The Kernel of a General Licensing Game: the Optimal Number of Licensees*

Naoki Watanabe† and Shigeo Muto‡

March, 2006

Extended Abstract

Patent licensing policies in oligopolistic markets have been studied only as non-cooperative mechanisms; upfront fee or royalty in Kamien and Tauman (1984, 1986), and auction in Katz and Shapiro (1985, 1986). After these seminal papers, the main concern of researchers was focused on the optimal licensing mechanism that maximizes the licensor's revenue from a patented innovation. For instance, Kamien, Oren and Tauman (1992) showed that in the Cournot competition for a homogeneous good it is never optimal for an external licensor to license a cost-reducing innovation by means of royalty only. Muto (1993) found that in the Bertrand duopoly with differentiated commodities there is some cases where it is optimal for an external licensor to license by means of the royalty only.

On the other hand, licensing agreements are basically contract terms signed by licensors and licensees as negotiation results (Macho-Stadler et al. (1996)). This paper hence seeks into the original viewpoint and studies patent licensing as bargaining outcomes.

*Very Preliminary and Incomplete

†Graduate School of Systems and Information Engineering, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8573, Japan. E-mail: naoki50@sk.tsukuba.ac.jp.

‡Department of Social Engineering, Graduate School of Decision Science and Technology, Tokyo Institute of Technology, 2-12-1 Oh-Okayama, Meguro, Tokyo 152-8552, Japan. E-mail: muto@soc.titech.ac.jp

As the first attempt of this agenda, Tauman and Watanabe (2005) showed that in the Cournot market, when the number of firms is large, the Shapley value of the patent holder in a cooperative approach approximates his payoff in the non-cooperative auction game traditionally studied.[1] Their analysis was, however, limited to the asymptotic equivalence. For a finite industry, Driessen, Muto and Nakayama (1992) studied a similar problem on information tdading. Their concern was, however, confined to payoff distributions in the grand coalition (i.e., every player shares the information).

We hence study coalition structures formed by an external licensor of a patented innovation and firms operating in oligopolistic markets and licensing agreements reached as the bargaining outcomes under those coalition structures. For this aim, we consider cooperative solutions with coalition structures. No-sidepayments among coalitions are allowed, as in Aumann and Maschler (1964), Aumann and Drèze (1974) and the references therein.[2]

A key is how to define the worth of a coalition of players. Watanabe and Tauman (2003) proposed a definition that reflects a sophisticated nature of events under a subtle mixture of conflict and cooperation: licensees can form a cartel S to enhance their oligopolistic power, whereas non-licensees may react also by forming some cartels.[3] Then, the licensees in S might not merge into a single entity, but gather as smaller subcartels in S forming the headquarter-subsidiaries relationship.

In this paper, no cooperation among firms is allowd in the market (by law). Under some conditions, however, firms in any groups will decide not to coordinate their strategies, even if they are allowed to cooperate in the market, as shown in Watanabe and Tauman. Hence, the coalition in this paper means a group of a licensor and potential licensee firms in negotiation, and so the coalition structure provides an implication on how many potential licensees the licensor should negotiate with. Watanabe and Muto (2005, 2006) showed a condition where each symmetric bargaining set with

[1] It is remarkable that the two approaches asymptotically coincide, since the patent holder does not have full bargaining power in the cooperative approach and the Shapley value measures the fair contribution of the patent holder to the total industry profit.

[2] A related work was done by Thrall and Lucas (1963).

[3] Tauman and Watanabe (2005) simplified this definition.

a coalition structure is a singleton in this setup. This paper further shows that the kernel is always a singleton for any permissible coalition structure, and so the optimal number of licensees that maximizes the licensor's revenue is uniquely determined.

In the literature, linear demand and cost functions, Cournot or Bertrand oligopoly, cost-reducing or quality-improving innovation, perfect or imperfect patent protection are assumed. We analyze a much less specified model. In particular, our model covers many patterns of piracy, resale and spillover of innovations to non-licensees.(For example, Muto (1987) analyzed a case of resale-free.) Those phenomena are often observed, but as a nature of patented innovation, it is difficult to expect which pattern actually occurs. Hence, we formalize a general patent licensing game, and study the licensing agreements in the game. Instead, we retain the traditional assumption that all firms have an identical production technology before an innovation is licesed and that every licensee firm of the innovation can use the same technology. Hence, we confine our main concern to symmetric payoffs to licensee firms.

Sen and Tauman (2002) showed the optimal number of licensees in a Cournot industry from the traditional viewpoint of non-cooperative licensing game. This paper investigates the same feature in a more general licensing game with cooperative theory.

References

[1] Aumann, R. J., Drèze, M., 1974. Cooperative games with coalition structures. Int. J. of Game Theory 3, 217-237

[2] Aumann, R. J., Maschler, M., 1964. The bargaining set for cooperative games, In: Advances in Game Theory, Dresher, M., Shapley, L. S., and Tucker, A. W. (Eds.), Princeton University Press, 443-476

[3] Driessen, T., Muto, S., and Nakayama M., 1992. A cooperative game of information trading: the core, the nucleolus and the kernel. ZOR-Methods and Models of Operations Research 36, 55-72

[4] Kamien, M. I., 1992. Patent licensing, In: Handbook of Game Theory vol. 1, Aumann, R. J., Hart, S. (Eds.), Elsevier Science, Amsterdam/New York, pp. 332-354

[5] Kamien, M. I., Oren, S. S., Tauman, Y., 1992. Optimal licensing of cost-reducing innovation. J. Math. Econ. 21, 483-508

[6] Kamien, M. I., Tauman, Y., 1984. The private value of a patent: a game theoretic analysis. J. of Econ. Suppl. 4, 93-118

[7] Kamien, M. I., Tauman, Y., 1986. Fees versus royalties and the private value of a patent. Quart. J. Econ. 101, 471-491

[8] Katz, M. L., Shapiro, C., 1985. On the licensing of innovation. Rand J. Econ. 16, 504-520

[9] Katz, M. L., Shapiro, C., 1986. How to license intangible property. Quart. J. Econ. 101, 567-589

[10] Macho-Stadler, I., Martinez-Giralt, X. and J. D. Pérez-Castrillo (1996) "The role of information in licensing contract design," *Research Policy* 25(1), 43-57

[11] Muto, S., 1987. Possibility of relicensing and patent protection. Europ. Econ. Rev. 31, 927-945

[12] Muto, S., 1990. Resale-proofness and coalition-proof Nash equilibria. Games Econ. Behav. 2, 337-361

[13] Muto, S., 1993. On licensing Policies in Bertrand Competition. Games Econ. Behav. 5, 257-267

[14] Nakayama M., Quintas, L., 1991. Stable payoffs in resale-proof trades of information. Games Econ. Behav. 3, 339-349

[15] Sen, D., 2005, Fee versus royalty reconsidered," Games Econ. Behav. 53, 141-147 (2005)

[16] Sen, D., Tauman Y., 2002. General licensing schemes for a cost-reducing innovation. Working paper, Department of Economics SUNY at Stony Brook

[17] Tauman, Y., Watanabe, N., 2005. The Shapley value of a patent licensing game: the asymptotic equivalence to non-cooperative results. forthcoming in Econ. Theory

[18] Thrall, R. M., Lucas, W. F., 1963. n-person games in partition function form. Naval Res. Ligist. Quart. 10, 281-298

[19] Watanabe, N., Muto, S., 2005. Stable profit sharing in patent licensing: general bargaining outcomes, mimeo. Hitotsubashi University

[20] Watanabe, N., Muto, S., 2006. Licensing agreements as bargaining outcomes: general results ans two examples, Adv. Math. Econ. 8, 433-447

[21] Watanabe, N., Tauman, Y., 2003. Asymptotic properties of the Shapley value of a patent licensing game. mimeo., Kyoto University