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Innovation, licensing, and price vs. quantity competition

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ABSTRACT

In this paper, we develop a differentiated duopoly model with endogenous cost-reducing R&D and review the argument on welfare effect of price and quantity competition in the presence of technology licensing. We show that, with licensing, the standard conclusion on duopoly (Singh and Vives, 1984) is completely reversed. Cournot competition induces lower R&D investment than Bertrand competition does. Moreover, Cournot competition leads to lower prices, lower industry profit, higher consumer surplus and higher social welfare than Bertrand competition.

1. Introduction

In their seminal work, Singh and Vives (1984) (henceforth SV) consider a differentiated duopoly model and derive the well-known proposition that Bertrand competition leads to lower prices and higher welfare compared to Cournot competition. Industry profits are lower (higher) in Bertrand than in Cournot competition when the goods are substitutes (complements).

In the present paper, we develop a differentiated duopoly model where one of the firms engages in cost-reducing innovation and licenses its innovation to its rival firm by means of two-part tariff.[1] The purpose of this paper is two-fold. The first is to compare the innovator's incentive to do R&D in the presence of licensing under different modes of competition.[2] The second and also most important goal of the paper is to show that, as a consequence of R&D and licensing, the existing welfare ranking obtained by SV is completely overturned. It is shown that Cournot competition results in lower R&D expenditure, lower industry profits, greater consumer surplus and greater social welfare.

To fully understand the intuition underlying the results, we need to explain three effects. One is the *efficiency effect* induced by R&D investment. The second one is the *price effect*. That is, without R&D and licensing, fierce competition in Bertrand case reduces prices and increases outputs and hence, improves consumer surplus and social welfare. The third one is the *collusive effect* resulted from a licensing agreement including a positive royalty rate. As suggested by Fauli-Oller and Sandonis (2002, 2003), using a contract with a positive royalty rate allows the licensor not only to manipulate the licensee's marginal cost but also to strategically make itself a commitment to charge a higher price, and thereby raises the licensing income. As a consequence, the usage of positive royalty rate plays a role in softening competition through making both the licensor and the licensee less aggressive.

With technology licensing, a Bertrand competitor has an incentive to do more R&D which allows it to charge a higher royalty rate, and thereby induces strong collusive effect. The collusive effect benefits the producers but hurts the consumers. As a result, industry profit is higher, but consumer surplus and social welfare are lower in Bertrand than in Cournot competition.

This paper marries two strands of literature: first, studies on technology licensing and second, analyses on welfare implications of quantity and price competition. The former issue has developed mainly along two lines: One strand focuses on the licensing contracts. Major contributions are provided by Erkal (2005), Kabiraj (2004), Kamien and Tauman (1986, 2002), Katz and Shapiro (1985) and Wang (1998). The focus of these studies is to analyze whether a fixed fee or a royalty contract is optimal when the innovating firm itself is (not) a

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[1] In a survey of U.S. firms, Rostoker (1984) finds that, royalty alone was used 39% of the time, fixed fee 13%, and royalty plus fixed fee 46%.

[2] R&D used in the present context refers to process, rather than product R&D.

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producer.[3] The second strand emphasizes welfare effects and antitrust implications of technology licensing, see for instance, Fauli-Oller and Sandonis (2002, 2003)[4] and Kabiraj (2005).[5] Neither of these approaches integrated R&D decision and welfare comparison between Bertrand and Cournot competition, which are the tasks of the current paper.

Regarding the latter issue, there are some notable works. Some models seem to support the standard welfare ranking in SV. For example, Motta (1993) develops a vertical product differentiation model with endogenous quality choice and shows that the economy as a whole is better off under price competition than under quantity competition. Zanchettin (2006) uses a differentiated duopoly model with asymmetric costs and demonstrates that, although industry profit is higher under Bertrand competition when asymmetry is strong and/or products are weakly differentiated, price competition always produces lower prices and larger welfare than quantity competition does.

However, the standard view that Bertrand equilibrium is welfare superior to Cournot equilibrium has recently been challenged by a number of theoretical models. By incorporating input outsourcing, Arya et al. (2008) find that the standard conclusions on Cournot and Bertrand competition can be completely reversed. Hackner (2000) extends the model of SV to allow for arbitrary number of firms, and argues that the results in SV are sensitive to the duopoly assumption. Mukherjee (2007) builds an asymmetric cost duopoly model with homogenous products and shows that whether or not Bertrand competition is more efficient than Cournot competition depends on the bargaining power of the licenser and the cost difference between the firms. Qiu (1997) focuses on a cost-reducing model and argues that Cournot competition induces higher R&D expenditure than Bertrand competition, but the traditional welfare conclusion in SV relies on R&D productivity, spillovers and product differentiation. Finally, Symeonidis (2003) develops a differentiated duopoly model with product R&D and finds that quantity competition always generates more R&D investment, higher prices and greater profits. The welfare implication is dependent on R&D spillovers and product differentiation.

While previous studies provide some valuable insights, they either assume away R&D decisions or rule out technology licensing. Casual observation shows that both R&D and technology licensing become major economic activities and play important roles for success and growth of firms and economies. As reported by Howells (2008), the largest R&D investor, Daimler–Chrysler, spent \$7.69 billion on its research and development in 2005. Global R&D investment totaled some \$1 trillion in 2006. The European Commission had a target of 3% R&D expenditure as percentage of GDP by 2010. There are currently more than 1 million people who are working in R&D sectors in the United States. The importance of patent licensing is also recognized by firms and governments. Well-known examples include Nokia vs. Qualcomm,[6] MercExchange vs. Ebay (EBAY), KSR vs. Teleflex (TFX),[7] and Apache Software Foundation vs. Microsoft.[8] From 8 to 9 March 2006, an international conference on technology transfer was held in Hanoi, Vietnam.[9] Organized by the Climate Technology Initiative (CTI), this conference was attended by 144 participants from 11 Asian countries. The objective of the seminar was to foster technology transfer in the Asian region.

Our model differs from models of "pure licensing", such as the ones used by Kamien and Tauman (1986, 2002), Mukherjee (2007) and Wang (1998), in important ways, including endogenous cost-reducing R&D. The present model is also different from such models of pure welfare comparisons between Cournot and Bertrand equilibrium like those in SV, Motta (1993), Qiu (1997) and Symeonidis (2003) by allowing for both R&D investment and technology licensing.

The remainder of the paper is organized as follows. In the next section, the baseline model is provided. It augments the SV model by incorporating cost-reducing innovation and technology licensing. The licensing contract is assumed to be two-part tariff. In Section 3, we derive the pre- and post-licensing equilibrium by modeling the market structure as a Cournot duopoly. In Section 4, we repeat the same exercise in a Bertrand game. In Section 5, we compare R&D incentive, industry profit, consumer surplus and social welfare under quantity and price competition. Section 6 concludes the paper. The proofs are presented in the Appendix.

2. The basic model

There are two firms, 1 and 2, each producing a good, good 1 and 2. The inverse demands are $p_i = 1 - x_i - dx_j$, where p_i is the price of firm i, x_i and x_j are the outputs of firms i and j, $i, j = 1, 2$, $i \neq j$. $d \in (0, 1)$ captures the degree of product differentiation. The two firms have identical initial marginal cost c, $c < 1$. Different from Qiu (1997) and Symeonidis (2003), who model R&D rivalry, we assume that only firm 1 can undertake a cost-reducing R&D.[10] In the present paper, we abstract from issues of uncertainty regarding the outcome of innovation. If firm 1 engages in process innovation, then by spending $\frac{1}{2}k^2$ on R&D it can reduce its marginal cost by k.[11] Throughout this paper, to rule out corner solutions, we assume that c is large enough. The two firms compete in either Cournot or Bertrand fashion.[12]

The timing of the game is as follows. First, firm 1 decides whether to license its technology to firm 2 by making a take-it-or-leave-it offer in the form (r, f), where r is a per-unit output royalty and f is a fixed fee. Second, given its licensing decision, firm 1 invests in its cost-reducing innovation. Third, given firm 1's licensing contract, firm 2 decides whether to accept this two-part tariff. If firm 2 rejects, it competes with firm 1 by employing its initial technology. If it accepts, firm 2 competes with firm 1 by utilizing the new technology. In the final stage, both firms simultaneously choose their outputs or prices and compete against each other. We will solve the game by using backward induction.

[3] In an interesting paper, Poddar and Sinha (2004) have analyzed the licensing contract by using a linear city model. Li and Geng (2008) have investigated the case where a patent holder licenses its innovation to a durable good monopoly. In a vertically differentiated duopoly, Li and Song (2009) have shown that licensing the new technology is always superior to licensing the obsolescent technology, from the viewpoint of the innovating firm.

[4] Fauli-Oller and Sandonis (2002) show that, under some circumstances, licensing can reduce welfare. However, they model the cost reduction as an exogenous variable. The present paper complements their work by adding a stage where the innovating firm selects the level of cost reduction.

[5] Very recently, the literature on licensing models has become richer and more diverse. For example, Liao and Sen (2005) discuss the welfare implications of licensing in the presence of subsidy. Lin (1996) demonstrates that fixed-fee licensing may encourage collusion. Mukherjee (2005) analyzes the effect of licensing on non-cooperative and cooperative R&D. Mukherjee and Mukherjee (2005) model technology licensing between foreign and domestic firms.

[6] http://www.engadget.com/2007/11/14/nokias-patent-licensing-case-against-qualcomm-dropped-by-dutch/.

[7] http://seekingalpha.com/article/34302-supreme-court-attacks-patent-licensing-companies.

[8] http://xml.coverpages.org/ni2004-09-03-a.html.

[9] http://www.iisd.ca/ymb/ctiijs/ymbvol92num5e.html.

[10] The R&D models used in Motta (1993) and Symeonidis (2003) are product innovations.

[11] There are many papers that have used this approach to model process innovations, for instance, Lin and Saggi (2002) and Qiu (1997).

[12] The analysis of R&D incentives in the absence of licensing when only one firm can invest in cost-reducing innovation has been done by Bester and Petrkis (1993), they have neither considered the case where only one firm is active nor analyzed welfare effect of Cournot and Bertrand competition.