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EFFICIENT HORIZONTAL MERGERS IN POLLUTING INDUSTRIES WITH GREEN R&D AND ENDOGENOUS TAXATION

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Abstract: We investigate the feasibility of horizontal mergers in a homogeneous triopoly where firms production is polluting the environment, firms compete in quantities and invest in green R&D, and a regulator endogenously sets environmental taxation. We show that the degree of alignment between private and social incentives decreases in the intensity of pollution.

Key words: mergers, environmental externality, social welfare, green R&D, Pigouvian taxation.

JEL Classification Number: L13, L41, Q51.

1. INTRODUCTION

The cornerstone of the lively discussion about horizontal mergers is the so-called efficiency defense, whereby efficiency gains driven by the merger may indeed more than offset the negative consequences on consumer surplus, and therefore justify the merger itself (see Salant *et al.*, 1983, Perry and Porter, 1985, Gaudet and Salant, 1991, 1992 and Farrell and Shapiro, 1990, *inter alia*). Conversely, few efforts have been carried out to investigate the social consequences of mergers in markets where production entails a negative environmental externality. In this vein, some contributions consider the effects on emission permits policies and mergers. For instance, in a perfectly competitive industry with pollution permits, Hennessy and Roosen (1999) show that permit incentives may motivate a merger of otherwise independent firms. Ehrhart *et al.* (2008) investigate the EU emission trading law. Their analysis sheds light on loopholes that foster tacit

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collusion in oligopolistic Cournot markets.

In this note, we revisit the well known issue of the firms' incentive to merge in a Cournot triopoly, by combining the efficiency effect based on production costs (in particular, on average cost) with the environmental implications of the industry output contraction that goes along with the merger in a polluting market. We consider a market in which a regulator sets the optimal taxation of pollution, there are three symmetric firms (see Rodrigues, 2001 and Fridolfsson and Stennek, 2005, *inter alia*) investing in green R&D and competing in quantities. We establish the necessary and sufficient conditions for the merger of two firms out of the original three to be both profit- and welfare-improving. This situation takes place given a sufficiently large sunk costs. Moreover, the necessary sunk costs in order for the merger to be socially desirable is always higher than the necessary level in the private case.

Our results show that an increase in polluting effects of production contributes to un-align private and social incentives towards horizontal mergers. The intuition behind this is to be found in the fact that the internalisation of pollution through the Pigouvian taxation is mainly borne by the firms, so that the private incentive in merging is stronger than the social incentive in order to lower the tax burden.

Our analysis is related to Frikku and Lahiri (2011). Unlike our analysis, they consider firms being asymmetric in environmental impact of production and marginal cost of abatement, pollution is a linear function of production (we assume it quadratic) and take into account the presence of a consumption tax and the case in which the Pigouvian tax is exogenous. More importantly, their analysis focusses on the role of environmental policy in affecting the incentive of polluting firms to engage in mergers and acquisitions, whereas we are interested in comparing social with private incentives towards the merger, and their determinants.

2. THE MODEL

We consider an industry with $n \in \{2, 3\}$ firms competing à la Cournot. Firms produce the same homogeneous good, whose production goes along with a negative environmental externality. Pollution is taxed by a regulator at the rate t_n on emissions while a firm can reduce its tax burden by undertaking environmental R&D, z_n , to reduce its emissions. For the sake of simplicity we assume away the presence of spillovers, so that a firm's emissions are $e_n = q_n - z_n > 0$. The damage function is $E = d (\sum e_n)^2$, where $d > 0$ represents the marginal damage of emissions. Firms have symmetric cost function:

$$C(q_n, z_n) = cq_n + \gamma \frac{z_n^2}{2} + F, \quad (1)$$

where q_n is the quantity produced by each firm, $c > 0$, $\gamma \in (0, 1]$ is a parameter measuring the cost of investing in R&D,¹ and $F > 0$ is a sunk cost. The inverse demand is linear, $p = a - nq_n$, hence a firm's profit function is $\pi_n = pq_n - C(q_n, z_n) - t_n e_n$.

¹ The normalisation of γ to the unit interval, which results from an appropriate choice of measurement unit, is useful and provokes no further loss of generality.

Consumer surplus is measured by $CS_n = n^2 q_n^2 / 2$, while social welfare is defined as the sum of industry profits, consumer surplus and tax revenue, minus pollution:

$$W_n = \sum_{n=1}^n \pi_n + CS_n + nt_n e_n - E. \quad (2)$$

The timing of the game is as follows. In stage 1, the regulator sets the environmental tax so as to maximise welfare. In stage 2, firms invest in green R&D. In stage 3 market competition takes place. The equilibrium concept is the subgame perfect equilibrium by backward induction.

3. RESULTS

Throughout the analysis, for notational simplicity we shall define market size as $m = a - c$. Initially, we examine the pre-merger scenario, in which $n = 3$. In the competition stage, the market equilibrium is the traditional Cournot result given by:

$$q_3 = \frac{m - t_3}{4}. \quad (3)$$

Notice that the equilibrium quantity does not depend on abatement directly, but it is affected by it through taxation. In the second stage, each firm chooses the green R&D investment. The amount of R&D in equilibrium is proportional to the unitary tax, $z_3^* = t_3 / \gamma$, and the second order condition is

$$\frac{\partial^2 \pi_3^*}{\partial z_3^2} = -\frac{1}{\gamma} < 0.$$

In the first stage, the regulator chooses t_3 in order to maximise welfare. The equilibrium rate t_3 is:

$$t_3^* = \frac{m\gamma [6d(4 + \gamma) - \gamma]}{6d(4 + \gamma)^2 + \gamma(16 + 3\gamma)}. \quad (4)$$

The tax is levied for

$$d > \frac{\gamma}{6(4 + \gamma)}. \quad (5)$$

Equilibrium profits and social welfare are:

$$\pi_3 = \frac{m^2 [36d^2(2 + \gamma)(4 + \gamma)^2 + 12d\gamma(4 + \gamma)(8 + \gamma) + \gamma^2(32 + 17\gamma + 2\gamma^2)]}{2[6d(4 + \gamma)^2 + 2\gamma(16 + 3\gamma)]^2} - F, \quad (6)$$

and

$$W_3 = \frac{3m^2(5 + \gamma)(6d + \gamma)}{12d(4 + \gamma)^2 + 2\gamma(16 + 3\gamma)} - 3F, \quad (7)$$

respectively.

Consider now the case where two firms decide to merge, so that $n = 2$. In order for the merger to give rise to an efficiency gain, we pose that the firm resulting from the merger bears a single fixed cost F . Now the Cournot-Nash individual equilibrium output is:

$$q_2 = \frac{m - t_2}{3}, \quad (8)$$

the amount of R&D in equilibrium is again $z_2^* = t_2/\gamma$, and the welfare-maximising tax rate is:

$$t_2^* = \frac{m\gamma [4d(3 + \gamma) - \gamma]}{4d(3 + \gamma)^2 + \gamma(9 + 2\gamma)}. \quad (9)$$

In this case, the tax is levied for

$$d > \gamma/4(3 + \gamma). \quad (10)$$

Comparing (10) with (5) it emerges that

$$\frac{\gamma}{4(3 + \gamma)} > \frac{\gamma}{6(4 + \gamma)},$$

for $\gamma \geq 0$, so that (10) is sufficient condition in order the tax to be levied before and after the merger.

Equilibrium profits and social welfare are:

$$\pi_2 = \frac{m^2 [16d^2(2 + \gamma)(3 + \gamma)^2 + 8d\gamma(3 + \gamma)(6 + \gamma) + \gamma^2(2 + \gamma)(9 + 2\gamma)]}{2[4d(3 + \gamma)^2 + \gamma(9 + 2\gamma)]^2} - F, \quad (11)$$

and

$$W_2 = \frac{3m^2(5 + \gamma)(6d + \gamma)}{4d(3 + \gamma)^2 + \gamma(9 + 2\gamma)} - 2F, \quad (12)$$

respectively.

We are now in a position to evaluate whether the merger is socially efficient in an industry where production pollutes the environment. One can set out by noting that the incentive compatibility constraint in order for two firms to merge spontaneously is $\pi_2 - 2\pi_3 > 0$. This condition holds for all²

$$F > \hat{F} \equiv \frac{m^2 [16d^2(2 + \gamma)(3 + \gamma)^2 + 8d\gamma(3 + \gamma)(6 + \gamma) + \gamma^2(2 + \gamma)(9 + 2\gamma)]}{2[4d(3 + \gamma)^2 + \gamma(9 + 2\gamma)]^2} - \frac{m^2 [36d^2(2 + \gamma)(4 + \gamma)^2 + 12d\gamma(4 + \gamma)(8 + \gamma) + \gamma^2(32 + 17\gamma + 2\gamma^2)]}{2[6d(4 + \gamma)^2 + 2\gamma(16 + 3\gamma)]^2} > 0. \quad (13)$$

Given the strict profit-seeking behaviour of firms, condition (3) obviously replicates what is known from the previous literature mentioned in the introduction. We then need to establish the conditions such that merging is socially efficient. This can be done by comparing the social welfare levels with 2 or 3 firms. We have that $W_2 > W_3$ holds for all $F > \tilde{F}$, where

$$\tilde{F} \equiv \frac{m^2 [10d\gamma(7 + \gamma) + \gamma^2(7 + \gamma) + 24d(7 + 21\gamma + 9\gamma^2 + \gamma^3)]}{2[4d(3 + \gamma)^2 + \gamma(9 + 2\gamma)][6d(4 + \gamma)^2 + \gamma(16 + 3\gamma)]}. \quad (14)$$

We can easily establish that

² It can be easily ascertained that the condition $\gamma \in (0, 1]$ suffices to ensure the positivity of \hat{F} .

LEMMA 1. For all $d > 0$ and $\gamma \in (0, 1]$, the level of sunk cost \tilde{F} above which merger is socially desirable is always higher than the level of sunk cost \hat{F} above which merger is profitable.

PROOF. Comparing $\tilde{F} - \hat{F}$ yields:

$$\begin{aligned} \tilde{F} - \hat{F} \propto & 576d^4 (3 + \gamma)^2 (4 + \gamma)^2 [3 + \gamma (11 + 3\gamma)] + \\ & \gamma^4 (9 + 2\gamma) (48 + 51\gamma + 13\gamma^2 + \gamma^3) + \\ & 2d\gamma^3 (4320 + 7579\gamma + 4156\gamma^2 + 993\gamma^3 + 106\gamma^4 + 4\gamma^5) + \\ & 96d^3\gamma (2160 + 3549\gamma + 1953\gamma^2 + 400\gamma^3 - 3\gamma^4 - 11\gamma^5 - \gamma^6) + \\ & 4d^2\gamma^2 (15984 + 19536\gamma + 10743\gamma^2 + 3401\gamma^3 + 626\gamma^4 + 59\gamma^5 + 2\gamma^6) > 0. \end{aligned} \quad (15)$$

To complete the proof of the above claim, it suffices to observe that

$$2160 + 3549\gamma + 1953\gamma^2 + 400\gamma^3 > 3\gamma^4 + 11\gamma^5 + \gamma^6$$

for all $\gamma \in (0, 1]$. Since all other terms are strictly positive, indeed $\tilde{F} - \hat{F} > 0$ over the whole parameter constellation being considered. ■

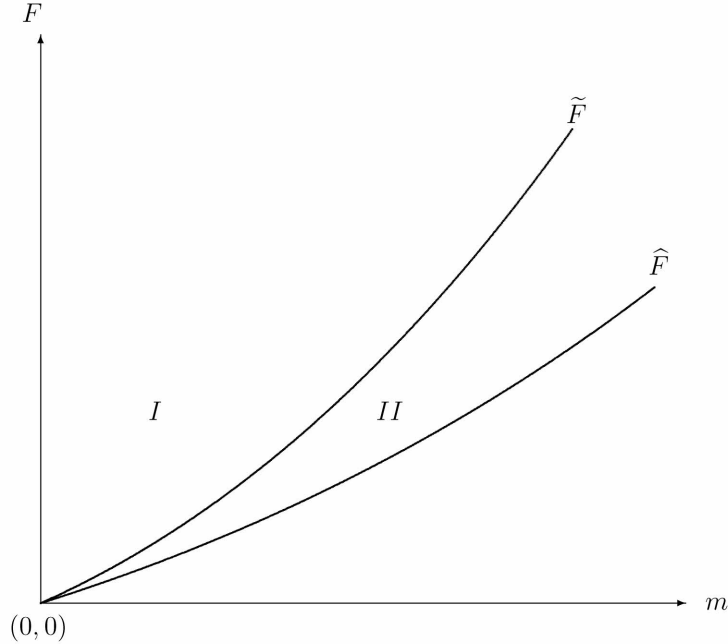


Figure 1. Merger incentives

Private and social incentives towards the merger can be appreciated by referring to Figure 1. We are interested in the portion of the space $\{m, F\}$ lying above \hat{F} , wherein

a private incentive to merge does exist. In region *I*, private and social incentives are aligned; therefore, an antitrust authority should allow the merger to take place. In region *II*, there is a conflict as firms would like to merge but the antitrust authority should intervene to prevent them from doing so.

The results occurring in region *II* can be explained as follows. The higher competition in the non-merger case lowers the total amount of profits, and pollution is higher compared to the merger case. These negative effects on social welfare are more than offset by the higher output and tax revenue emerging in a triopoly. When the sunk costs are at least equal to \tilde{F} , the decrease in total profits makes merger socially desirable.

Consider next the change in the threshold levels due to a variation in either γ or d . Unfortunately, it is not possible to obtain analytical solutions. Thus we evaluate the comparative static through a numerical analysis by setting relevant values to d and γ . Begin by the variation of the threshold levels \hat{F} and \tilde{F} with respect to γ , when $d = 1$. Differentiating \hat{F} and \tilde{F} with respect to γ yields:

$$\left. \frac{\partial \hat{F}}{\partial \gamma} \right|_{d=1} \propto \left. \frac{\partial \tilde{F}}{\partial \gamma} \right|_{d=1} \propto 22176 + 1380\gamma - 13283\gamma^2 + 4788\gamma^3 + 450\gamma^4. \quad (16)$$

It can be easily ascertained that (16) is positive for $0 < \gamma \leq 1$. Then, consider the variation of \hat{F} and \tilde{F} with respect to d , when $\gamma = 1$. Differentiating \hat{F} and \tilde{F} with respect to γ yields:

$$\left. \frac{\partial \hat{F}}{\partial d} \right|_{\gamma=1} \propto \left. \frac{\partial \tilde{F}}{\partial d} \right|_{\gamma=1} \propto 348d - 8, \quad (17)$$

which is positive for $d \geq 1$. The results can be summarised as follows.

LEMMA 2. *Both the threshold levels \hat{F} and \tilde{F} increase with the cost of investing in R&D and with the marginal damage of emission.*

The above lemma amounts to saying that, if the cost of R&D is sufficiently high, then it is less likely that the merger is welcome both by a social planner and a firm. While this results is quite intuitive, it is less obvious to understand why an increase in the marginal damage of emissions lowers the incentives to merge. The reason is due to the fact that the tax burden is higher after the merger:

$$e_2 t_2^* - e_3 t_3^* \Big|_{\gamma=1} = 1062720d^3 + 114636d^2 - 12952d - 1079 > 0,$$

for $d \geq 1$. Since the Pigouvian tax is endogenously determined according to the level of environmental damage, the increase in profits due to the merger is more than compensated by the increase in the tax burden if d is high enough. Therefore, t is a disincentive to merge and, indirectly, a tool to regulate competition. Moreover, the same effect on \hat{F} and \tilde{F} given by a variation in γ or d is explained by the fact that a change in γ or d mainly affects a firm's profits rather than other components of social welfare.

Finally, we investigate the change in the alignment of social and private incentives followed by a variation in the marginal impact of production on pollution. It emerges that:

$$\left. \frac{\partial (\tilde{F} - \widehat{F})}{\partial d} \right|_{\gamma=1} = \frac{1243 + 4d [8579 + d (50351 + 24d (8047 + 40800d))]}{(11 + 64d)^2 (19 + 150d)^2} > 0, \quad (18)$$

that is, the region wherein the conflict exists expands as the marginal damage of emissions increases. This discussion can be summarised in.

PROPOSITION 1. *The impact of production on pollution reduces the alignment between private and social incentives towards horizontal mergers.*

The source of this result is to be found in the fact that the negative effect of production on pollution lowers both \widehat{F} and \tilde{F} , as suggested by Lemma 2, but its effect is stronger on the private rather than social incentive. Thus the effects of emission internalised by the government through taxation is mainly borne by firms, so that the incentive in merging becomes weaker for them than for the government.

This simple modelisation, inserting externalities in the standard approach to merger analysis in a Cournot industry points thus to the need of a close coordination between authorities in charge of antitrust themes on one side and environmental issues on the other.

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