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Interfaces with Other Disciplines

Licensing radical product innovations to speed up the diffusion

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ABSTRACT

We present a differential game to study how companies can simultaneously license their innovations to other firms when launching a new product. The licensee may cannibalize licensor's sales, albeit this can be compensated by gains from royalties. Nonetheless, patent royalties are generally so low that licensing is not an attractive strategy. In this paper we consider the role of licensing to speed up the product diffusion. Word of mouth by licensee's customers and licensee's advertising indirectly push forward sales of the licensing company, accelerating new product diffusion. We find evidence that licensing can be a potentially profitable strategy. However, we also find that a weak Intellectual Property Right (IPR) protection can easily diminish the financial attractiveness of licensing.

1. Introduction

Innovation is about much more than developing new products; it is about exploiting the products through optimal business processes. Instead of commercializing the innovation alone, an innovative consumer product firm can license the product to other firms. Many companies do both things, competing with their own licensees. This behavior cannot be easily explained in an static context, and we present a differential game to explain the phenomenon.

A license is a contract by which an IPR holder firm (licensor) transfers the right to exploit its innovation to another firm (licensee) under certain conditions and for a certain period of time. Licensing generates two forces on licensor's profit (Fosfuri, 2006): *revenue effect* (licensing payments by the licensees to the IPR holder) and *rent dissipation effect* (erosion of licensor's profit due to additional competition in the product market). At first glance, licensing IPR is a daring decision as the rent dissipation effects might be stronger than the revenue effect. The early literature on licensing is focused on static models (for a review see, e.g., Shapiro, 1985 & Kamien, 1992). More recently, Arora and Fosfuri (2003) develop a framework to understand licensing and competition. Indeed, a monopolist IPR holder will not license as the rent dissipation effect is greater than the revenue effect. Moreover, in practice, we observe that royalties are often low, and licensors capture only a small fraction of the rents from the innovation (e.g., Caves, Crookel, & Killing, 1983; Arora, 1997). Arrow's (1962) remarks show how striking this feature is: "Patent royalties are generally so low that the profits from exploiting one's own invention are not appreciably greater than those derived from the use of others' knowledge". Surprisingly, licensing is a pervasive phenomenon. According to the *License! Global* 2008 Annual Report, the total worldwide retail sales of licensed merchandise reached $191.7 billion in 2007. How can this contradiction be explained?

A potential solution to this conundrum could lie hidden in the dynamics of innovation adoption. The diffusion of new products is typically modeled with first order differential equations where the solution is an "S" shape curve. After commercialization, the early diffusion of innovations is usually characterized by slow growth that is eventually followed by a sharp increase known as sales "takeoff" (e.g., Mahajan, Muller, & Bass, 1990; Rogers, 1995; Golder & Tellis, 1997). This paper considers an alternative reason to license: *sales diffusion acceleration*. This third effect is neglected in static models of licensing. Competition between licensor and licensees results in faster sales diffusion due to higher innovation awareness through the combined marketing effort and cross word-of-mouth effects. As a result, for a monopolistic IPR holder, *sales diffusion acceleration* and *revenue effects* dominate *rent dissipation effect* (loss of the market to the licensees), and licensing takes place. The marketing literature supports this idea. Armstrong and Collopy (1996) and Luo, Rindfleisch, and Tse (2007) argue that competitor-oriented decisions, such as exclusivity, are harmful to financial performance. Recently, Peres and Van den Bulte (2010) consider that word-of-mouth turns product monopoly suboptimal.

This paper studies the use of licenses as a strategy to speed up new product diffusion in the long-term using differential games.

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We point out that licensing can be a beneficial strategy for the IPR holders because there is an increase in profits due to the acceleration of the sales diffusion process, in comparison to the case of monopoly. However, the success of a licensing strategy also depends on the strength of the IPR system. When the IPR is strongly protected, it seems logical to think that an IPR holder would have more incentives to exploit its innovations in monopoly than in a competitive industry. Several studies have empirically considered the relationship between patent protection and licensing, finding that there is a higher propensity to license in industries with strong patent protection (e.g., Anand & Khanna, 2000; Arora & Ceccagnoli, 2006; Gambardella, Giuri, & Luzzi, 2007). In contrast, we study this phenomenon in a dynamic context, and we conclude licensing could be a sound strategy in the long-term.

The moderator role of IPR is better highlighted when we study licensing decision in markets where the IPR holder faces weak competition from pirate companies who sell copy products with lower quality. From the IPR holder's perspective, licensing is a beneficial decision due to licensing payments and faster sales diffusion. However, pirates are better off when selling copy products than licensed products with higher quality as in the latter case they have to pay licensing fees to the IPR holder. Although not completely ruled out, comparative statics suggests that licensing is a less desirable strategy in the context of weak IPR protection from either the perspective of the IPR holder or the pirates. This can partially explain, for instance, the slowness of music industry to allow licensing through the internet to stop the boom of piracy occurring in the last decade. Pirates are less interested in this arrangement. This is supported by the empirical evidence indicating that licensing is less common in this context (Anand & Khanna, 2000; Arora & Ceccagnoli, 2006; Gambardella et al., 2007).

The paper proceeds as follows: For each framework, strong and weak IPR protection, an analytical dynamic model is presented, featuring the licensor–licensee behavior as an open-loop Nash equilibrium in a differential game, computing firms' optimal policies for marketing mix and licensing fees. We characterize optimal licensing, pricing and advertising strategies, and we analyze the sensitivity of the optimal profits to the main parameters using numerical methods. We conclude the paper with some remarks and suggestions for future research. An Online Appendix contains technical results.

2. New product diffusion literature

The diffusion of new products has drawn considerable attention in marketing literature for both radical product innovations (e.g., Bass, 1969; Mahajan et al., 1990; Sultan, Farley, & Lehmann, 1990; Chandrasekaran & Tellis, 2007; Muller, Peres, & Mahajan, 2009) and incremental product innovations such as "new generations" (e.g., Norton & Bass, 1987; Mahajan & Muller, 1996). A variety of extensions have incorporated competitive marketing mix variables to control the diffusion process (e.g., Robinson & Lakhani, 1975; Horsky & Simon, 1983; Kalish, 1985; Horsky & Mate, 1988; Bass, Krishnan, & Jain, 1994, 2000; Krishnan, Bass, & Jain, 1999). The diffusion literature deals mainly with monopolies of category level growth, but there are some extensions for rival brands (e.g., Parker & Gatignon, 1994; Bayus, Kim, & Shocker, 2000; Prasad & Mahajan, 2003; Savin & Terwiesch, 2005; Libai, Muller, & Peres, 2009; Krishnamoorthy, Prasad, & Sethi, 2010). Usually the diffusion can be controlled by elements of the marketing mix (price, advertising, distribution or product decision variables) considering an optimal control problem (in monopolistic context), or a differential game (when there are few companies competing with each other).

Consider n players which maximize an objective function subject to a state equation determined by a set of control variables u_{it} and a state variable x_{it}. For durable products, the state variable x_{it} usually denotes the cumulative sales for company i since the origin $t = 0$. For nondurable products, the state variable x_{it} usually denotes the current sales for company i at period t. Notice that x_{it} can be a scalar or a vector (for example, sales to several segments). The diffusion process $x_t = (x_{1t}, \ldots, x_{nt})$ follows a differential equation,

$$\dot{x}_t = g(x_t, u_t, t), \qquad x_0 = c,$$

where $u_t = (u_{1t}, \ldots, u_{nt})$, g is a continuously differentiable function, and the sales at time t are given by $g(x_t,\ u_t,\ t)$. For nondurable products, x_t is interpreted directly as sales for all the competing companies. Usually $c = 0$, but sometimes sample units are initially given away and the diffusion starts with a different sales level. The catalog of alternative specifications for the differential equation is extremely large. Table 1 presents some of the most popular specifications, where $W(\cdot)$ denotes a non-negative continuously differentiable function and all the considered parameters are non-negative.

In the competitive models, marketing mix controls can be introduced similarly to the monopolistic context. There are many variations on these ideas, even for the simplest models. For example, the following alternatives have been considered for the classical Bass model for durables:

$$\text{Jeuland, see also Floyd} \quad \dot{x}_{it} = \left(p + q\frac{x_{it}}{M}\right)(M - x_{it})^{1+\gamma},$$

$$\text{Easingwood, Mahajan and Muller} \quad \dot{x}_{it} = \left(p + q\left(\frac{x_{it}}{M}\right)^{\delta}\right)(M - x_{it}),$$

$$\text{Nelder, McGowan, and others} \quad \dot{z}_{it} = \left(p + q z_{it}^{\beta}\right)\left(1 - z_{it}^{\alpha}\right), \quad x_{it} = M z_{it}.$$

These references with some additional examples can be found in Mahajan et al. (1990) and Muller et al. (2009). Applying differential games, Krishnamoorthy et al. (2010) explore optimal pricing and advertising strategies for two competing firms. Note that in empirical applications the estimated parameters of a model can vary widely with the considered data and also with small changes in the specification. For example, in a classical Bass model, the intercept p can take quite different levels if advertising is included to accelerate the diffusion (in the same way that the parameters of a simple linear regression change when a moderator variable is included).

The choice of one model or another depends largely on the specific dataset and product category considered. Once the dynamics of the market have been specified, and reasonable values for the parameters are available (estimated from initial data, data from similar markets, using meta-analysis, or qualitative research methods), marketers typically use the model for planning optimal marketing mix policies. This is particularly challenging when several firms compete. When there is competition, the equilibrium path is a solution of a differential game where each player maximizes an objective function

$$\Pi^i(u, x) = \int_0^{\infty} G^i(u_t, x_t, t)\, dt$$

where G^i are continuously differentiable functions, and the optimization is constrained by the differential equation system. In particular, for an (open-loop) Nash equilibrium $(x^*,\ u^*)$

$$\Pi^i(x^*, u_1^*, \ldots, u_N^*) = \max_{u_i, x} \Pi^i(x, u_1^*, \ldots, u_{i-1}^*, u_i, u_{i+1}^*, \ldots, u_N^*), \qquad (1)$$

subject to a dynamic system constraint, for all $i = 1, \ldots, N$. The solution is characterized by the Hamilton–Jacobi–Bellman first-order conditions for each agent i, for details see Appendix. In general,