Environmental regulation and mergers within the eco-industry

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Abstract

The welfare implications of a merger in an environment industry are considered in a Cournot-Nash context. The traditional analysis of mergers is extended in two ways. First, we examine how the environmental policy may affect the incentives to merge in this specific sector. Second, we show that mergers in the environment industry impact welfare beyond what is observed in other sectors due to an extra effect on the environment. This could result in a conflict between an anti-trust agency, whose mandate is to focus on consumers' and firms' surplus, and a benevolent regulator considering the overall welfare.

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1 Introduction

Reducing pollution in an economically efficient way has become a main challenge for recent societies. The environment industry - or *eco-industry* sector - now plays a major role in reaching this goal. The eco-industry consists of activities that measure, prevent, limit, minimize or correct environmental damages (OECD/Eurostat, 1999). Both theoretical and empirical analysis of the sector has developed recently. The optimal environmental policy when taking into account the presence of an eco-industry has been studied in a closed economy context (David & Sinclair-Desgagné 2005, Nimubona & Sinclair-Desgagné 2005, Canton et al. 2005, Requate 2005) and in an open economy (Fees & Muehlheusser 2002, Canton 2006, Copeland 2005). However, few contributions seem to take into account the changes in market structure that may occur within the eco-industry.

We focus here on the analysis of mergers and acquisitions. A few articles deal with the link between the environmental regulation and the incentives to merge (Hennessy & Roosen 2002, Benchekroun & Ray-Chaudhuri 2006) but none of them examines mergers in an environment industry. One explanation to this lack of analysis about mergers and pollution can be found in the usually positive correlation between production and pollution. As merger activities tend to reduce production, they also lower the negative impact on the environment. Therefore, partial equilibrium analysis of mergers do not need to consider the impact on the environment. It is not the case anymore when ones deals with the eco-industry sector.

Furthermore, mergers and acquisitions do take place in many sub-sectors of the eco-industries. As stipulated in a WTO report, "the available evidence suggests that there is a tendency towards increasing concentration in the environmental industry. A study on mergers and acquisitions in the US in the environmental industry suggests that scale benefits and consumer preferences favour large firms which tend to achieve higher returns than their smaller rivals (European Commission, 1994). Technological developments favour large firms because environmental processes are becoming more complex and integrated, and small firms find it difficult to fund the necessary equipment investments. At the same time, more stringent regulations induce customers like municipalities to use few large environmental service suppliers in order to more easily monitor compliance and trace liability. As a result of these developments, the number of mergers and acquisitions increased between 1987 and 1991 at annual rate of 56 per cent to reach 223 transactions in 1991. More recent reports from industry sources suggest that half the private market in the United States is controlled by the top ten companies" (WTO, 1998).

Mergers between firms in the same industry have long been a public policy concern. Some discussions have focused on the welfare implications of mergers (Williamson 1968, Farrell & Shapiro 1990). On the one hand, mergers may give rise to efficiency gains, such as scale economies, that reduce the cost of production. On the other hand, mergers can reduce industry competition and thus result in higher prices for consumers. Authorities then make a

trade-off between the positive and negative effects of the merger in order to decide whether to accept it or not.

Other contributions have analyzed the incentives for firms to merge (Perry & Porter 1985, Allain & Souam 2004) by comparing their profit before and after merger. In that literature, a keystone paper is the one of Salant et al. (1983). The authors study merger-profitability via presenting the impact of a merger on the Cournot-Nash equilibrium of the market. With linear demand and cost functions, it is notably shown that the number of merged firms has to represent at least 80% of the initial number of firms so as to be sure that the merger is profit-enhancing. This high threshold can be explained by two reasons. First, the outsiders' reaction, which increase production and outweigh the reduction in production from the merged entity. Second, linearity in cost and demand functions. Fauli-Oller (1997) shows that in a setting where symmetric firms compete à la Cournot and costs are linear, the degree of concavity of the demand function is identified as the main determinant of merger profitability. The more concave the demand function, the less profitable the merger. An important caveat of both analysis is that firms after merger remain identical to the ones before merger. Asymmetric linear oligopolies are studied by Fauli-Oller (2002) and Heubeck et al. (2006). However, there is no scale effect when cost functions are assumed linear. Perry & Porter (1985) are the first to relax the assumption of linearity in cost functions. They also add another heterogeneity in the sense that some firms are leaders and others are followers. The authors do not study any welfare implications. Cost economies are however one of the two elements of the basic trade-off induced by mergers on welfare. Mergers reduce production costs but increase firms' market power. If the former effect dominates the latter, a merger can be welfare-enhancing. Farrell & Shapiro (2000) present in more details what can be called cost-economies and how it impacts welfare. Synergies are necessary, so as to benefit from a lower production cost that none of the pre-merger firms could have achieved. These synergies are modeled as a fixed industry capital stock, shared by incumbent firms. The more concentrated the capital stock, the lower production costs. Based on this assumption, McAfee & Williams (1992) proceeds to the analysis of welfare implications of horizontal mergers. We build our model on their framework.

Compared to other sectors, mergers in the eco-industry induce specific effects. First, the incentives to merge are now influenced by the environmental policy. More precisely, the stringency of this policy affects the demand for environmental goods and services, which modifies the merger profitability for the environment firms. Second, the welfare implications of mergers now go beyond consumers and firms' surplus. It also affects the quality of the environment. The traditional trade-off between the cost economies and the loss in consumers' surplus induced by a merger must now be extended.

We examine the policy implications of these two specific effects. We assume a perfectly competitive polluting industry. An emission tax is introduced in order to reduce pollution.

Therefore, it procures an abatement good or service from an oligopolistic environment industry. We consider horizontal mergers in the eco-industry. Following Perry & Porter (1985) and McAfee & Williams (1992), we assume mergers induce synergies that reduce the per unit production costs. Theses synergies are modeled as a fixed capital asset that firms combine when they merge. The more concentrated the capital stock, the lower production costs. We show that a stronger tax policy reduces the incentives to merge within the eco-industry (section 3). We derive the conditions under which a merger in the eco-industry is welfare increasing (section 4). We then identify the cases when an anti-trust agency's objective, which would neglect the environment, may differ from the position of a benevolent regulator (section 5).

2 The basic model

Consider a representative price-taking firm that produces one consumption good and sells it on a competitive market at a per unit price P. The marginal production cost for this good is assumed to be constant and is denoted as c. Along with the consumption good, the firm produces some pollutant. For an output level x, the amount of polluting emissions is given by $e(x, A)$, where A represents the firm's abatement effort. Without much loss in realism, we specify the emission function as $e(x, A) = \frac{1}{2}(x - A)^2$. We then have $e_x(x, A) > 0$ (more production entails more pollution), $e_A(x, A) < 0$ (more abatement decreases total emissions), $e_{xx}(x, A) > 0$ (emissions from the last unit produced increase with the production level), and $e_{AA}(x, A) > 0$ (abatement is subject to diseconomies of scale). Last, we have $e_{xA}(x, A) < 0$ (the higher the abatement, the less the last unit produced generates pollution)[1]. The polluting sector purchases abatement goods and services from a specialized environment industry. p is the per unit price of abatement A.

Let us assume the polluting firm is subject to an emission tax t. It then maximizes the following profit:

$$\max_{x,A} \Pi = Px - cx - pA - te(x, A) \tag{1}$$

Normalizing the final consumers' demand as $P(x) = 1 - x$, basic calculations lead to the following optimal levels of production and abatement for the polluting firm:

$$x = 1 - c - p \tag{2}$$

$$A = 1 - c - \frac{1 + t}{t} p \tag{3}$$

Let $p(A)$ denote the inverse demand function faced by the environment firms, where A stands

[1]Compared to David & Sinclair-Desgagné (2005), Nimubona & Sinclair-Desgagné (2005) and Canton et al. (2005), we relax the assumption of an additively separable emission function.

for total purchases of abatement goods and services. Given (3), the inverse demand is $p(A) = \alpha_1 - \alpha_2 A$, where $\alpha_1 = \frac{(1-c)t}{1+t}$ and $\alpha_2 = \frac{t}{1+t}$.

The eco-industry is initially composed of n identical firms competing à la Cournot. Following McAfee & Williams (1992), total costs of a firm i in the eco-industry are assumed to be equal to $\frac{a_i^2}{2k_i}$, where a_i is the firm's output and k_i its capital investment. Firms are identical and $\sum_{i=1}^{n} k_i = K$. Therefore, each firm holds the share $k_i = k = \frac{K}{n}$ of a global amount of specific assets in the economy. Define

$$\beta_i = \frac{\alpha_2 k_i}{\alpha_2 k_i + 1}$$

and

$$B = \sum_{i=1}^{n} \beta_i$$

β_i indicates on the market share of firm i whereas B indicates on the size of the market.

The following equilibrium is derived for the initial case where all firms are equal[2] (see McAfee & Williams (1992)).

$$a = \frac{\alpha_1}{\alpha_2} \frac{\beta}{1+B}$$

$$A = \frac{\alpha_1}{\alpha_2} \frac{B}{1+B}$$

$$p = \frac{\alpha_1}{1+B}$$

and the profit of a firm in the eco-industry is:

$$\pi^{up} = pa - \frac{a^2}{2k} \tag{4}$$

3 Mergers within the eco-industry

3.1 The profitability threshold of a merger

Let us assume that s firms in the eco-industry choose to merge. Total capital of the merged firm is sk. Indexing by s the equilibrium values for the merged firm and by o those for each $(n-s)$ remaining firms (the *outsiders*), we have

$$\beta_s = \frac{\alpha_2 sk}{\alpha_2 sk + 1}$$

$$\beta_o = \beta = \frac{\alpha_2 k}{\alpha_2 k + 1}$$

[2] In this case, $k_i = k, \forall i$ and $\beta_i = \beta, \forall i$. Therefore $a_i = a, \forall i$.

In this case, B becomes $B_m = \beta_s + (n-s)\beta_o$, which yields:

$$B_m = \frac{s(\alpha_2 k)^2(1+n-s) + n\alpha_2 k}{(s\alpha_2 k+1)(\alpha_2 k+1)}$$

and

$$a_s = \frac{\alpha_1}{\alpha_2}.\frac{\beta_s}{1+B_m}$$

$$a_o = \frac{\alpha_1}{\alpha_2}.\frac{\beta_o}{1+B_m}$$

Total output is then

$$A_m = \frac{\alpha_1}{\alpha_2}.\frac{B_m}{1+B_m}$$

and the market price is

$$p_m = \frac{\alpha_1}{1+B_m}$$

We show easily that $B_m < B$ and $p_m > p$.

A merger is not always profitable for firms merging. Two main incentives induce firms to merge. First, it reduces their production costs. Second, total output is reduced, which increases the market price and the firms' profit (Perry & Porter 1985, Fauli-Oller 2002). However, Stigler (1950) and others have argued that firms which do not participate in the merger may actually benefit more than the participants. They expand their output and profit fully from the higher market price (i.e. they free-ride), contrarily to the insiders who reduce their output. In sum, merger's participants do not capture the entire profit that results from their merger (see Perry & Porter (1985) and Salant et al. (1983)). This may dissuade firms from merging.

Following the methodology used by Allain & Souam (2004), let us show that a s-firm merger is profitable for the insiders only if s is superior to a unique threshold $\hat{s}$. The profit of the merged firm is equal to $\pi_s^{up} = a_s p_m - \frac{a_s^2}{2sk}$. Using the standard analysis on mergers, we compare the profit of the merged entity with s times the individual profit before merger, given by (4). We show that the sign of the difference is the same as the sign of the following expression (see Appendix 8.1 for some detail):

$$\begin{aligned} g(s,n,\alpha_2) &= (\alpha_2 k+1)^2(2s\alpha_2 k+1)[1+(n+1)\alpha_2 k]^2 \\ &- (2\alpha_2 k+1)[s(\alpha_2 k)^2(2+n-s)+\alpha_2 k(n+s+1)+1]^2 \end{aligned} \quad (5)$$

We show that this expression is negative when s is inferior to a given threshold $\hat{s}$ and positive when $s > \hat{s}$, which leads us to:

Lemme 1 *There exists a unique threshold on the number of insiders (s) from which a merger in the eco-industry becomes profit-enhancing.*

A quick proof of the existence and unicity of this threshold is given in Appendix 8.1.

3.2 The impact of a change in the environmental policy

Let us examine how a change in the environmental policy affects the environment firms' incentives to merge. A change in the tax t affects the polluters' abatement decisions as given by the inverse demand function $p(A) = \alpha_1 - \alpha_2 A$, where $\alpha_1 = \frac{(1-c)t}{1+t}$ and $\alpha_2 = \frac{t}{1+t}$. Note that a tax increase not only increases the demand for abatement (through α_1) but also affects the price elasticity of abatement demand (through α_2). However, α_1 does not appear in $g(s, n, \alpha_2)$ and thus does not affect the threshold value from which a merger is profitable[3]. The main impact of a variation in the environmental policy on merger profitability then occurs via a change in α_2.

Let us first look into the case of a two-firms merger. A two-firms merger is profit-enhancing if and only if:

$$g(2, n, \alpha 2) > 0 \tag{6}$$

where

$$g(2, n, \alpha 2) = 1 - 2(n-5)\alpha_2 k + [17 + (2-3n)n](\alpha_2 k)^2 + 4[1 - (n-2)n](\alpha_2 k)^3$$

The sign of this expression, and its variation with α_2, are studied in Appendix 8.2, which leads us to:

Proposition 1 *Increasing the environmental tax either reduces the incentive for two firms in the eco-industry to merge (when $n \geq 3$) or has no effect on it (when $n = 2$).*

The case when $n = 2$ is a particular case where the duopoly always has an incentive to merge and form a monopoly. The level of the tax then has no effect on the incentives to merge.

Our result is confirmed in the general case of a s-firms merger through a wide range of simulations. A rise in α_2 (i.e. a rise in t) increases the level $\hat{s}$ from which a merger becomes profitable. In other words, as the environmental tax becomes stricter, less mergers in the eco-industry are profitable. The intuition associated to this result is the following. As explained before, mergers involve two different effects affecting the incentives to merge: an anticompetitive effect (industry output is reduced which increases the price) and a cost-minimizing one. The tax affects the first effect by modifying the price-elasticity of abatement demand (α_2) which affects the eco-industry's market power. A higher tax, for instance, reduces the elasticity of demand for abatement. At low elasticities of demand, a merger induces a higher price rise than at high elasticity levels. As a result, outsiders produce more post-merger than when elasticity is high.

[3] As c, the marginal production cost of polluting firms only appears in α_1, we note that polluters' production costs do not influence the merger profitability of the environment industry.

In other words, the free-riding behavior of the outsiders is amplified when price elasticity of demand is low. The incentives to merge are thus reduced.

Our result according to which a higher tax reduces the profitability of a merger is in line with the empirical observation that horizontal mergers generally occur in declining industries (Dutz 1989). This result is both confirmed by other theoretical work and real-world observation. From a theoretical point of view, Fauli-Oller (2002) has shown in a context of linear cost and demand functions and asymmetric firms that when demand increases, merger profitability decreases. In practice, firms do not merge when the market is in expansion, but rather when the market is mature. It was the case on the American market for waste management, where the main U.S. firms secured their growth via mergers and acquisitions at a time where the market was stable (Berg et al. 1998).

This section has shown that a higher environmental tax generally reduces the incentives for mergers in the eco-industry. Let us now investigate whether such mergers would improve or deteriorate social welfare.

4 Welfare analysis

Social welfare is defined as the sum of the final consumers' surplus (CS), the polluting industry's profit (Π) and the eco-industry's total profits ($\Pi^{up} = \sum_{i=1}^{n} \pi_i^{up}$) minus the social damage due to pollution. Each unit of emissions causes a social damage ν. We have:

$$CS = \int_0^x P(u)du - Px$$

$$\Pi = Px - cx - pA - te(x, A)$$

$$\Pi^{up} = \sum_{i=1}^{n} (pa_i - \frac{a_i^2}{2k_i}) = pA - \sum_{i=1}^{n} \frac{a_i^2}{2k_i}$$

Tax revenues are given to consumers as lump-sum transfers. Net welfare is then written as follows:

$$W = \int_0^x P(u)du - cx - \sum_{i=1}^{n} \frac{a_i^2}{2k_i} - \nu e(x, A) \tag{7}$$

Each term in the welfare function is modified by a merger within the eco-industry[4]. Let us look into these modifications in more detail.

[4] As we assume non-separability between the polluter's decisions to abate and to produce, the final consumers are also affected by a merger in the eco-industry.

4.1 The eco-industry's total production costs

Before any merger, firms are identical and the eco-industry's total production costs are:

$$\eta = \frac{na^2}{2k}$$

After s firms in the eco-industry have merged, the eco-industry's total costs are:

$$\eta_m = \frac{a_s^2}{2sk} + (n-s)\frac{a_o^2}{2k}$$

Appendix 8.3 shows that the sign of the difference in eco-industry's total costs $\eta - \eta_m$ is given by the following polynomial expression:

$$\psi = (\alpha_2 k)^3[ns^2 - s(n^2+n-1) + (n+1)^2] + 2(\alpha_2 k)^2(s+2n+2) + \alpha_2 k(s+2n+5) + 2$$

If the first term in ψ (that is $(\alpha_2 k)^3[ns^2 - s(n^2+n-1) + (n+1)^2]$) is positive, then the whole expression is necessarily positive. If this term is negative, then the whole expression may either be positive or negative. The following Lemma summarizes the different cases:

Lemme 2 *There are cases when the merger may increase total production costs in the eco-industry. This may only happen in an industry with at least five firms and when the number of firms merging (s) is small compared to the total number of firms in the eco-industry (n).*

Proof: See Appendix 8.3.

The intuition associated with this result is simple. Mergers always reduce the production costs of the merged entity compared to the total costs of the participants before the merger. This results from the size effect of the merger through a concentration of capital and from the fact that the merged entity produces less than the firms before the merger ($a_s < sa$). However, the outsiders always increase their production costs after the merger: they produce more ($a_o > a$) for a given per unit production cost. As a result, the effect of the merger on the eco-industry's total production costs is ambiguous. Costs are more likely to increase if the proportion of insiders compared to outsiders is low, i.e. if s is small compared to n. Therefore, everything else equal, an increase in n reduces the probability that the merger reduces total production costs in the eco-industry.

However, n also impacts the amount of capital that each firm holds ($k = \frac{K}{n}$) (as is common in the literature, we assume that the capital of each firm i depends on the total number of firms in the industry, i.e. there is a total amount of capital in the economy that is allocated among firms)[5]. As a result, the higher n, the smaller the capital detained by each firm and the higher

[5]In the literature, we often have $k = 1/n$, see Allain and Souam for instance.

the cost economies opportunities due to a concentration in capital. Therefore, an increase in n has ambiguous effects on the eco-industry's total production costs after merger. We can check that when $K = 1$, production costs always decrease after a merger, whatever the number of insiders or outsiders. Intuitively, if the amount K of capital shared in the economy is rather low, a s-firms merger concentrates this capital enough for cost economies from the merged entity to compensate the outsiders' reaction. It is not the case anymore when K is too high.

4.2 The effect on pollution

Considering the optimal values of production and abatement for polluting firms ($x = 1 - c - p$ and $A = 1 - c - \frac{1+t}{t}p$), net pollution is equal to:

$$e(x, A) = \frac{1}{2}(x - A)^2 = \frac{1}{2}(\frac{p}{t})^2 \tag{8}$$

Rather intuitively, the higher the price p for pollution abatement, the higher net pollution. Conversely, the higher the tax t, the lower net pollution. The price p increases when a merger occurs in the eco-industry ($p_m > p$). Therefore, for a given tax rate, a merger unambiguously deteriorates the quality of the environment. The difference between pre-merger and post-merger environmental damage is:

$$E = \nu(\frac{p^2 - p_m^2}{2t^2}) \tag{9}$$

This expression is necessarily negative, i.e. the merger increases the environmental damage in the economy. It is interesting to examine briefly how a change in the environmental policy affects the difference E. When the tax is increased, it has a direct decreasing effect on the deterioration of the environment (it increases the denominator in (9)). However, it also amplifies the difference between p_m and p (see Appendix 8.4) and thus increases the loss in environmental quality. As a result, the emission tax has ambiguous effects on the extent of the environmental damage generated by a merger in the eco-industry. According to our simulations, a tax increase amplifies the loss in environmental quality for low values of the initial tax. Increasing an environmental tax may thus have surprising indirect negative effects on the quality of the environment, via the potential mergers in the eco-industry. On the other hand, a stricter environmental policy reduces the incentives to merge (see section 3). The influence of the environmental tax on the level of pollution when taking into account the mergers in the eco-industry then results from complex and contradictory effects, which open scope for further research.

We also note that an increase in the number of firms decreases the negative consequences of a merger on the environmental damage, as it reduces the difference between p_m and p (see Appendix 8.4).

4.3 Downstream consequences

Let us now study the impact of a merger on polluting firms' profits and final consumers' surplus (two first terms in (7)). Given the functions of our model, we have at an equilibrium that $x = 1 - c - p$ and thus $P = c + p$ (recall that $P = 1 - x$). The difference in the sum of consumers' and polluters' surplus (downstream users' surplus) between before and after the merger is written:

$$D = \frac{1}{2}(p^2 - p_m^2) < 0 \tag{10}$$

This expression is unambiguously negative as $p_m > p$. In other words, downstream users are always worse-off when a merger in the eco-industry occurs. This is due to the fact that the price of final goods increases with the merger, due to the increase in the price of abatement ($P = c + p$). The consumers' surplus thus decreases (first term in (7)). Polluters' costs (second term in (7)) are reduced (x decreases) but not enough for the total effect on downstream users to be positive.

Note that as the environmental tax increases (i.e. α_2 increases), the difference between p_m and p increases and the loss D is amplified. As seen before, a stricter environmental policy may amplify the welfare decreasing effects of a merger. Conversely, a higher number of incumbent firms in the market tends to reduce the negative impacts of a merger on downstream users. Once again, the consequences of a merger are less important when the initial price of environmental goods is low, which would be the case if competition was initially important in the market.

4.4 Total welfare effect

A merger within the eco-industry has contrary effects on welfare. Its effect on the environmental quality and on downstream users is always negative whereas its effect on the eco-industry's production costs is ambiguous. In order to obtain a precise condition for which a merger in the eco-industry is welfare enhancing, we rewrite the welfare function given by (7). Details leading to the following expression can be found in Appendix 8.5.

$$W = 1/2 - \frac{c(2-c)}{2} - \frac{\alpha_1^2}{2(1+B)^2}[1 + \frac{B}{t}(1+t)(1-B.h) + \frac{\nu}{t^2}] \tag{11}$$

where $h = \sum_{i=1}^{n}(\frac{a_i}{A})^2 = \sum_{i=1}^{n}(\frac{\beta_i}{B})^2$ is the Herfindahl index of the sector.

Only the last part of this expression is modified by a merger within the eco-industry (c remains unchanged). Therefore, a merger is welfare-enhancing if and only if:

$$\frac{\alpha_1^2}{2(1+B_m)^2}\left[1 + \frac{B_m}{t}(1+t)(1-B_m.h_m) + \frac{\nu}{t^2}\right] < \frac{\alpha_1^2}{2(1+B)^2}\left[1 + \frac{B}{t}(1+t)(1-B.h) + \frac{\nu}{t^2}\right]$$

where h_m is the Herfindhal index after the merger.

By simply rearranging this expression, we get the following proposition:

Proposition 2 *A merger within the eco-industry is welfare-enhancing if and only if:*

$$\frac{B(1-B.h)(1+B_m)^2 - B_m(1-B_m.h_m)(1+B)^2}{(1+B)^2-(1+B_m)^2} > \frac{\nu+t^2}{t(1+t)} \tag{12}$$

As B_m is unambiguously lower than B, the denominator of the LHS of expression (12) is necessarily positive. The RHS of expression (12) is also always positive. Therefore, the following corollary can be added:

Corollaire 1 *A necessary condition for a merger to be welfare-enhancing is:*

$$\frac{B(1-Bh)}{B_m(1-B_m h_m)} > \left(\frac{1+B}{1+B_m}\right)^2 \tag{13}$$

The condition in Corollary 13 is equivalent to the condition under which a merger decreases total production costs in the eco-industry. As a merger deteriorates the downstream users' surplus and the environment quality, it must necessarily reduce the eco-industry's production costs in order to be welfare-increasing. However, a reduction in production costs in the eco-industry is not a sufficient condition to increase welfare. It has to overweight the loss in welfare due to decreased surplus and increased environmental damage, elements that appear in Proposition 2.

Many interesting interpretations can be associated to Proposition 2. First, as ν increases, the merger in the eco-industry is less likely to be welfare-increasing (the RHS of expression (12) increases in ν). This result is not surprising given that mergers in the eco-industry unambiguously increase pollution. If pollution is more damaging to society, the effects of a merger are also more damaging.

Appendix 8.6 shows the impact of the number of incumbent firms n on the welfare-increasing condition. n only affects the LHS of expression (12), where it has an ambiguous effect. First, we have already seen that the difference $(p^m - p)$ decreases with n. In other words, increasing n reduces the negative consequences of a merger on the environment and on downstream users. Second, when n increases for a given s, the proportion of outsiders in the industry decreases.[6] Third, when n increases, the amount of specific capital held by each firm is reduced, increasing the opportunity of cost economies for a merger. So, the overall impact of an increase in n on the welfare-increasing condition is in general uncertain. It can be shown that when $K = 1$, an increase in n always increases the probability for a merger to be welfare enhancing as cost economies increase with an increase in n. However, this condition is not satisfied when K, the capital to be shared among the firms in the market, becomes high enough.

[6]Recall that outsiders' production costs always increase after a merger.

The tax rate t appears on the LHS of expression (12) through α_2, which unambiguously increases B and B_m and decreases h_m[7]. It also appears on the RHS of the expression, which increases in t if t is not too low. On the one hand, increasing t enlarges the market and amplifies the loss a merger generates on downstream users. On the other hand, a higher tax rate can reduce the environmental loss induced by the merger and has ambiguous effects on production costs. Overall, the tax rate has uncertain effects on the welfare implications of a merger (see Apendix 6).

5 Conflicts of interests

5.1 Profits and welfare

We have studied the conditions under which a merger in the eco-industry is welfare-enhancing. However, this merger may or may not occur, depending on whether it is profit-enhancing for the insiders. It is thus useful to compare the conditions under which a merger occurs (i.e. is profit-enhancing) and is desirable (i.e. welfare-enhancing). A s-firm merger is profit-enhancing if and only if $\pi_s^{up} > s\pi^{up}$, i.e.:

$$\frac{(1+B)^2}{(1+B_m)^2} > \frac{(s\alpha_2 k+1)^2(2\alpha_2 k+1)}{(\alpha_2 k+1)^2(2s\alpha_2 k+1)} \tag{14}$$

Using Corollary 1, we obtain that if $\frac{B(1-Bh)}{B_m(1-B_m h_m)} < \frac{(s\alpha_2 k+1)^2(2\alpha_2 k+1)}{(\alpha_2 k+1)^2(2s\alpha_2 k+1)}$, then a) if a merger occurs in the eco-industry it will never be welfare-enhancing and b) a welfare-enhancing merger will never occur. The policy implications are the following. In case a), all mergers in the eco-industry should be prohibited. In case b), the regulator may consider subsidizing welfare-improving mergers. Farrell and Shapiro (1990) discuss the possibility to implement compulsory actions or subsidies to regulate mergers. Fauli-Oller (2002) gives several examples of countries where fiscal incentives are implemented to encourage mergers.

Appendix 8.7 details how this condition can be rewritten as follows:

$$2s[n-(s+1)](\alpha_2 k)^2 + [n(1+s) - s(5+s)]\alpha_2 k - 2s > 0 \tag{15}$$

By doing comparative statics, we note that this scenario leading to policy intervention is more likely to happen for a high number of incumbent firms under the restriction that $K < \frac{5+s}{2\alpha_2}$. If K is higher than that threshold, then an increase in n only increases the LHS of expression 15 if n is not too high. If the merger only involves a low share of the incumbent firms, then a higher initial environmental tax increases the likelihood of this scenario—the LHS of expression 15 necessarily

[7] In our model, as pre-merger firms are symmetric, $h = 1/n$ and thus does not depend on t.

increases in α_2 if $\frac{n}{s} > \frac{5+s}{1+s}$. So, when a merger involves few firms and the environmental tax is already high, there is less chance to find a positive scenario of a merger increasing welfare. On the contrary, a merger that would create a monopoly ($n = s$) always leads to a reduction in production costs, while also being profitable.

The different possible scenarios are now illustrated on the following graph, where the profitability of an s-firm merger and the impact on production costs are performed, according to the number s of merging firms.

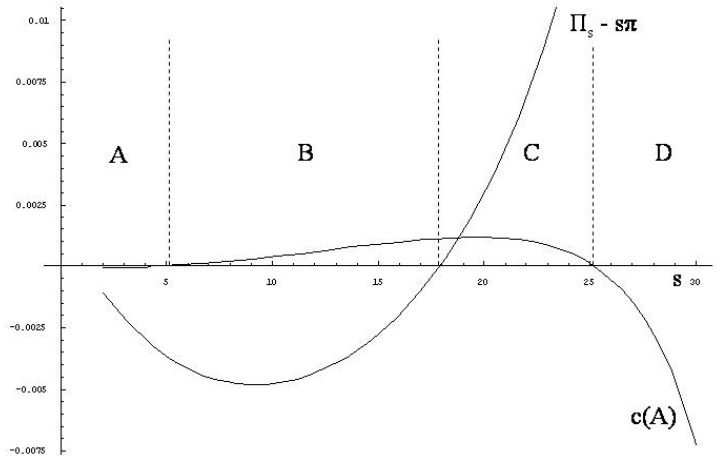

Figure 1: Production costs and profits according to the size of the merger

Part A corresponds to the case where a merger would reduce production costs but will not happen because it is not profitable. Part B means that a merger would neither be profitable nor increase welfare. Part C signifies that a profitable merger would reduce welfare while part D is the optimistic scenario, where a profitable merger reduces production costs and therefore potentially increase welfare. D corresponds to the case where an important share of the incumbent firms are involved in the merger. Expression 15 is actually the condition that excludes the possibility to be in scenario D.

5.2 Anti-trust agency vs. benevolent regulator

The task of merger control is to evaluate mergers in light of their welfare effects on different interest groups and to take a decision based on this evaluation. Competition authorities use several standard data such as firms' market share, the industry's level of concentration and relevant barriers to entry (see Khemani & Shapiro (1993) and Bergman et al. (2005) for more on that point). The US Horizontal Merger Guidelines says that a merger might be challenged

unless it is expected to deliver such cost-savings that it is also beneficial to consumers. In the EU, mergers are allowed unless they harm consumers' interests. The 1991 Canadian Merger Enforcement Guidelines considers welfare standard giving the same weight to consumers and producers. In other words, welfare standards seem to generally consider consumers' surplus and producers' interests.[8] However, the impact of the merger on the environmental data does not seem to be a relevant criterium for these authorities. Given these observations, we consider an anti-trust agency that takes into account the effect of the merger on polluters', environment firms' and consumers' surplus only. It maximizes the following function:

$$S = 1/2 - \frac{c(2-c)}{2} - \frac{\alpha_1^2}{2(1+B)^2}[1 + \frac{B}{t}(1+t)(1-Bh)]$$

and accepts the merger if and only if:

$$\frac{B(1-Bh)(1+B_m)^2 - B_m(1-B_m h_m)(1+B)^2}{(1+B)^2 - (1+B_m)^2} > \frac{t}{t+1} \tag{16}$$

We show easily that $\frac{\nu+t^2}{t(1+t)} > \frac{t}{t+1}$. As a result, the condition in Proposition 2 is stricter than condition (16): the anti-trust agency may accept a merger which is welfare-decreasing.

Proposition 3 *When the following condition is verified, the anti-trust agency may approve a merger in the environment sector which reduces total welfare:*

$$\frac{t}{t+1} < \frac{B(1-Bh)(1+B_m)^2 - B_m(1-B_m h_m)(1+B)^2}{(1+B)^2 - (1+B_m)^2} < \frac{v+t^2}{t(1+t)}$$

According to this result, collaboration between anti-trust agencies and environmental protection agencies should be considered when dealing with mergers in an environment industry. Like the energy or defense sector, the eco-industry has specific features that involve special considerations.

5.3 Illustration

Figure 2 illustrates our main results in the case of a two-firm merger ($s = 2$) in the (n, t) graph.

Each curve represented in Figure 2 is an iso-curve, on which differences in profits, welfare, and welfare without environmental damage, are equal to zero[9]. Above the iso-profit curve, a two-firm merger is profit-reducing for insiders. Conversely, below the curve, it is in the interest of the two firms to merge. Within the welfare curve, a merger is welfare-increasing. Outside it, it

[8]The relative weight given to each interest group might change from one country to an other (Fridolsson 2007).

[9]To be more precise, the "profit" curve illustrates the points where the difference between the profit of the merged entity and two times the individual profit before merger is equal to zero.

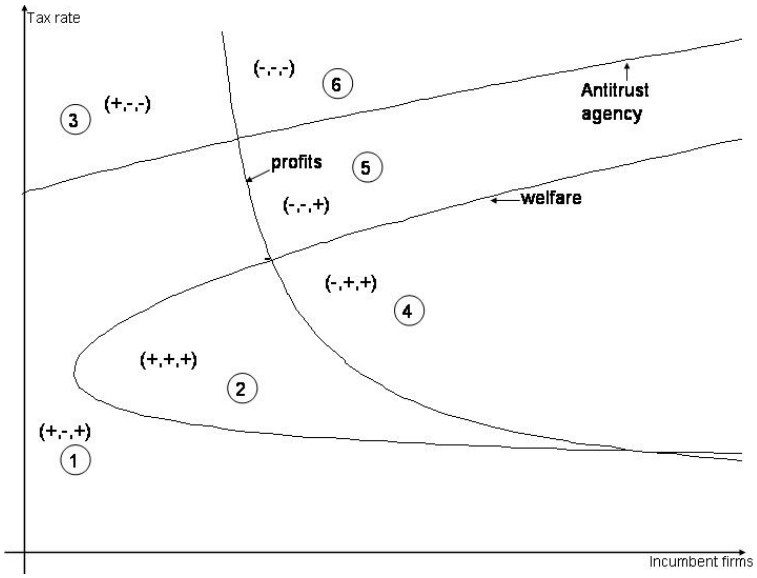

Figure 2: Welfares and profits according to the number of firms and pollution tax rates

is welfare-reducing. Welfare without environmental damage, i.e. what a competition authority would consider, is represented by the third curve. Above the curve, profits and consumers' surplus are reduced following a two-firm merger. Below it, they increase.[10]

According to Figure 2, a two-firm merger is profit-increasing for rather low values on n and t. This is due to the fact that the cost economies associated to the merger are higher when the proportion of insiders compared to the total number of firms in the industry is high. Moreover, the observation regarding the tax is in line with our result according to which a tighter environmental policy reduces incentives to merge.

On Figure 2, a merger seems to be welfare-increasing when the number of firms is above a certain threshold and the pollution tax admits intermediate values. This means that in the two-firm merger case, a higher number of firms n unambiguously plays in favor of a welfare-increasing merger, whereas the role of the emission tax remains ambiguous.

Regarding the anti-trust agency's decision, the area where it accepts the merger in Figure 2 unsurprisingly includes the area where total welfare is increased (the agency accepts a merger more often than a benevolent regulator).

The curves in Figure 2 are obtained for given values of ν, c and K. However, a change in the marginal cost c has no impact on these curves as it changes the value of profits and welfares but not the point where they become equal to zero. Changes in ν and K affect the size of the areas in which the merger is profit- or welfare-increasing but does not affect the shape of the iso-curves. Our economic interpretations of Figure 3 thus remain valid when ν, c and K vary.

[10]The sign of each variable is presented between brackets on each part of Figure 2, where for each (a, b, c), a stands for profits, b for welfare and c for welfare without environmental damage.

In sum, six cases can be discussed:

- case 1: a two-firm merger is profit increasing but welfare reducing even though an anti-trust agency would accept the merger;
- case 2: it is the most optimistic scenario. When the initial number of firms is rather low and the pollution tax chosen among intermediate values, a two-firm merger increases profits, is accepted by the anti-trust agency and increases total welfare;
- case 3: for high tax rates and a low number of firms, profits increase but both welfares—whatever the definition taken—decrease. Neither a benevolent regulator nor a competition authority should allow the merger;
- case 4: for intermediate values of t and n, a merger would increase both welfare definitions, but would not occur, as it reduces profits. From a social point of view, mergers should in that case be subsidized;
- case 5: when the number of firms is high and the pollution tax relatively high, a two-firm merger does not occur. If it had occurred it would have reduced total welfare and would have been accepted by the anti-trust agency;
- case 6: When both variables take high values, none of the considered functions is increased following a two-firm merger.

Conflicts of interests between what is profit-enhancing and what is welfare-improving appear in case 1 and 3 when firms want to merge. Conversely, in case 4, it would be socially desirable if two firms merged but it is not in their interest. In case 1 and 5, a competition authority and a benevolent regulator have opposite points of view about the implications of a two-firm merger. In case 2 and 6, no conflicts appear.

6 Discussion

Two possible extensions should be considered in future work on mergers and environmental policies. So far, we have considered that the environmental tax of the regulator was given, without specifically focusing on the level of the tax rate or on whether the regulator should adjust its policy to the mergers activity within the eco-industry. Here are two intuitive ways to look more precisely at these issues.

First, one can wonder whether a merger—although it reduces competition—can compensate a sub-optimal level of environmental taxation and increase in that way the overall welfare. When there exists one distortion in the economy, it is always welfare improving to remove it.

However, the literature on second-best policies precises that with more than one distortion, it is not always welfare-enhancing to remove one of them. The corollary is that increasing one distortion—that is, in our case, reducing competition in the depollution market—can possibly increase the overall welfare. We present some intuitions on what the marginal impact of a merger would be on welfare if the political tax is chosen above or below the scenario maximizing the overall welfare. First of all, one can check that an increase in $p(A)$ induces an increase in the optimal tax rate. Intuitively, it should generally be the case but as the post-merger production costs are different, it has to be clearly demonstrated. Therefore, assuming this increase in the optimal tax, it narrows the gap with a political tax chosen above the optimal one and conversely widened it with a tax chosen below the optimal tax rate. So a merger, by increasing the price of environmental goods, should be more favorable to the welfare of the economy if the initial tax was too high rather than too low compared to the optimal decision. In the latter case, it does not mean that the merger cannot increase welfare, it just means that it can be the case because of cost economies, but not because the merger intrinsically compensates the sub-optimal level of taxation.

Second, Benchekroun & Ray-Chaudhuri (2006), in a work in progress, study the impact of the environmental taxation on the merger profitability within the polluting industry. They show that an optimal environmental taxation is increasing in the number of firms in the market, so a merger would decrease the post-merger optimal tax. This would have a positive impact on the *ex ante* merger profitability. Using the same methodology, one could wonder what would be the impact on merger incentives within the eco-industry if the post-merger tax was adjusted to the new market structure. The intuition could be that the post-merger tax would increase, due to the increase in the price of abatement activities, increasing the post-merger profit and therefore the incentives to merge.

7 Conclusion

This paper examines the links between the environmental policy and the incentives to merge within an eco-industry. First, we show that a tighter environmental policy, in our case an emission tax, reduces the incentives for environment firms to merge. Strengthening the environmental policy increases the eco-industry's initial market power, which reduces the gains in profits that are obtained from a merger. Second, we study the welfare impacts of a merger in the eco-industry. Beyond the traditional effects of a merger on consumers' surplus and firms profits, a merger in the pollution abatement sector deteriorates the quality of the environment. We find that a merger in the eco-industry is welfare increasing when the social damage due to pollution is not too high, when the number of firms in the eco-industry is rather high and when the emission tax admits intermediate values. Moreover, we derive the condition under which an

anti-trust agency, which would ignore the environmental impact of the merger, may approve a welfare-decreasing merger.

This paper also demonstrates the contradictory welfare effects of an emission tax when taking into account mergers in the environment industry. When a merger occurs in the eco-industry, its welfare implications depend on the level of the tax. In some cases for instance, a higher environmental tax increases the social losses generated by the merger. On the other hand, increasing the emission tax may dissuade a merger that could have been welfare-decreasing. In further work, these indirect effects of the tax should be taken into account when determining the optimal environmental policy in an economy where mergers may occur in the eco-industry. Analyzing the mergers within the polluting industry as a complement to mergers in the environment industry also opens scope for further research.

8 Appendix

8.1 Proof of Lemma 1

The profit of the merged firm is:

$$\pi_s^{up} = \frac{\alpha_1^2 sk(\alpha_2 k+1)^2(2s\alpha_2 k+1)}{2[s(\alpha_2 k)^2(2+n-s)+\alpha_2 k(n+s+1)+1]^2} \tag{17}$$

The profit before the merger is:

$$\pi^{up} = \frac{\alpha_1^2 k(2\alpha_2 k+1)}{2(1+B)^2(\alpha_2 k+1)^2} \tag{18}$$

After some simplifications, we obtain that the difference $\pi_s^{up} - s\pi^{up}$ has the same sign as the following expression:

$$\frac{(\alpha_2 k+1)^2(2s\alpha_2 k+1)}{(s(\alpha_2 k)^2(2+n-s)+\alpha_2 k(n+s+1)+1)^2} - \frac{(2\alpha_2 k+1)}{(1+(n+1)\alpha_2 k)^2}$$

which has the same sign as:

$$\begin{aligned} g(s,n,\alpha_2) &= (\alpha_2 k+1)^2(2s\alpha_2 k+1)[1+(n+1)\alpha_2 k]^2 \\ &- (2\alpha_2 k+1)[s(\alpha_2 k)^2(2+n-s)+\alpha_2 k(n+s+1)+1]^2 \end{aligned}$$

We prove the existence and unicity of the threshold for which g is positive following Allain & Souam (2004)'s methodology. g is a 4th degree polynomial in s and thus admits four roots. It is decreasing and is equal to zero in $s=1$, $\forall n>1$. When $s=n$, the polynomial value is always strictly positive. Consequently, there is at least one value $\hat{s} \in [1,n]$ for which the polynomial

is equal to zero. Furthermore, $\lim_{s\to-\infty} g(n,s,\alpha_2) = -\infty$, i.e. there is a root included between $-\infty$ and 1. As, $\lim_{s\to+\infty} g(s,n,\alpha_2) = -\infty$, there is another root included between n and $+\infty$. Therefore, the root $\hat{s}$ included in $[1,n]$ is unique. When $s \in [1,\hat{s}]$, g is negative and when $s \in [\hat{s},n]$, g is positive.

8.2 Proof of Proposition 1

$g(2,n,\alpha_2)$ is a polynomial function of α_2 of degree 3. It has at most three roots. $g(2,n,0) = 1$ and $g(2,n,1) < 0$ when $n \geq 3$. Therefore, there is at least one root included between 0 and 1. We also note that $g(2,n,-1)$ is negative and $\lim_{\alpha_2\to-\infty} g(2,n,\alpha_2) = +\infty$. Thus, the two other roots are necessarily negative. In sum, a two-firm merger is profitable as long as the environmental tax leads to an α_2 lower than a threshold $\hat{\alpha_2}$. If $n = 2$, then $g(2,n,1) > 0$ and $g(2,n,\alpha 2)$ is positive for all α_2 included in [0,1].

Figure 3 represents $g(2,n,\alpha 2)$ in function of α_2 when n=4. As shown in this figure, $g(2,n,\alpha 2)$ becomes negative as α_2 increases. In other words, as the tax is increased, the merger is less likely to be profit-enhancing. As shown in Figure 4, when $n = 2$ the function $g(2,n,\alpha 2)$ is always positive so the variation of α_2 does not affect the incentives to merge.

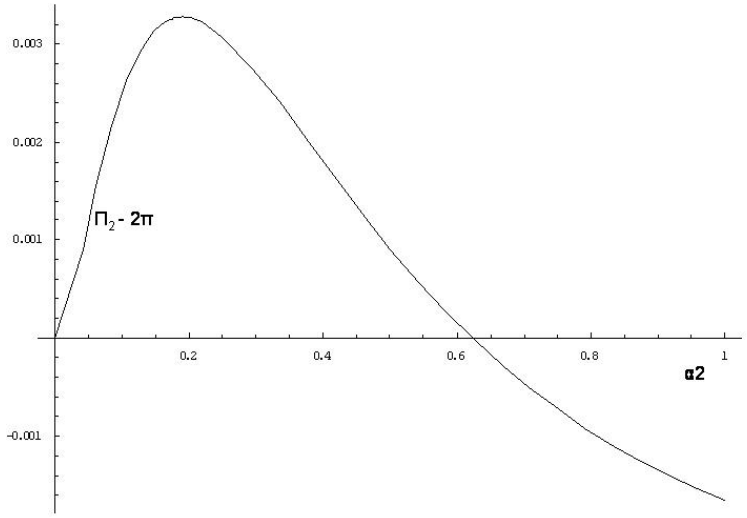

Figure 3: The impact of a change in the environmental policy on a two-firm merger profitability

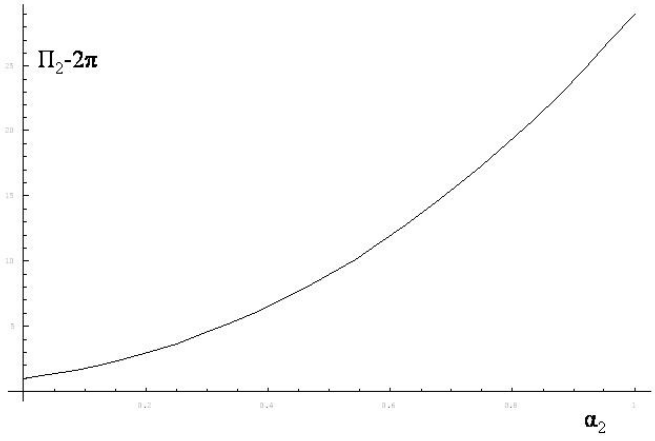

Figure 4: The impact of a change in the environmental policy on a two-firm merger profitability in a duopoly case

8.3 Analysis of the cost economies in the eco-industry following a merger

Using the expressions for a, a_s and a_o given in section 2, the difference in production costs is equal to:

$$\eta - \eta_m = \frac{\alpha_1^2 k}{2}[\frac{n}{[\alpha_2 k(n+1)+1]^2} - \frac{s(\alpha_2 k+1)^2 + (n-s)(s\alpha_2 k+1)^2}{[s(\alpha_2 k)^2(n-s+2)+\alpha_2 k(n+s+1)+1]^2}]$$

which can be rewritten as:

$$\eta - \eta_m = \frac{\alpha_1^2 \alpha_2 k^2 s(s-1)}{2} \cdot \frac{\psi}{[\alpha_2 k(n+1)+1]^2[s(\alpha_2 k)^2(n-s+2)+\alpha_2 k(n+s+1)+1]^2}$$

with

$$\psi = (\alpha_2 k)^3[ns^2 - s(n^2+n-1) + (n+1)^2] + 2(\alpha_2 k)^2(s+2n+2) + \alpha_2 k(s+2n+5) + 2$$

$\eta - \eta_m$ has the same sign as ψ. Let us study the sign of the first term in ψ so as to precise in which cases the difference in production costs can be negative. In order to do so, we study the sign of:

$$\Delta = ns^2 - s(n^2+n-1) + (n+1)^2 \tag{19}$$

The discriminant of this second degree polynomial in s is:

$$\Theta = n^4 - 2n^3 - 9n^2 - 6n + 1$$

Θ has four roots among which three are excluded from the analysis for being inferior to 1. The fourth root is approximately equal to 4.36. That is, for all n inferior or equal to 4, Θ is negative and thus Δ is positive for all values on s. In other words, in an eco-industry initially composed of strictly less than five firms, a merger will always reduce total production costs.

When n is superior or equal to 5, the polynomial (19) is negative when s is included in an interval $[s_1, s_2]$ with:

$$s_1 = \frac{n^2 + n - 1 - \sqrt{n^4 - 2n^3 - 9n^2 - 6n + 1}}{2n}$$

and

$$s_2 = \frac{n^2 + n - 1 + \sqrt{n^4 - 2n^3 - 9n^2 - 6n + 1}}{2n}$$

We can show easily that $1 < s_1 < s_2 < n$ when $n \geq 5$. However, we also show that $s_1 < 2$ when $n \geq 5$. This root is thus excluded from our analysis as the number of firms merging cannot be inferior to two. As a result, the polynomial (19) is negative when the number of firms is inferior to s_2 and positive when it is superior to s_2. Total production costs in the eco-industry may increase with the merger only if the polynomial (19) is negative, that is, only if n is superior or equal to 5 and s is rather small compared to n.

8.4 Effect of a change in t or n on the difference $p_m^2 - p^2$

(i) Variation in t:

How the difference $p_m^2 - p^2$ varies according to t is given by the sign of its derivative, i.e. $2\left(\frac{\partial p_m}{\partial t} p_m - \frac{\partial p}{\partial t} p\right)$.

We have:

$$p = \frac{\alpha_1}{1 + B}$$

$$p_m = \frac{\alpha_1}{1 + B_m}$$

and

$$B = \frac{n\alpha_2 k}{\alpha_2 k + 1}$$

$$B_m = \frac{\alpha_2 s k}{\alpha_2 s k + 1} + (n - s)\frac{\alpha_2 k}{\alpha_2 k + 1}$$

As $B_m < B$, we have that $p_m > p$.

We also note that when the environmental tax increases, both the price before merger and the price after merger increase, i.e. $\frac{\partial p}{\partial t} > 0$ and $\frac{\partial p_m}{\partial t} > 0$.

Furthermore, studying the fraction $\frac{p_m}{p} = \frac{1+B}{1+B_m}$, we can show that it always increases in t (via the increase in α_2). Therefore, $\frac{\partial p_m}{\partial t} p - p_m \frac{\partial p}{\partial t} > 0$, which yields $\frac{\frac{\partial p_m}{\partial t}}{\frac{\partial p}{\partial t}} > \frac{p_m}{p}$.

We are then sure that $\frac{\partial p_m}{\partial t} > \frac{\partial p}{\partial t}$ and so $\frac{\partial p}{\partial t}p - \frac{\partial p_m}{\partial t}p_m < 0$. The difference in prices is amplified by an increase in the environmental tax.

(ii) Variation in n:

How the difference $p^2 - p_m^2$ varies according to n is given by the sign of its derivative, i.e. $2\left(\frac{\partial p}{\partial n}p - \frac{\partial p_m}{\partial n}p_m\right)$.

First, the price after merger is always higher than the price before merger, i.e. $p_m > p$. Second, we know that when the number of incumbent firms increases, both the price before merger and the price after merger decrease, i.e. $\frac{\partial p}{\partial n} < 0$ and $\frac{\partial p_m}{\partial n} < 0$.[11]

Furthermore, studying the fraction $\frac{p_m}{p} = \frac{1+B}{1+B_m}$, we can show that it always decreases in n. Therefore, $\frac{\partial p_m}{\partial n}p - p_m\frac{\partial p}{\partial n} < 0$, which yields $\frac{\frac{\partial p_m}{\partial n}}{\frac{\partial p}{\partial n}} > \frac{p_m}{p}$ (recall that both prices decrease in n). As the price after merger is always higher than the price before merger, we can deduce that $\frac{\frac{\partial p_m}{\partial n}}{\frac{\partial p}{\partial n}} > \frac{p}{p_m}$ and therefore an increase in n increases the $(p^2 - p_m^2)$ difference. As this difference is always negative, we can conclude that a higher number of incumbent firms reduces the negative consequences of a merger.

8.5 Expression of net welfare

Following McAfee & Williams (1992), and given that at an equilibrium a_i is given by the first order-condition for profit maximization, we have that:

$$p = \alpha_1 - \alpha_2 A = (\alpha_2 + k_i^{-1})a_i$$

We then obtain the following expression for the eco-industry's total profits:

$$\Pi^{up} = \frac{\alpha_1^2 B(1+Bh)}{2\alpha_2(1+B)^2}$$

where $h = \sum_{i=1}^{n}(\frac{a_i}{A})^2 = \sum_{i=1}^{n}(\frac{\beta_i}{B})^2$ is the Herfindahl index of the sector.

The overall turnover is:

$$T = \frac{\alpha_1^2 B}{\alpha_2(1+B)^2}$$

The difference between turnover and profits yields the following expression for total production costs:

$$CT = \frac{\alpha_1^2 B}{\alpha_2(1+B)^2}\frac{1-Bh}{2} \tag{20}$$

[11] Recall that $k = \frac{K}{n}$. Therefore, a change in n is going to affect the amount of capital that each firm holds.

which yields the following welfare function:

$$W = \frac{1}{2}\left(1 - (c + \frac{\alpha_1}{1+B})^2\right) - c\left((1-c) - \frac{\alpha_1}{1+B}\right) - \frac{\alpha_1^2 B}{\alpha_2(1+B)^2}\frac{1-Bh}{2} - \frac{\nu}{2t^2}\frac{\alpha_1^2}{(1+B)^2}$$

After some simplifications, this expression becomes equation (11).

8.6 The impacts of n and t on the welfare consequences of a merger

Let us recall that:

$$B = \frac{n\alpha_2 k}{\alpha_2 k + 1},\ B_m = \frac{s(\alpha_2 k)^2(1+n-s) + n\alpha_2 k}{(s\alpha_2 k + 1)(\alpha_2 k + 1)}$$

$$h = \frac{1}{n},\ h_m = \sum_{i=1}^{n-s+1}\left(\frac{\beta_i}{B_m}\right)^2 = (n-s)\left(\frac{s\alpha_2 k + 1}{s\alpha_2 k(1+n-s)+n}\right)^2 + \left(\frac{s(\alpha_2 k+1)}{s\alpha_2 k(1+n-s)+n}\right)^2$$

Using these equations, it becomes possible to simplify expression (12). First, we develop the following term:

$$B(1-Bh) = \frac{n\alpha_2 k}{(\alpha_2 k+1)^2}$$

Furthermore, it is noteworthy that:

$$B_m(1-B_m h_m) = B(1-Bh) - \frac{s(s-1)(\alpha_2 k)^2(2+\alpha_2 k(s+1))}{(1+\alpha_2 k)^2(1+s\alpha_2 k)^2}$$

So, we can rewrite expression (12) as follows:

$$-\frac{n\alpha_2 k}{(\alpha_2 k+1)^2} + \Psi\frac{(1+B)^2}{(1+B)^2 - (1+B_m)^2} > \frac{\nu + t^2}{t(1+t)} \tag{21}$$

where $\Psi = \frac{s(s-1)(\alpha_2 k)^2(2+\alpha_2 k(s+1))}{(1+\alpha_2 k)^2(1+s\alpha_2 k)^2}$ does not depend on n.

- First, we present the consequences of a change in n on the welfare-increasing condition. The first term on the LHS of (21) is decreasing in n. $\frac{(1+B)^2}{(1+B)^2-(1+B_m)^2}$ increases in n if and only if:

  $$\frac{\partial B}{\partial n}(1+B_m) - \frac{\partial B_m}{\partial n}(1+B) < 0$$

  which is actually the case as $\frac{\partial B_m}{\partial n} > \frac{\partial B}{\partial n}$ and $B_m < B$. Moreover, the sign of a change in n on Ψ is ambiguous. Therefore, the overall impact of a change in n on the LHS of Equation (12) is ambiguous.

  However, we can show that in the case of a two-firms merger, if K is not too high, then an increase in n always increases the likelihood that a merger will be welfare-enhancing.

Downstream consequences are always reduced with an increase in n. In addition to it, when K is not too high, cost economies are increased with an increase in n.

- Second, we present the consequences of a change in t on the welfare-increasing condition. The first term on the LHS of (21) increases in t if $\alpha_2 < 1/k$. $\frac{(1+B)^2}{(1+B)^2-(1+B_m)^2}$ decreases in t if and only if:

$$\frac{\partial B}{\partial t}(1+B_m) - \frac{\partial B_m}{\partial t}(1+B) > 0$$

We have previously shown (cf. Appendix 4) that it was indeed the case, as the difference between the price before merger and the price after merger increases when t increases. Furthermore, Ψ is necessarily increasing in t. The variations of the second term of the LHS of expression (21) are ambiguous. The RHS of (21) increases in t if $t > \frac{2\nu+2\sqrt{\nu(\nu+1)}}{2}$. Overall, the impact of a change in t remains uncertain.

We can only show that a more stringent environmental policy leads to a less concentrated post-merger market, i.e. it decreases h_m.

$$\frac{\partial h_m}{\partial \alpha_2} = -\frac{2(n-s)(s-1)^2 s}{(n+s\alpha_2 k(1+n-s))^3} < 0$$

8.7 Another expression of conflicts between what increases profits and what increases welfare

Let us simplify the following expression:

$$\frac{B(1-Bh)}{B_m(1-B_m h_m)} < \frac{(s\alpha_2 k+1)^2(2\alpha_2 k+1)}{(\alpha_2 k+1)^2(2s\alpha_2 k+1)} \tag{22}$$

We know from Appendix 8.6 that $B_m(1-B_m h_m) = B(1-Bh) - \frac{s(s-1)(\alpha_2 k)^2(2+\alpha_2 k(s+1))}{(1+\alpha_2 k)^2(1+s\alpha_2 k)^2}$. So,

$$\begin{aligned}\frac{B_m(1-B_m h_m)}{B(1-Bh)} &= 1 - \frac{s(s-1)(\alpha_2 k)(2+\alpha_2 k(s+1))}{n(1+s\alpha_2 k)^2} \\ &= \frac{n(1+s\alpha_2 k)^2 - s(s-1)(\alpha_2 k)(2+\alpha_2 k(s+1))}{n(1+s\alpha_2 k)^2}\end{aligned}$$

So, expression (22) can be rewritten as follows:

$$\frac{n(1+s\alpha_2 k)^2}{n(1+s\alpha_2 k)^2 - s(s-1)(\alpha_2 k)(2+\alpha_2 k(s+1))} < \frac{(s\alpha_2 k+1)^2(2\alpha_2 k+1)}{(\alpha_2 k+1)^2(2s\alpha_2 k+1)} \tag{23}$$

which leads, after simplification, to expression (15).

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