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Innovation and social desirability of merger

Arijit Mukherjee
Loughborough University

Prabal Roy chowdhury
Indian Statistical Institute

Abstract

Although regulatory authorities are putting more emphasis to the long-run effects of mergers and acquisitions due to their effects on innovation, several merger proposals have been challenged due to their adverse innovation effects. In a simple model with endogenous R&D investment, we show that the effects of merger on the R&D investment, consumer surplus and social welfare depend on the degree of knowledge spillover and the slope of the marginal cost of doing R&D. Hence, the social desirability of merger may depend on the effectiveness of the patent system and the cost of innovation.

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Contact: Arijit Mukherjee - ar_25@hotmail.com, Prabal Roy chowdhury - prabalrc@isid.ac.in.
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1. Introduction

It is believed that in the absence of significant synergic benefits, the firms' gains from horizontal mergers come at the expense of the consumers (Farrell and Shapiro 1990), and create concerns for the antitrust authorities. However, this view generally ignores non-production activities of the firms such as innovation (see the survey by Jacquemin and Slade 1989). In recent years, the regulatory authorities are putting more emphasis on the long-run effects of mergers and acquisitions due to their effects on innovation. The Schumpeterian view suggests that merger creates positive effects on innovation by increasing product market concentration (Schumpeter 1943). However, there are also concerns about the adverse effects of mergers and acquisitions on innovation (Arrow 1962). As discussed in several papers by Gilbert and Sunshine (1995), Gilbert and Tom (2001) and Gilbert (2006), many merger proposals in the USA in recent decades have been challenged due to their adverse innovation effects. For example, the DOJ/FTC annual reports to Congress show that between 1990 and 1994, the agencies allege adverse innovation effects in about 3% of the merger challenges, while from 1995 to 1999, the concern about the adverse innovation effects has risen to 18% of the merger challenges, and between 2000 to 2003, the concern has increased to 38% of the merger challenges (Gilbert 2006).

In a simple model with an innovator and an imitator, we show that the effects of a horizontal merger on the R&D investment, consumer surplus and social welfare depend on the degree of knowledge spillover, which may depend on the effectiveness of the patent system, and the slope of the marginal cost of R&D. Merger may either increase or decrease the R&D investment irrespective of the effectiveness of the patent system. However, merger increases consumer surplus and social welfare if the patent system is not very effective, which allows large cost reduction through imitation, and the slope of the marginal cost of R&D is not very high. Hence, the social desirability of horizontal merger may depend on the effectiveness of the patent system and the cost of innovation.[1]

Our paper can be related to an earlier paper by Brod and Shivakumar (1999), that examines the effects of product market cooperation between the competing innovating firms on the R&D investments, profits and consumer surplus. However, the two papers focus on different economic scenarios. First, their paper is on product market cooperation only, thus creating the same amount of knowledge spillover under non-cooperative and cooperative product market behavior. In contrast, our paper considers merger between the firms, and therefore, knowledge spillover is complete in the merged firm, which acts like a monopolist producing with the best available technology, while knowledge spillover is imperfect (except for the special case of a perfect knowledge spillover) under non-cooperative product market behavior. Hence, the scope of cooperation in their paper is limited to the output stage, while the firms in our analysis cooperate completely. Second, they consider innovation by both firms, while we consider an industry with an innovator and an imitator. Hence, their paper may be appropriate in industries with symmetrically R&D capable firms (see, e.g., Roy Chowdhury 2005), while our paper is appropriate in industries with technology leaders and technology followers, as in Gallini (1992), Mookherjee and Ray (1991), Roy Chowdhury (1997), Mukherjee (2003) and Mukherjee and Pennings (2004), to

[1] A vast literature has been devoted to analyze the welfare effects of strong patent protection, which is assumed to eliminate imitation or knowledge spillover. We do not review that literature here. Instead, we refer the readers to Mazzoleni and Nelson (1998) for an overview on the benefits and costs of patent protection. In contrast to the previous works, the present paper considers that patent protection can never be perfect and cannot eliminate imitation completely.

name a few.[2] Third, they do not look at the effects of product market cooperation on social welfare, while that is the main purpose of this paper. Hence, unlike our paper, they do not consider the social desirability of horizontal merger.

Fershtman and Gandal (1994), which has been extended by Brod and Shivakumar (1999), also show the effects of product market cooperation on the R&D investments, profits and consumer surplus. However, they share all the above-mentioned differences between our paper and Brod and Shivakumar (1999). In addition, they do not consider knowledge spillover, and therefore, do not provide an answer to the social desirability of merger depending on knowledge spillover.[3]

Our results differ significantly from Fershtman and Gandal (1994) and Brod and Shivakumar (1999). In contrast to them, we show that merger may either increase or decrease the R&D investment if knowledge spillover is low. For the comparable situations of Fershtman and Gandal (1994) (i.e., with no knowledge spillover in our analysis) and Brod and Shivakumar (1999) (i.e., with homogeneous products in their analysis), we show that the industry profit is *always higher* under merger, while the former paper shows that the industry profit is lower under merger if the slope of the marginal cost of R&D is lower, and the latter paper shows that the industry profit is always lower. We further show that consumer surplus is higher under merger if the slope of the marginal cost of R&D is small and knowledge spillover is significant. This is in contrast to Fershtman and Gandal (1994), which ignore knowledge spillover and show that consumer surplus is *always lower* under merger. Our result also qualifies the related result of Brod and Shivakumar (1999), which show that consumer surplus is *always higher* under merger if the products are homogeneous. Lastly, as already mentioned, unlike them, we also show the welfare implications of merger.

There is another literature showing the effects of the intensity of competition on the R&D investment, welfare and growth. For example, Delbono and Denicolò (1990), Qiu (1997), Roy Chowdhury (2005) and Mukherjee (2011) compare the effects of Cournot and Bertrand competition on the R&D investments, profits and welfare under partial equilibrium.[4] Aghion et al. (1997, 2001 and 2005) and D'Aspremont et al. (2002) consider general equilibrium growth models with R&D competition to show the effects of Cournot and Bertrand competition. Hence, these papers show the effects of different strategic variables. In contrast, merger in our analysis affects the product market structure by reducing the number of producers.

The remainder of the paper is organized as follows. Section 2 describes the model and derives the results. Section 3 concludes.

2. The model and the results

An innovator (firm 1) and an imitator (firm 2) produce homogeneous products with a marginal cost of production of c.

[2] In an open economy with a foreign technology leader, Mattoo et al. (2004) consider the effect of cross-border merger on R&D investment and domestic welfare, in the absence of knowledge spillover.

[3] Davidson and Ferrett (2007) consider "merger paradox" by looking at the profits of the merged and the non-merged firms following a bilateral merger in an oligopoly industry with competing innovating firms. However, unlike our paper, they consider all innovating firms, no knowledge spillover under non-cooperative product market behavior and complete knowledge sharing under merger, and do not show the implications of merger on the consumers and on social welfare.

[4] Instead of considering Cournot and Bertrand competition, Boone (2000 and 2001) parameterize intensity of competition. While Boone (2000) ignores knowledge spillover in R&D, Boone (2001) examines a scenario where the innovators and the producers are different firms.

Firm 1 invests in R&D to reduce its marginal cost of production. We assume that x amount of R&D investment reduces its marginal cost of production to $(c-x)$, and the cost of R&D is $C(x)=\frac{\tau x^2}{2}$. As τ increases, it increases the cost of R&D. Knowledge spillover (or imitation) reduces firm 2's marginal cost of production to $(c-\beta x)$, where $\beta \in [0,1]$. $\beta = 0$ implies no knowledge spillover and $\beta = 1$ implies complete knowledge spillover. Hence, the term β can represent the strength of the patent system. The situation with $\beta = 0$ considers a completely effective patent system, while the situation with $\beta = 1$ considers a completely ineffective patent system.[5]

Assume that the inverse market demand function is

$$P = a - q, \tag{1}$$

where P is price and q is the aggregate output of firms 1 and 2.

We will consider two different scenarios for the product market competition, called non-cooperation and merger. Under non-cooperation, the firms choose their outputs simultaneously to maximize their own profits. Under merger, the merged firm behaves like a monopolist and produces with the best available technology.

We consider a three-stage game. At stage 1, the firms decide on merger. At stage 2, firm 1 invests in R&D to reduce its marginal cost of production. At stage 3, the firms produce their outputs simultaneously and the profits are realized. We solve the game through backward induction.

We will do our analysis under the following assumption:

A1. $\tau > Max\{\frac{2(1-\beta)(2-\beta)}{3}, \frac{a}{2c}, \frac{2(2-\beta)(a+c(1-\beta))}{9c}\}$.

Assumption **A1** will ensure that the equilibrium output of firm 2 will be positive under non-cooperation, and $(c-x) \geq 0$ under both non-cooperation and merger.

2.1 Non-cooperation

First, consider the game under non-cooperation at stage 3 where the firms choose their outputs like Cournot duopolists to maximize their own profits.

Given the R&D investment decided upon at stage 2, firms 1 and 2 maximize $\underset{q_1}{Max}(a-q-c+x)q_1$ and $\underset{q_2}{Max}(a-q-c+\beta x)q_2$ respectively, where q_1 and q_2 are the outputs of firms 1 and 2 respectively.

The equilibrium outputs of firms 1 and 2 can be found as, respectively

$$q_1 = \frac{(a-c+2x-\beta x)}{3} \text{ and } q_2 = \frac{(a-c+2\beta x - x)}{3}. \tag{2}$$

The equilibrium profits of firms 1 and 2 are respectively

$$\pi_1^n = \frac{(a-c+2x-\beta x)^2}{9} - \frac{\tau x^2}{2} \quad \text{and} \quad \pi_2^n = \frac{(a-c+2\beta x - x)^2}{9}. \tag{3}$$

Firm 1 maximizes π_1^n with respect to R&D, so that the equilibrium R&D is

[5] Alternatively, β can be interpreted as the length of patent protection, so that the second firm can only imitate after a time β elapses. This is consistent with an interpretation of the current model as a reduced form approximation of a dynamic framework. We are indebted to the associate editor, Quan Wen, for this point.

$$x^n = \frac{2(a-c)(2-\beta)}{(9\tau - 2(2-\beta)^2)}. \quad (4)$$

We find that $x^n \le c$ if $\frac{2(2-\beta)[a+c(1-\beta)]}{9c} \le \tau$, which is assumed to hold. The restriction $\frac{2(2-\beta)[a+c(1-\beta)]}{9c} \le \tau$ also satisfies the second order condition for the above maximization problem, which is $\frac{2(2-\beta)^2}{9} < \tau$.

We find from (2) and (4) that the equilibrium outputs of firms 1 and 2 are respectively

$$q_1^n = \frac{3\tau(a-c)}{(9\tau - 2(2-\beta)^2)} \quad \text{and} \quad q_2^n = \frac{(a-c)(3\tau - 2(1-\beta)(2-\beta))}{(9\tau - 2(2-\beta)^2)}.$$

The equilibrium output of firm 2 is positive for $\tau > \frac{2(1-\beta)(2-\beta)}{3}$. For any $\beta \in [0,1]$, the equilibrium output of firm 2 is positive provided $\tau > \frac{4}{3}$.

The total output and consumer surplus are respectively

$$q^n = \frac{2(a-c)(3\tau - (1-\beta)(2-\beta))}{(9\tau - 2(2-\beta)^2)} \quad \text{and} \quad CS^n = \frac{2(a-c)^2(3\tau - (1-\beta)(2-\beta))^2}{(9\tau - 2(2-\beta)^2)^2}. \quad (5)$$

We find from (3) and (4) that the equilibrium profits of firms 1 and 2 are respectively

$$\pi_1^n = \frac{\tau(a-c)^2(9\tau - 2(2-\beta)^2)}{(9\tau - 2(2-\beta)^2)^2} \quad \text{and} \quad \pi_2^n = \frac{(a-c)^2(3\tau - 2(1-\beta)(2-\beta))^2}{(9\tau - 2(2-\beta)^2)^2}.$$

The industry profit is

$$\pi^n = \pi_1^n + \pi_2^n = \frac{(a-c)^2(\tau(9\tau - 2(2-\beta)^2) + (3\tau - 2(1-\beta)(2-\beta))^2)}{(9\tau - 2(2-\beta)^2)^2}. \quad (6)$$

Under non-cooperation, social welfare is $W^n = \pi^n + CS^n$.

2.2 Merger

Now consider the game under merger where the firms behave like a monopolist. Under merger, it is optimal for the firms to produce in firm 1 only, since the cost of production is lower in firm 1 for any positive R&D investment.

The sequence of moves under merger is as follows. At stage 1, if the firms decide to merge, then, at stage 1a, firm 1 gives a take-it-or-leave-it offer with a lump-sum payment, F, to firm 2, and firm 2 accepts the offer if it is not worse-off compared to non-cooperation. If firm 2 accepts the offer, firm 1 pays F and acquires firm 2. At stage 2, firm 1 determines the R&D investment. At stage 3, firm 1 produces like a monopolist and the profit is realized. If at stage 1a, firm 2 does not accept the offer of firm 1, the firms play the non-cooperative game from then onwards.

Since firm 1 gives a take-it-or-leave-it offer to firm 2, the equilibrium offer F^* will be equal to firm 2's profit under non-cooperation, so that $F^* = \pi_2^n$.

It is worth noting that F^* does not affect the R&D investment of firm 1 since it is a lump-sum payment offered by firm 1. This, in turn, implies that our assumption of full bargaining power of firm 1 will not affect our qualitative results.

Given the R&D investment of firm 1, it maximizes $\underset{q}{Max}(a - q - c + x)q - F^*$.

The equilibrium output and the equilibrium profit of firm 1 are respectively

$$q^c = \frac{(a-c+x)}{2} \quad (7)$$

$$\pi_1^c = \frac{(a-c+x)^2}{4} - F^* - \frac{\tau x^2}{2}. \tag{8}$$

Maximizing (8), we get the equilibrium R&D investment as

$$x^c = \frac{(a-c)}{(2\tau-1)}. \tag{9}$$

We assume that $\frac{a}{2c} \leq \tau$, which ensures $x^c \leq c$. The restriction $\frac{a}{2c} \leq \tau$ satisfies the second order condition for the above maximization problem, which is $\frac{1}{2} < \tau$.

The total output and consumer surplus under merger are respectively

$$q^c = \frac{\tau(a-c)}{(2\tau-1)} \quad \text{and} \quad CS^c = \frac{\tau^2(a-c)^2}{2(2\tau-1)^2}. \tag{10}$$

We find from (8) and (9) that the profit of firm 1 is $\pi_1^c = \frac{\tau(a-c)^2}{2(2\tau-1)} - F^*$. The profit of firm 2 is $\pi_2^c = F^* = \pi_2^n$.

The industry profit under merger is

$$\pi^c = \pi_1^c + \pi_2^c = \frac{\tau(a-c)^2}{2(2\tau-1)}. \tag{11}$$

Social welfare under merger is $W^c = \pi^c + CS^c$.

3. The comparison between non-cooperation and merger

We begin by compare the equilibrium R&D investment under non-cooperation and merger.

Proposition 1: *Merger increases the R&D investment if and only if* $\beta \geq \tau + \frac{3}{2} - \frac{1}{2}\sqrt{4\tau^2 + 14\tau + 1}$.

Proof: The proof follows from equations (4) and (9). ■

Example 1. Let $a=4$, $c=2$, $\beta=1$ and $\tau=2$. If $\beta=1$, assumption **A1** simplifies to $\tau > \frac{a}{2c}$, which is satisfied. The right hand side (RHS) of the condition in Proposition 2 simplifies to 0.05, which is satisfied. Thus, for these parameter values, merger increases R&D investments. Next, consider $a=4$, $c=2$, $\beta=0$ and $\tau=2$. If $\beta=0$, assumption **A1** reduces to $\tau > Max\left\{\frac{4}{3}, \frac{a}{2c}, \frac{4(a+c)}{9c}\right\}$, which is satisfied. However, the condition in Proposition 2 is not satisfied with $\beta=0$, suggesting that merger reduces R&D investment in this situation.

The reason for the above result is as follows. On one hand, higher profit under merger compared to non-cooperation encourages firm 1 to invest more in R&D. On the other hand, there is a strategic effect under non-cooperation. If firm 1 increases the R&D investment under non-cooperation, its market share and profit increase under non-cooperation. Higher τ and higher β tend to reduce the strategic incentive for R&D investment. While the former factor makes R&D more costly, the latter effect reduces the innovator's return from R&D investment. Both these effects reduce the strategic effect under non-cooperation and generate higher R&D investment under merger.

Let us now compare the total profits under non-cooperation and merger. This result shows that the central policy question analyzed in this paper, i.e. whether merger should be allowed or not, is of interest, as otherwise the firms will not merge even if merger is allowed for.

Proposition 2: *The industry profit is always higher under merger compared to non-cooperation.*

Proof: The proof follows from a simple revealed preference argument. Under merger, the merged firm acts as a monopolist and can always mimic the amount of R&D investment under non-cooperation, i.e., x^n, as well as the aggregate output under non-cooperation, i.e., q^n. If the merged firm mimics the R&D investment under non-cooperation, the total revenues of the firms and the costs of undertaking R&D are the same under merger and non-cooperation. The production costs are however lower under merger, since a part of the total output, i.e., q_2^n, is produced at a marginal cost of $(c-x^n)$ under merger, while that amount of output is produced at a marginal cost of $(c-\beta x^n)(>(c-x^n))$ under non-cooperation. Hence, the profit under merger cannot be lower to that of under non-cooperation. ■

The above proposition suggests that even though the R&D investment may be higher under non-cooperation, the higher product-market concentration under merger makes the industry profit always higher under merger compared to non-cooperation.

Now compare the output levels under non-cooperation (q^n) to that of under merger (q^c). Since, consumer surplus is an increasing function of the total output, this also allows us to compare the consumer surplus under non-cooperation (CS^n) to that of under merger (CS^c).

Proposition 3: *Consider Assumption **A1**.*

(a) If $\tau<\frac{4}{3}$, there exists $\widehat{\beta}(\tau)\in(0,1)$ such that $CS^n<CS^c$ if and only if $\beta>\widehat{\beta}(\tau)$.

(b) If $\tau>\frac{4}{3}$, we get that $CS^n>CS^c$.

Proof: If the equilibrium outputs of the firms are positive, which happens under assumption **A1**, consumer surplus under non-cooperation and merger are given by (5) and (10) respectively. we find that $CS^c>CS^n$ if and only if $2\tau\beta^2-4\tau\beta+6\tau-3\tau^2-2\beta^2+6\beta-4\equiv Z(\beta)>0$. Further, $Z'(\beta)=4\tau\beta-4\tau-4\beta+6$, $Z''(\beta)=4(\tau-1)$ and $Z(1)=\tau(4-3\tau)$.

(a) Consider $\tau\le 1$. Straightforward calculations show that $Z(0)<0<Z(1)$, $Z(\beta)$ is concave and $Z'(0)>0$. Whereas for $1<\tau<\frac{4}{3}$, $Z(0)<0<Z(1)$, $Z(\beta)$ is convex and $Z'(0)>0$. Thus, for both these cases, $Z(\beta)$ is increasing in $\beta\in[0,1]$ with $Z(0)<0<Z(1)$, suggesting that there exists $\widehat{\beta}(\tau)\in(0,1)$ *such that* $CS^n<CS^c$ *if and only if* $\beta>\widehat{\beta}(\tau)$.

(b) Next, consider the case of $\tau\ge\frac{4}{3}$. In this situation, $Z(\beta)$ is convex, $Z(0)<1$ and $Z(1)<1$, suggesting that $Z(\beta)$ is negative for all $\beta\in[0,1]$. ■

Example 2. Let $a=4$, $c=3$, $\beta=1$ and $\tau=\frac{3}{4}$. Given that $\beta=1$, assumption A1 simplifies to $\tau>\frac{a}{2c}$, which is satisfied. Consequently, from Proposition 3(a), so that $CS^c>CS^n$. Next, consider $a=4$, $c=3$, $\beta=1$ and $\tau=2$. Consequently, the hypothesis of Proposition 3(b) is satisfied, so that $CS^c<CS^n$.

Whether consumer surplus with be higher or lower under merger compared to non-cooperation depends on the trade-off between product-market concentration and R&D investment. On one hand, merger tends to reduces consumer surplus by increasing product-market concentration. On the other hand, if merger increases R&D investment, it increases production efficiency and tends to increase consumer surplus. Since the R&D investment is higher under merger for lower τ and higher β, consumer surplus is also higher under merger compared to non-cooperation for lower τ and higher β.

Corollary: *Given Proposition 2, welfare under merger to exceed that under non-cooperation, i.e. for $W^c>W^n$, it is sufficient to have $CS^c>CS^n$. Thus, we can claim from Proposition 3(a) that, for $\tau<\frac{4}{3}$ and $\beta>\widehat{\beta}(\tau)$, welfare under merger exceeds that under non-cooperation.*

For parameter values such that $CS^c<CS^n$, welfare comparison is less transparent. Given that the expressions under non-cooperation are cumbersome, we do not get general analytical results, and concentrate on two extreme situations: (i) $\beta=0$, i.e., the patent system is very effective, and (ii) $\beta=1$, i.e., the patent system is ineffective.

Proposition 3 shows that consumer surplus is lower under merger compared to non-cooperation if $\beta=0$. We will see that welfare is also lower under merger compared to non-cooperation for $\beta=0$.

Finally, we will show that, at $\beta=1$, even if consumer surplus is lower under merger compared to non-cooperation, welfare can be higher under merger compared to non-cooperation. Given continuity, these results imply that merger is not socially desirable under an effective patent system where β is low, while consumers and society may prefer merger under an ineffective patent system where β is high. Hence, if the patent system is ineffective, the antitrust authority will allow (not allow) merger if the slope of the marginal cost of R&D is small (high). However, the antitrust authority will not allow merger if the patent system is effective.

Proposition 4: *If $\beta=0$, social welfare is always higher under non-cooperation compared to merger.*

Proof: If $\beta=0$, assumption **A1** reduces to $\tau>Max\left\{\frac{4}{3},\frac{a}{2c},\frac{4(a+c)}{9c}\right\}$. We find that in this situation that $W^n>W^c$ if and only if $45\tau^4+65\tau^3+88\tau^2-240\tau+48>0$, which holds for $\tau>Max\left\{\frac{4}{3},\frac{a}{2c},\frac{4(a+c)}{9c}\right\}$. ■

Proposition 5: *Suppose, $\beta=1$.*

(a) Consumer surplus is higher under merger (non-cooperation) for $\tau\in\left(\frac{a}{2c},\frac{4}{3}\right)$ $\left(\tau>\frac{4}{3}\right)$.

(b) Social welfare is higher under merger (non-cooperation) for $\tau \in \left(\frac{a}{2c}, \frac{23+\sqrt{241}}{18}\right)$ $\left(\tau > \frac{23+\sqrt{241}}{18}\right)$.

Proof: If $\beta = 1$, assumption **A1** reduces to $\tau > \frac{a}{2c}$.

(a) If $\beta = 1$, we get that $CS^c \gtreqless CS^n$ for $\tau \lesseqgtr \frac{4}{3}$. Therefore, consumer surplus is higher under merger (non-cooperation) for $\tau \in \left(\frac{a}{2c}, \frac{4}{3}\right)$ ($\tau > \frac{4}{3}$).

(ii) If $\beta = 1$, we get that $W^c \gtreqless W^n$ for

$$9\tau^3 - 23\tau^2 + 8\tau \lesseqgtr 0. \tag{12}$$

We get $\tau = 0$, $\tau = \frac{23-\sqrt{241}}{18}$ and $\tau = \frac{23+\sqrt{241}}{18}$ are the roots of the equation $9\tau^3 - 23\tau^2 + 8\tau = 0$. Since τ must be greater than $\frac{a}{2c} (> \frac{1}{2})$, the only relevant root for our analysis is $\tau = \frac{23+\sqrt{241}}{18}$. Further, left hand side of (12) is continuous and convex in τ for $\tau > \frac{1}{2}$ and it is negative at $\tau = \frac{1}{2}$. Hence, social welfare is higher under merger (non-cooperation) for $\tau \in \left(\frac{a}{2c}, \frac{23+\sqrt{241}}{18}\right)$ $\left(\tau > \frac{23+\sqrt{241}}{18}\right)$. ■

It follows from Proposition 5(a) that consumer surplus is higher under non-cooperation for $\tau > \frac{4}{3}$ but welfare is higher under merger for $\tau \in \left(\frac{a}{2c}, \frac{23+\sqrt{241}}{18}\right)$. Since $\frac{4}{3} < \frac{23+\sqrt{241}}{18}$, it implies that there are $\tau \in \left(Max\left\{\frac{4}{3}, \frac{a}{2c}\right\}, \frac{23+\sqrt{241}}{18}\right)$ such that consumer surplus is higher under non-cooperation but welfare is higher under merger.

Example 3. Let $a = 4$, $c = 2$, $\beta = 1$ and $\tau = 2$. If $\beta = 1$, assumption **A1** simplifies to $\tau > \frac{a}{2c}$, which is satisfied. Moreover, $\frac{4}{3} < \tau = 2 < \frac{23+\sqrt{241}}{18} (= 2.14)$. Hence, it follows from Proposition 7(b) that welfare is higher under merger.

If the patent system is ineffective, it reduces the R&D investment, and therefore, consumer surplus and social welfare significantly under non-cooperation. So, even if merger increases concentration in the product market, the positive effect of higher R&D investment under merger dominates the negative effect of product market concentration if R&D is not very costly (i.e., τ is small), and creates higher consumer surplus and welfare under merger compared to non-cooperation.

4. Many Firms and Price Competition

We now discuss some robustness issues. First, consider the case with one innovating firm and $(n-1)$ non-innovating firms, where $n \geq 3$. One interesting possibility that arises here is the issue of partial merger, where the innovating firm forms a merger with m non-innovating firms, where $m < (n-1)$. It is trivial that the issue of partial merger cannot be addressed if $n = 2$. Given the result in Salant et al. (1983), it is not clear however if partial merger can happen in equilibrium. Since a complete analysis of this issue is beyond the scope of this paper, we restrict ourselves to an intuitive discussion of the welfare effects of a partial merger vis-à-vis complete merger. While both kinds of merger will have a contractionary effect on total output (as competition is lessened), the reduction in output is going to be relatively less under partial merger. Consequently, the reduction in consumer surplus will be less under partial merger. On the other hand, with a partial merger, the internalization of the spillover effect will be less, as firms outside the partial merger will still be free-riding on the R&D investment of the innovating firm. Consequently the innovating firm will have less of an incentive to invest in R&D under partial merger. Hence, various effects are at play here, and the welfare comparison can go either way.

Next, we briefly discuss the implications of price competition. As argued by Kreps and Scheinkman (1983), the Cournot outcome can arise under price competition in the presence of capacity constraints, when the firms can endogenously decide on their capacity levels (and the residual demand function is parallel). Thus, our results go through under price competition whenever, following the R&D stage, there is a two stage sub-game where the firms first decide on their capacity levels, and then on prices. Alternatively, consider price competition with differentiated products. Given that the central feature of quantity competition is that the strategic variables, i.e., quantities, are strategic substitutes, our analysis will go through whenever the prices are strategic substitutes.[6] However, it is important to see how the outcomes change if prices are strategic complements.

We plan to take up both the issues mentioned above in our future work.

5. Conclusion

Although regulatory authorities are putting more emphasis on the long-run effects of mergers and acquisitions due to their effects on innovation, several merger proposals have been challenged due to their adverse innovation effects. We show that the effects of merger on the R&D investment, consumer surplus and social welfare depend on the degree of knowledge spillover and the slope of the marginal cost of R&D.

We show that the R&D investment may be either higher or lower under merger if knowledge spillover is small, while the R&D investment is always higher under merger if knowledge spillover is significant. The industry profit is always higher under merger. However, consumer surplus and social welfare are higher under merger if knowledge spillover is significant and the slope of the marginal cost of R&D is small. Hence, the social desirability of merger depends on the effectiveness of the patent system and the cost of innovation.

Our analysis suggests that merger and patent policies may need to be adopted in conjunction. However, it may worth noting that the strength of the patent system of an economy may not influence knowledge spillover completely. Mansfield et al. (1981) find that 60% of a sample of patented innovations is imitated within four years. Further, it is often the case that patent application is not successful, thus creating a threat of imitation (Amir and Wooders 1999). Griliches (1990) shows that the success rate of getting patent protection are 65% in the US, 90% in France, 80% in the UK and 35% in Germany.[7] The probability of success of a patent application depends on "certain minimal standards of novelty and potential utility and these standards can change over time both as a result of changes of perception of what is an innovation and the result of changing 'applications' pressure on a relatively fixed number of patent office workers" (Griliches 1990, p. 1690). Hence, due to the uncertainty in patent approval, knowledge spillover may occur even under the strongest patent

[6] Singh and Vives (1984) show that the prices are strategic complements (substitutes) if the products are substitutes (complements).

[7] If the firms opt for trade secrecy rather than patents, accidental leakage or duplication may create competition in the product market (Denicolò and Franzoni 2004). Bessen (2005) shows that knowledge diffusion is not lower under trade secrecy than under patent protection.

system. If the patent system cannot control knowledge spillover or imitation effectively, the government needs to adopt the merger policy accordingly.

As a final remark, it has been argued that subsidizing the innovator might be an effective alternative to the patent system (Spence 1984). However, as argued in Kremer (1998), subsidization may not be effective since the government might not know the costs and expected benefits of the innovation. Further, allowing the government officials wide discretion to set payments for the innovation may lead to rent-seeking and to expropriation of the innovators. Hence, our analysis is important for those situations where subsidization by the government is not an effective tool.

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