stands for how *less* deterrent a subsidiary is to R&D activities of rival competitors, a proxy variable for R&D-deterring activities Q_1 or Q_2 with a negative correlation. We also use in the latter data source some controlling variables, such as total sales, current net profit, capital adequacy ratio, and foreign-owned capital ratio. Further to control how active a parent's firm is in acquiring patent rights, we take advantage of a variable of patent rights maintained.

2.1.2 Law and Order Data

Regarding the degree of law and order X in each host-country where these corporations are located overseas, we use some indices in the World Bank *Worldwide Governance Indicators* and Transparency International *Corruption Perceptions*

Index. The following proxies for law and order are used alternatively in estimation:

1. Control of corruption: "capturing perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests".

2. Rule of law: "capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence".

3. Political stability and absence of violence/terrorism: "capturing perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically motivated violence and terrorism".

4. Regulatory Quality: "capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development."

5. Government Effectiveness: "capturing perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies."

6. Voice and Accountability: "capturing perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media."

7. Corruption Perceptions Index(Transparency International): "based on how corrupt their public sector is perceived to be. a composite index – a combination of polls – drawing on corruption-related data collected by a variety of reputable institutions. Reflecting the views of observers from around the world, including experts living and working in the countries and territories evaluated."

2.2 Estimation

2.2.1 Identification of Legal Enforcement Schemes

A critical point in estimation is how to identify legal enforcement schemes in each host country. We use a clue as to the legal-scheme identification in legal origin theory advocated by La Porta, Lopez-de-Silanes and Shleifer(2008). Each country has a legal origin historically transplanted and evolving over time, either common law or civil law. In general, the overall role of the judiciary or courts in countries with common law traditions is likely to be stronger than in civil

law countries, because of the importance of precedent[3]. The general property of legal origins suggests an identification of the civil law countries as ones with a legal enforcement scheme of regulation. We follow a dummy variable of legal origins used La Porta, Lopez-de-Silanes and Shleifer(2008), indicating whether the legal origin of the company law or commercial code of the country is common law(i.e., English legal origin) or civil law(i.e., French, Socialist, German, and Scandinavian legal origins).

Concerning an identification of liability rules, strict liability or negligence, in common law countries, we utilize data on how efficient the judiciary procedures are in the World Bank *Doing Business*. Under a legal enforcement of negligence that requires government to detect liable activities, less efficiency is likely to emerge in the judiciary processes. The index of enforcing contracts "assesses the efficiency of the judicial system by following the evolution of a commercial sale dispute over the quality of goods and tracking the time, cost and number of procedures involved from the moment the plaintiff files the lawsuit until payment is received". We split each year countries into two groups, negligence scheme or strict liability, applying a criterion above or below a median value of the index for all the countries with common law origin.

2.2.2 Average Multi-Valued Treatment Effect Estimation

We estimate ATET via average multi-valued treatment effect estimation consisting of potential outcome model and treatment model. A linear potential outcome model has a dependent variable of either R&D expenses/ total sales ratio or amount of overseas technical transfer/ total sales. Independent variables consist of each law and order variable x, TFP estimates from Levinson-Petrin productivity estimator, in addition to controlling firm-level variables, macroeconomic variables of each host country, real GDP growth rate, dependence ratio on foreign trade defined as a sum of import and export divided by GDP, and time dummies.

On the other hand, a treatment model is multinomial logit, whose independent variables are the same x variable that in the potential outcome model, the macro variables and time dummies. In both estimated models, robust standard errors are used.

In Figure 8 on R&D activities, shaded cells indicate the cases satisfying the hypothetical sign condition shown in Figure 6, suggesting strong evidence for the theoretical model. Regarding with estimation results on R&D-deterring activities in Figure 9, we also infer that the model can explain the hypotheses

[3] Another candidate for identification is to utilize a general saliency that property rights are require to be more secure under English common law than under French civil law(La Porta, Lopez-de-Silanes, Shleifer, and Vishny, 1999). It can be interpreted as higher P_D, government's detection rate of incumbent's deterrence under civil law than under common law. As a result, case 1 in text would be more probable under civil law, while case 3 more probable under common law. Consequently, under common law, the second-best choice with incumbent's high R&D-deterring activities is more likely.

$E(y_i-y_j\|t=k)$; #5291		X: law & order(from World Bank, *Worldwide Governance Indicators*, if not specified)						
k	(i,j)	Control of Corruption	Rule of Law	Political Stability and Absence of Violence/Terrorism	Regulatory Quality	Corruption Perceptions Index(Transparency International)	Government Effectiveness	Voice and Accountability
1 Regulation	(1,2)	.000769	.0005704	-.0014981	.000906	.0007785	-.0014523	.0038465
	(1,3)	.0015931*	.0022263***	.00087	.0011825	.0016034*	.0017521**	.0030928***
	(2,3)	.0008241	.0016559	.0023681	.0002764	.0008249	.0032044*	-.0007537
2 Strict Liability	(1,3)	.0074171**	.0085626**	.0048927**	.007362*	.0069133**	.0088698**	.0052673**
	(2,1)	.0078814	.0065488	.0104555**	.0073598	.0084949	.0062007	.0104788**
	(2,3)	.0152985***	.0151114***	.0153482***	.0147218***	.0154082***	.0150705***	.0157461***
3 Negligence	(1,2)	-.0024862	-.0027192	-.0049285	-.0023759	-.002984	-.0026819	-.0054075**
	(3,1)	-.0033165**	-.0039921**	-.0019697**	-.0024476**	-.0030316**	-.0037093**	-.0016742
	(3,2)	-.0058027*	-.0067113*	-.0068982**	-.0048236*	-.0060156*	-.0063912**	-.0070817***

Figure 8: Average Multi-Valued Treatment Effect Estimation: Results on R&D Expenses

on sign conditions on ATET in Figure 7, though more weakly than in case of R&D activities.

3 Conclusion

We presented a game-theoretic model of innovation and legal enforcement for competition policy. The model generates testable hypotheses on signs on average effects of legal enforcement on entrant's R&D or incumbent's deterrence activities, conditional on law and order degree in host countries. Average multi-valued treatment effect estimation suggests evidence, on one hand strong for the model in case of R&D expenses, and on the other hand, weaker for explaining overseas technical transfer. The evidence implies, whatever scheme for competition policy achieves the first best more likely in countries with higher law and order, which plays an implicit but substantial role in considerations of how antitrust fosters innovation. Legal enforcement scheme does matter to innovation.

$E(y_i\text{-}y_j \mid t=k)$; #2006		X: law & order(from World Bank, *Worldwide Governance Indicators*, if not specified)						
k	(i,j)	Control of Corruption	Rule of Law	Political Stability and Absence of Violence/Terrorism	Regulatory Quality	Corruption Perceptions Index(Transparency International)	Government Effectiveness	Voice and Accountability
1 Regulation	(1,2)	.0008552**	.0009312***	.0009631***	.0009582***	.0008121**	.0009599***	.0007871*
	(1,3)	.0003225	.0005397*	-9.64e-06	.0001344	.000307	.0003824	.000677**
	(2,3)	-.0005327	-.0003916	-.0009727**	-.0008239**	-.0005051	-.0005775	-.0001101
2 Strict Liability	(1,3)	-.0002322	-.0005423	.0000625	-.000766	-.0001893	-.0005047	-.0002645
	(2,1)	.0002334	.0002594	.0001849	.0002332	.0002499	.0002468	.0001926
	(2,3)	1.22e-06	-.0002829	.0002474	-.0005329	.0000606	-.0002579	-.0000718
3 Negligence	(1,2)	.0008313**	.0009058**	.0006113	.0009292***	.000822**	.0009157**	.0012091**
	(3,1)	-.0002419	-.0003106	-.0000105	-.0001323	-.0002487	-.0002971	-.0004555
	(3,2)	.0005894	.0005952	.0006008	.0007969**	.0005732	.0006186	.0007536

Figure 9: Average Multi-Valued Treatment Effect Estimation: Results on Overseas Technical Transfer

Appendix

A. Proof of Proposition 4

Here we make a proof of Proposition 4 on subgame-perfect equilibria of the R&D competition game under optimal legal enforcement schemes. We solve the game below, via backward induction.

1. First, we consider a case under anarchy decided by government at a timing 0.

   (a) When an incumbent takes Q_1 action at a timing 1, then the best-response R&D activities chosen at a timing 2 would be R_2, since the expected profits which the R&D cost 0 or SC and the expected fine are excluded from the expected monopoly profits SD in case of a higher R&D investment R_2

   $$P_2S(D-C) - (1-P_2)SC = S(P_2D - C)$$

   is higher than those in case of a lower R_1

   $$P_1S(D-0) + (1-P_1)0 = P_1SD$$

on account of Condition 1. Similarly, when an incumbent takes Q_2 action at a timing 1, then the best response of the entrant would be R_1, since the R_1's expected profits P_1SD are higher than the R_2's ones $S(P_1D - C)$.

(b) At a timing 1 in turn taking account of the entrant's best responses, an incumbent would choose the best response Q_2 since the expected profits less the R&D-deterrence cost less the expected fine in case of the Q_2

$$P_1S(0 - C) + (1 - P_1)S(D - C) = S[(1 - P_1)D - C]$$

are higher than those in case of the Q_1

$$P_2S(0 - 0) + (1 - P_2)SD = S(1 - P_2)D$$

due to Condition 1.

2. Next, suppose that government follows strict liability for legal enforcement at a timing 0.

(a) At a timing 2, an entrant's best responses are unqualifiedly decided. In response to an incumbent's choice Q_1, the entrant make a decision R_2 comparing the expected profits in both choices

$$\begin{aligned} P_2S(D - C) + (1 - P_2)(0 - SC - F) &= S(P_2D - C) - (1 - P_2)F \\ &> P_1S(D - 0) + (1 - P_1)(0 - F) \\ &= P_1SD - (1 - P_1)F, \end{aligned}$$

while it makes a response R_1 to the incumbent choice Q_2, resulting the expected profits $P_1SD - (1 - P_1)F$ in comparison with lower $S(P_1D - C) - (1 - P_1)F$ if taking R_2.

(b) Unlike the entrant's best responses, an incumbent's deterrence decision entails a qualification that in order to achieve the first-best outcome, it is sufficient for the incumbent to follow the activities Q_1. A comparison in the expected profits $(1 - P_2)(SD - F)$ from Q_1 or $(1 - P_1)(SD - F) - SC$ from Q_2 answers the best response of the incumbent, so that a qualifying condition for the first-best choices (Q_1, R_2) is

$$\frac{F}{S} > \frac{(P_2 - P_1)D - C}{P_2 - P_1}. \tag{A.1}$$

3. Third, we presume that at a timing 0 government settles on negligence, where it has to detect activities of the incumbent or entrant for anti-competition resulting no innovations.

(a) The best responses of an entrant at a timing 2 is contingent on a qualification concerning a probability P_L of government detecting

the entrant's choice of lower R&D activities. In case of an incumbent choice Q_1, a higher level of the R&D activities R_2 is superior in the expected profits of the entrant to a lower one R_1, since the former gives the higher expected value

$$P_2S(D-C)+(1-P_2)[P_L(0-SC)-(1-P_L)SC]=S(P_2D-C)$$

than what the latter does

$$P_1(SD-0)+(1-P_1)[P_L(0-F)-(1-P_L)0]=P_1SD-(1-P_1)P_LF$$

irrespective of anything but Condition 1. However, If an incumbent decides higher deterrence Q_2, then the entrant's expected profits from either of the R&D activities R_1 or R_2 cannot be ranked without a qualification. In a comparison between the expected profits $P_1SD-(1-P_1)P_LF$ and $S(P_1D-C)$ from R_1 or R_2, respectively, the best response would be R_1 if

$$\frac{F}{S}<\frac{C}{(1-P_1)P_L} \tag{A.2}$$

or otherwise R_2.

(b) Under negligence scheme, an incumbent also takes into account a detection probability P_D in deciding the best response to the entrant's actions. The expected profits are $(1-P_2)SD$ from the deterrence Q_1 or $S[(1-P_1)D-C]-(1-P_1)P_DF$ from Q_2. The first-best choices (Q_1,R_2) can be attained if

$$\frac{F}{S}>\frac{(P_2-P_1)D-C}{(1-P_1)P_D}. \tag{A.3}$$

4. Finally, we consider a case of regulation set enforceable by government at a timing 0. Similarly to the negligence scheme, the best responses of an entrant and an incumbent depend on each detection probability for government.

   (a) An entrant's best response to an incumbent choice of Q_1 is R_2 in a straightforward way to compare the expected profits $S(P_2D-C)$ from R_2 and P_1SD-P_LF from R_1. However, the entrant's best response to Q_2 relies on relative magnitude of the expected profits , P_1SD-P_LF for R_1 or $S(P_1D-C)$ for R_2. If

   $$\frac{F}{S}>\frac{C}{P_L}, \tag{A.4}$$

   then a higher R&D expenditure R_2 should be chosen.

(b) With an incumbent's decision-making, relative magnitude of the expected profits $(1-P_2)SD$ for Q_1 and $S[(1-P_1)D-C]-P_DF$ for Q_2 matters. If

$$\frac{F}{S} > \frac{(P_2-P_1)D-C}{P_D}, \tag{A.5}$$

then the incumbent takes Q_1 activities.

5. At a timing 0, a benevolent government decides which legal enforcement schemes to maximize the social profits, taking into account the best responses of both the entrant and the incumbent at the timing 2 and 1. The decision does depend on the relative magnitude of $\frac{F}{S}$ expressed by the inequalities (A.1), (A.2), (A.3), (A.4) and (A.5) above. Among the 5 threshold values, the magnitude relationships are trivial on $\frac{C}{P_L} < \frac{C}{(1-P_1)P_L}$ and $\frac{(P_2-P_1)D-C}{P_D} < \frac{(P_2-P_1)D-C}{(1-P_1)P_D}$. So that we classify possible cases into case 1: $\frac{C}{P_L} > \frac{(P_2-P_1)D-C}{P_D}$; case 2: $\frac{C}{P_L} < \frac{(P_2-P_1)D-C}{P_D} < \frac{C}{(1-P_1)P_L}$; case 3: $\frac{C}{(1-P_1)P_L} < \frac{(P_2-P_1)D-C}{P_D}$. In Figure 3, 4 and 5, the subgame-perfect equilibria in each case would be evident. QED.

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